USER-AVATAR BOND: RISK AND OPPORTUNITIES IN GAMING AND BEYOND

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EDITORIAL
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Editorial: User-Avatar Bond: Risk and Opportunities in Gaming and Beyond

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Editorial on the Research Topic

User-Avatar Bond: Risk and Opportunities in Gaming and Beyond

The proliferation and advancement of gaming and social media applications with embedded virtual reality features, such as virtual worlds and avatars, have significantly enhanced the potential for these media technologies to attract and engage users, alongside broadening usage and popularity (Stavropoulos et al., 2021). Nevertheless, concerns have also emerged about the perils to well-being arising from excessive usage and addiction-like behaviors (Colder Carras et al., 2021). Along this line, research continues to examine how the use of virtual reality enriched, and/or gamified applications, may either enhance or undermine one's wellbeing (Kruzan and Won, 2019; Stavropoulos et al., 2020; Houwelingen-Snippe et al., 2021). To respond to such questions and interpret users' adaptive and/or maladaptive trajectories, scholars aim to demystify the interplay between influences related to the user, their real-life surroundings, and the application itself (Stavropoulos et al., 2021; Lee and Lee, 2022; Ratan et al., 2022). Within this context, the avatar, or self-representation of the human user that facilitates engagement in a mediated environment (Nowak and Fox, 2018), has captivated scholar interest. While the term "avatar" originated from the Sanskrit "avatāra", meaning the re-incarnation of Hindu spirits in terrestrial form (Bailenson and Blascovich, 2004), it has become a central element of modern virtual experiences in which users control virtual entities resembling themselves in physical, behavioral, and/or psychological ways (Lee, 2004). Contributing to this line of inquiry as editors of a *Frontiers* Research Topic, we have assembled a collection of studies focused on the notion of the user-avatar bond (UAB).

The UAB relates to multiple previous areas of avatar-related research. Their many theoretical constructs have been developed to describe users' psychological connections with their avatars, such as embodiment (Kilteni et al., 2012; Peck and Gonzalez-Franco, 2021), monadic identification (Klimmt et al., 2010), polythetic identification (Downs et al., 2019), self-presence (Biocca, 1997; Ratan, 2012), avatar-self relevance (Ratan and Dawson, 2016), and the player-avatar relationship typology (Banks, 2015). Although distinct in name, these constructs often contain overlapping concepts, such as embodiment as a facet of avatar identification (Van Looy et al., 2012). As such, for this Research Topic we use the umbrella concept of UAB to include any research that involves any notions of a psychological association between the user and avatar, allowing us to focus on the notable correlates of such inter-connections. For example, multiple studies have found that when users customize their avatars, they experience an increased sense of closeness with them, which enhances their identification, enjoyment, and other outcomes of use (Hefner et al., 2007; Trepte and Reinecke, 2010; Birk et al., 2016; Kang and Kim, 2020; Koulouris et al., 2020). Further, sense of embodiment likely plays a role in the Proteus effect, of the phenomenon that an avatar's characteristics influence the user's subsequent behaviors (Yee and Bailenson, 2007, 2009; Ratan et al., 2020). Thus, while the individual's real-life background and knowledge, either directly and/or

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indirectly, predicate the avatar's formation, the avatar can also influence the user's conduct outside of the virtual world in subtle, although significant ways (e.g., distorted perceptions, cognitions, and even non-deliberate actions Ortiz de Gortari and Gackenbach, 2021; Navarro et al., 2022).

Research on the UAB is essential to developing an understanding of how avatar use may impact individual users specifically, as well as on the broad scale. In that extent, the UAB has been associated with both negative and positive outcomes, varying from disordered gaming vulnerability to improvements in e-health and cyber-education applications (Mastorci et al., 2020; Mkrttchian et al., 2020; Stavropoulos et al., 2020; Szolin et al., 2022). For instance, tendencies to identify with, embody, and even idealize the avatar potentially underpin the ability for games to help users battle depression and anxiety or develop dexterities necessary for professional performance (Peña et al., 2020). Ironically, the same engaging properties have been proposed to explain the UAB's contribution to disordered gaming patterns (Stavropoulos et al., 2019, 2020).

To address this complex dynamic, the present Research Topic includes a set of 14 studies coming from widely different, though contemporaneously complimentary perspectives. These articles capture recent global advancements in the field, deriving from Singapore (Chen et al.), the USA (Alon et al.; Banks and Bowman; Huang-Isherwood and Peña; Jeong et al.; Prettyman and Bolls; Wang et al.; Lynch et al.), Korea (Ahn et al.; Erb et al.), Canada (Czerwonka et al.) and Taiwan (Lin and Wu; Lin et al.). Furthermore, the studies informing this Research Topic reflect the current methodological diversity embraced by leading UAB scholars, including model-driven literature reviews (Lynch et al., 2022), thematic analysis (Erb et al.) and a series of advanced experimental and quantitative designs (Alon et al.; Chen et al.; Lin and Wu; Lin et al.; Prettyman and Bolls). Subsequently, the range of analytical protocols operationalizing the various methods employed, include the parallel assessment of physical and virtual kinematics (Jeong et al.), semantic network analysis (Banks and Bowman), ordinary least squares (OLS) regressions (Wang et al.), analysis of variance and independent sample *t*-tests (Huang-Isherwood and Peña), mediation modeling (Ahn et al.), and a novel avatar-affordances framework analysis (Czerwonka et al.).

Such methodological and analytical wealth allows the results of the present Research Topic to significantly expand the available knowledge surrounding both (1) the conceptualization and the multifaceted description and (2) the applicability of the UAB. Indicatively, and considering the UAB concept, (1a) major underlying themes of "tolerance", "malleability" and "flexibility" were revealed (Erb et al.), and (1b) a new skilled-driven theoretical scaffolding of UABs was introduced (Lynch et al., 2022). Considering means contributing to the multifaceted UAB description, (1c) a ground-breaking creative method blending physical and virtual kinematics to portray the bond was introduced (Jeong et al.), while (1d) universal and idiosyncratic player-avatar relationship patterns were differentiated (Banks and Bowman). Despite these, (1e) avatar customization options in exergames were found to limit players from presenting the way they may have liked in the virtual world (Czerwonka et al.), challenging UAB's independence from real-world existing social biases. Considering the practical usage of the UAB, promising application domains related to (2a) physical activity, (2b) morality/risky behaviors, (2c) sexual identity and (2d) minorities' acceptance emerged. In relation to physical activity in particular, (2a1) the utilization of cartoon-avatars, that resemble children's body type, was shown to enhance engagement with active video games, leading to an increase in physical activity motivation (Alon et al.). Relatedly, (2a2) participants' gender and age were found to influence the effect of avatar body depiction on exercise engagement (Lin et al.; Lin and Wu). Together, these studies suggest that the interaction of user and avatar identity characteristics play an important role in the Proteus effect, potentially through mechanisms of social (e.g., upward) comparison. Considering morality, (2b1) an avatar's perceived morals were found to effect players' guilt and attributional responses (Ahn et al.), while (2b2) the UAB was found to influence feelings of guilt after committing game-simulated violent acts (Huang-Isherwood and Peña). Similarly, (2b3) identification with avatars in a virtual dating game was associated with choosing less sexually risky behaviors (Wang et al.). Considering sexual identity, (2c1) more strongly sex-typed participants were found to be more motivated by higher sex-salient avatars, as reflected by skin conductance and facial electromyography assessments during gameplay (Prettyman and Bolls). Finally, considering minorities' acceptance, (2d1) outgroup-member avatar embodiment was found to effectively improve the reception of immigrants (Chen et al.).

Despite the significant knowledge attained and the progress made, obstacles in maximizing the benefits and minimizing the risks related to the employment of UAB persist. A vast proportion of researchers continue to approach UAB from either a positive and/or a negative point of view without addressing the continuum of adaptive-to-maladaptive applications that avatar use may accommodate (Stavropoulos et al., 2021). There is a scarcity of multilevel UAB studies, examining within- and between-individual differences, whilst taking into consideration customization and application effects, as Lynch et al. would propose. A variety of psychometric scales assessing UAB experiences have been employed, limiting inevitably the comparability of international findings. The employment of modern methodologies, such as network analysis in the context of semantics (Banks and Bowman) and the comparative study of real and virtual kinematics (Jeong et al.) remain rare. Finally, interdisciplinary collaborations between communication, health, and allied health UAB researchers are present only in a minority of studies.

In this context, our conclusion is 2-fold. First, irrespective of proclamations on the "positive" and/or "negative" nature of UAB, *more consistent measurement and conceptualization approaches surrounding the composition and structure of the UAB are needed,* so that future studies' findings may be adequately compared and integrate to inform practice. Secondly, we must recognize that the communication-related, psychological, and information-science, past and present advancements in the field of UAB will provide the basis for future research and practice in our society's impending *metaverse* era.

AUTHOR CONTRIBUTIONS

VS and RR contributed to the literature review, the structure, and sequence of theoretical arguments. KL contributed to the theoretical consolidation of the current work, revised, and edited the final manuscript. All authors contributed to the article and approved the submitted version.

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REFERENCES

Bailenson, J. N., and Blascovich, J. (2004). "Avatars", in *Encyclopedia of human-computer interaction.* Berkshire Publishing Group.

Banks, J. (2015). *Object, me, symbiote, other: A social typology of player-avatar relationships*. First Monday. doi: 10.5210/fm.v20i2.5433

Biocca, F. (1997). The cyborg's dilemma: progressive embodiment in virtual environments. *J. Comput. Med. Commun.* 3, JCMC324. doi: 10.1111/j.1083-6101.1997.tb00070.x

Birk, M. V., Atkins, C., Bowey, J. T., and Mandryk, R. L. (2016). "Fostering intrinsic motivation through avatar identification in digital games", in *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, p. 2982–2995. doi: 10.1145/2858036.2858062

Colder Carras, M., Stavropoulos, V., Motti-Stefanidi, F., Labrique, A., and Griffiths, M. D. (2021). Draconian policy measures are unlikely to prevent disordered gaming. *J. Behav. Addict.* 10, 849–853. doi: 10.1556/2006.2021.00075

Downs, E., Bowman, N. D., and Banks, J. (2019). A polythetic model of player-avatar identification: Synthesizing multiple mechanisms. *Psychol. Popular Media Cult.* 8, 269–279. doi: 10.1037/ppm0000170

Hefner, D., Klimmt, C., and Vorderer, P. (2007). "Identification with the player character as determinant of video game enjoyment", in *International Conference on Entertainment Computing 2007*, p. 39–48. doi: 10.1007/978-3-540-74873-1_6

Houwelingen-Snippe, V., Ben Allouch, S., and Van Rompay, T. J. (2021). Virtual reality representations of nature to improve well-being amongst older adults: a rapid review. *J. Technol Behav. Sci.* 6, 464–485. doi: 10.1007/s41347-021-00195-6

Kang, H., and Kim, H. K. (2020). My avatar and the affirmed self: psychological and persuasive implications of avatar customization. *Comput. Hum. Behav.* 112, 106446. doi: 10.1016/j.chb.2020.106446

Kilteni, K., Groten, R., and Slater, M. (2012). The sense of embodiment in virtual reality. *Pres. Teleoperat. Virt. Environ.* 21, 373–387. doi: 10.1162/PRES_a_00124

Klimmt, C., Hefner, D., Vorderer, P., Roth, C., and Blake, C. (2010). Identification with video game characters as automatic shift of self-perceptions. *Media Psychol.* 13, 323–338. doi: 10.1080/15213269.2010.524911

Koulouris, J., Jeffery, Z., Best, J., O'Neill, E., and Lutteroth, C. (2020). "Me vs. Super(wo)man: effects of customization and identification in a VR exergame", in *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. Honolulu HI: USA. doi: 10.1145/3313831.3376661

Kruzan, K. P., and Won, A. S. (2019). Embodied well-being through two media technologies: Virtual reality and social media. *New Media Soc.* 21, 1734–1749. doi: 10.1177/1461444819829873

Lee, J. G., and Lee, K. M. (2022). Polite speech strategies and their impact on drivers' trust in autonomous vehicles. *Comput. Hum. Behav.* 127, 107015. doi: 10.1016/j.chb.2021.107015

Lee, K. M. (2004). Presence, explicated. *Commun. Theory.* 14, 27–50. doi: 10.1111/j.1468-2885.2004.tb00302.x

Mastorci, F., Bastiani, L., Trivellini, G., Doveri, C., Vassalle, C., and Pingitore, A. (2020). A new integrated approach for adolescent health and well-being: the AVATAR project. *Health Quality Life Outc.* 18, 1–9. doi: 10.1186/s12955-020-01291-6

Mkrttchian, V., Kharicheva, D., Aleshina, E., Panasenko, S., Vertakova, Y., Gamidullaeva, L. A., et al. (2020). Avatar-based learning and teaching as a concept of new perspectives in online education in Post-Soviet Union countries: Theory, environment, approaches, tools. *Int. J. Virt. Pers. Learn. Environ.* 10, 66–82. doi: 10.4018/IJVPLE.2020070105

Navarro, J., Peña, J., Cebolla, A., and Baños, R. (2022). Can avatar appearance influence physical activity? User-avatar similarity and Proteus effects on cardiac frequency and step counts. *Health Commu.* 37, 222–229. doi: 10.1080/10410236.2020.1834194

Nowak, K. L., and Fox, J. (2018). Avatars and computer-mediated communication: a review of the definitions, uses, and effects of digital representations. *Rev. Commun. Res.* 6, 30–53. doi: 10.12840/issn.2255-4165.2018.06.01.015

Ortiz de Gortari, A. B., and Gackenbach, J. (2021). Game transfer phenomena and problematic interactive media use: dispositional and media habit factors. *Front. Psychol.* 12, 1144. doi: 10.3389/fpsyg.2021.585547

Peck, T. C., and Gonzalez-Franco, M. (2021). Avatar embodiment. a standardized questionnaire. *Front. Virt. Real.* 1, 44. doi: 10.3389/frvir.2020.575943

Peña, J., Li, B. J., and Ratan, R. (2020). Digital embodiment and improving health outcomes: healthy avatars make for healthy people. In *Technology and Health*. Academic Press. pp. 27–47. doi: 10.1016/B978-0-12-816958-2.00002-2

Ratan, R., Beyea, D., Li, B. J., and Graciano, L. (2020). Avatar characteristics induce users' behavioral conformity with small-to-medium effect sizes: a meta-analysis of the proteus effect. *Media Psychol.* 23, 651–675. doi: 10.1080/15213269.2019.1623698

Ratan, R., and Dawson, M. (2016). When Mii is Me: a psychophysiological examination of avatar self-relevance. *Commun. Res.* 43, 1065–1093. doi: 10.1177/0093650215570652

Ratan, R., Miller, D. B., and Bailenson, J. N. (2022). Facial appearance dissatisfaction explains differences in zoom fatigue. *Cyberpsychol. Behav. Soc. Netw.* 25, 124–129. doi: 10.1089/cyber.2021.0112

Ratan, R. A. (2012). "Self-presence, explicated: Body, emotion, and identity extension into the virtual self", in R. Luppicini (Ed.), *Handbook of Research on Technoself,* 322–336. New York, NY: IGI Global. doi: 10.4018/978-1-4666-2211-1.ch018

Stavropoulos, V., Dumble, E., Cokorilo, S., Griffiths, M. D., and Pontes, H. M. (2019). The physical, emotional, and identity user-avatar association with disordered gaming: a pilot study. *Int. J. Mental Health Addic.* 20, 183–195. doi: 10.1007/s11469-019-00136-8

Stavropoulos, V., Gomez, R., Mueller, A., Yucel, M., and Griffiths, M. (2020). User-avatar bond profiles: How do they associate with disordered gaming?. *Addict. Behav.* 103, 106245. doi: 10.1016/j.addbeh.2019.106245

Stavropoulos, V., Motti-Stefanidi, F., and Griffiths, M. D. (2021). Risks and opportunities for youth in the digital era. *Eur. Psychol.* 27, 86–101. doi: 10.1027/1016-9040/a000451

Szolin, K., Kuss, D., Nuyens, F., and Griffiths, M. (2022). Gaming Disorder: A systematic review exploring the user-avatar relationship in videogames. *Comput. Human Behav.* 128, 107124. doi: 10.1016/j.chb.2021.107124

Trepte, S., and Reinecke, L. (2010). Avatar creation and video game enjoyment. *J. Media Psychol.* 22, 171–184. doi: 10.1027/1864-1105/a000022

Van Looy, J., Courtois, C., De Vocht, M., and De Marez, L. (2012). Player identification in online games: Validation of a scale for measuring identification in MMOGs. *Media Psychol.* 15, 197–221. doi: 10.1080/15213269.2012.674917

Yee, N., and Bailenson, J. (2007). The Proteus effect: The effect of transformed self-representation on behavior. *Human Commun. Res.* 33, 271–290. doi: 10.1111/j.1468-2958.2007.00299.x

Yee, N., and Bailenson, J. N. (2009). The difference between being and seeing: the relative contribution of self-perception and priming to behavioral changes via digital self-representation. *Media Psychol.* 12, 195–209. doi: 10.1080/15213260902849943

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The Effects of Sex-Type, the Sex of the Avatar, and Salience of the Sex of the Avatar on Emotional Valence and Arousal

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The objective of this study was to investigate the effects of avatar sex, salience of avatar sex, and player sex-type on less conscious embodied emotional arousal and valence vs. consciously perceived emotional arousal and valence elicited by a gaming experience. The experiment conducted a 2 avatar sex (female × male) × 2 salience of avatar sex (high × low) × 2 player sex-type (sex-typed × non-sex-typed) mixed model factorial design. Participants were randomly assigned to one of two gameplay conditions (high-salience male and female avatar or low-salience male and female avatar) and then played two 15-min sessions of a video game—one session playing the game as a male avatar and one session playing the game as a female avatar. The order in which participants played as either a male or female avatar was randomized. Psychophysiological indicators of arousal (skin conductance) and valence (facial electromyography) were recorded during gameplay. Self-report measures of arousal and valence were obtained immediately after each 15-min session of gameplay. Data analysis tested hypotheses concerning the effects of avatar sex, salience of avatar sex, and player sex-type separately on real-time embodied variation in arousal and valence as revealed through physiological indicators and conscious perception of arousal and valence obtained through self-report measures.

Keywords: avatars, arousal, valence, psychophyisology, gender, sex, salience

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INTRODUCTION

According to the Entertainment Software Association (2019) 65% of American adults play video games and 75% of American households have at least one member who plays video games. The number of men and women playing video games is roughly equivalent and the average gamer is 33 years old (Entertainment Software Association, 2019). Video games have become a prevalent and popular form of entertainment over the last three decades, enjoyed by adults and children of all sexes and genders. As the number of video games fans continues to grow, research on how specific game features, like avatars, affect players' gaming experiences becomes increasingly important.

The entertainment experience of playing video games, like most forms of entertainment media, is rooted in emotional processes, like emotional arousal (the strength of the emotion) and emotional valence (whether the emotion is positive or negative; Bradley and Lang, 2007; Potter and Bolls, 2012), and responses (Lang, 2009; Fisher et al., 2018; Raney and Bryant, 2019). Previous research suggests that emotional processes and responses elicited by features of video games (e.g., point of view) can vary by gender as well as the nature of the observed emotional process (Lim and Reeves, 2009). The nature of the observed emotional process can vary according to the level of consciousness at which the response occurred (i.e., conscious or subconscious) and whether the process is observed in real time (as is the case with physiological indicators of emotion) or after playing a game (Lim and Reeves, 2009). The widespread appeal of video games along with potential variation in the nature of emotional processes and responses to video games makes it particularly important to understand how users of different gender types emotionally process games and what factors within games impact that processing (Lonergan et al., 2018).

The objective of this study was to investigate how the sex of the avatar (SOTA) (i.e., the digital bodies that represent users in virtual environments), the salience of the SOTA (i.e., the degree to which a player is consciously aware of the sex of their avatar), and player sex-type affect the embodied emotional processing of video games and conscious emotional responses to the gaming experience. Specifically, we investigated how less conscious these factors affected the embodied processes of emotional arousal and emotional valence (i.e., emotional arousal and valence) and how they affect conscious perceptions of emotional arousal and emotional valence (i.e., conscious emotional arousal and valence).

This project approached the question of how the SOTA, salience of the SOTA, and participant sex-type impact players' conscious emotional arousal and valence and less conscious emotional arousal and valence from several theoretical perspectives. Specifically, it draws on insights from gender schema theory (GST) and the limited capacity model of motivated mediated message processing (LC4MP).

The LC4MP is a model of information processing (Lang, 2009). According to the LC4MP, humans are limited-capacity processors, which means that they only have a limited number of cognitive resources to dedicate to the processing of information at any given time. Information processing is made up of three "simultaneous and continuous" subprocesses: (1) encoding (taking in information), (2) storage (storing encoded information in long-term memory), and (3) retrieval (pulling information out of memory; Lang, 2009, p. 194). The allocation of cognitive resources to these subprocesses is both controlled and automatic. Controlled allocation of cognitive resources refers to when a person purposefully allocates their resources to a specific subprocess or subprocesses, such as when he or she is trying to pay attention or remember something. The automatic allocation of cognitive resources occurs when cognitive resources are allocated in response to the activation of a person's motivational systems by "stimulus properties or in unconscious support of the conscious goals of the user" (Lang, 2009, p. 195). The LC4MP maintains that people have two motivational systems called the aversive system (i.e., the avoid system), which is associated with negative stimuli, and the appetitive system (i.e., the approach system), which is associated with positive stimuli. The motivational systems are independent and can be active at the same time. Which system is active, along with the strength of that activation, impacts how cognitive resources are allocated. According to the LC4MP, activation of the appetitive system causes more resources to be allocated to encoding and storage, while activation of the aversive system leads to an increase in resources to encoding followed by a slight decrease in resources dedicated to encoding. The stronger the activation of the system, the greater its effects on resource allocation. According to the LC4MP, people's emotions are directly tied to the activation of the motivational system; emotional valence represents which motivational system is active (i.e., appetitive vs. aversive), and emotional arousal represents the strength of the activation of the system(s). For example, a picture of a mutilated corpse would cause a strong activation of the aversive system because it is a very negative stimulus. In the context of the present study, LC4MP acts as a framework for understanding and explaining how the sex of an avatar can affect players' conscious perceptions and less conscious embodied processes of emotional arousal and valence. The idea is that the SOTA is a stimulus feature that is motivationally relevant and thus can activate a person's motivational systems. To understand why the SOTA may be a motivationally relevant stimulus feature we must turn to the second major theory used in this study, GST.

A schema is a mental network of information related to a particular topic/object/issue/etc. that guides a person's perceptions (Bem, 1981b; Martin and Halverson, 1981). Gender schema theory maintains that people form schemas about "themselves and the sexes," called gender schemas, that guide their perceptions and that influence how they process information and behave (Martin et al., 2002, p. 911). When a person is presented with new information, they will process that information based on what is contained in their schema related to that information; this is known as "schematic processing" (Bem, 1981b). For example, if your gender schema included the idea that dresses are only for women, then when you see a person in a dress you would likely assume that the person is a woman. Information that is schematic (i.e., fits with a person's schema) is processed more easily because a mental structure already exists to process it, whereas information that is a-schematic (i.e., does not fit with a person's schema) is not processed as easily and requires more effort. According to GST, for certain people the gender identity associated with their biological sex is so central to their self-concept that they process all, or nearly all, information through the lens of their gender schema; these people are called "sex-typed" (Bem, 1981b). Individuals for whom the gender identity associated with their biological sex is not as central to their self-concept are called "non-sex-typed" and are less likely to process information in terms of their gender schema (Bem, 1981b). With regards to the present study, the ideas of gender schemas, schematic processing, and sex-typing can be used to explain how the SOTA can be a motivationally relevant cue that can affect individuals' emotional arousal and valence.

The basic idea is that people's schemas influence what is motivationally relevant to them or not. Information that fits within our pre-existing schemas (i.e., schematic information) should be more motivationally relevant than information that does not fit into our pre-existing schemas (i.e., a-schematic information). Previous research has established that schematic information leads to increased conscious perceptions of emotional arousal and positive emotional valence (Shapiro et al., 2002; Fujioka, 2005). Because conscious perceptions of emotional arousal and valence tend to mirror less conscious embodied processes of emotional arousal and valence (Greenwald et al., 1989), it is reasonable to suggest that schematic information has similar effects on embodied processes of emotional arousal and valence. Thus, schematic information should lead to increased emotional arousal and increased positive valence.

With regards to the present study, this means that (1) when sex-typed players use an avatar with a sex that matches their gender identity (e.g., male avatar with masculine gender) it should lead to higher emotional arousal and positive emotional valence compared with when they use an avatar that does not match their gender identity (e.g., male avatar with feminine gender) and (2) that non-sex-typed players' conscious perceptions and embodied processes of emotional arousal and valence should not differ, regardless of the sex of their avatar. Because sex-typed players are constantly processing information in terms of their gender schemas, when the SOTA matches their gender identities (i.e., is schematic) it is motivationally relevant and thus causes increased emotional arousal and valence; however, when the SOTA does not match with their gender identities (i.e., is a-schematic), it is not motivationally relevant and thus does not affect emotional arousal and valence. Additionally, because non-sex-typed players do not use their gender schemas as the basis for processing information, the SOTA should not be motivationally relevant to them regardless of whether or not it matches their gender identity, which means it should have no effect on their emotional arousal and valence.

However, there is reason to believe that same-sex avatars and opposite-sex avatars may affect sex-typed individuals' conscious perceptions and embodied processes of emotional arousal and valence differently. According to GST, in addition to possessing a readiness to process information in terms of their gender schemas, sex-typed individuals have a "generalized readiness to encode all cross-sex interactions in sexual terms" (Bem, 1981b, p. 361). This would suggest that for sex-typed people avatars of the opposite sex should be more motivationally relevant than avatars of the same sex. In other words, for sex-typed players an avatar of the opposite sex should be more motivationally relevant, and thus lead to higher emotional arousal and valence, than one of the same sex because the opposite-sex avatar is more relevant to basic survival needs (i.e., the need for procreation/mates Lang, 2009; Fisher et al., 2018).

These two differing sets of predictions can be reconciled when they are considered in relation to people's conscious and unconscious motivations/goals as described in the LC4MP. The predictions based on sex-typed individuals' tendency to process cross-sex interactions in sexual terms may reflect their subconscious goals, whereas those made based on their readiness to process all information in terms of their gender schema may be more reflective of sex-typed individuals' conscious goals. In the context of the present study, this means that it is likely that sex-typed participants' self-reported arousal and valence and their arousal and valence as indicated by psychophysiological measures will not match. Specifically, that when sex-typed participants' gender identities and the sex of their avatar match, they will report greater arousal and emotional valence then when using an avatar whose sex does not match their gender identity, while sex-typed participants' arousal and valence as indicated by physiological measures should do the opposite (i.e., when gender identity and avatar sex mismatch, arousal and valence would be higher than when using an avatar with a matching sex).

Unlike self-report measures, which are by their nature reliant on an individual's conscious perceptions, psychophysiological measures provide a way to see inside the "black box" of the human mind and capture some evidence of psychological phenomena, such as embodied processes of emotional arousal and valence, that participants may not be consciously aware of (Lang et al., 2009; Potter and Bolls, 2012). Because the predictions made based on sex-typed individuals' tendency to process cross-sex interactions in sexual terms are more concerned with "subconscious" motivations, we believe that the psychophysiological measures of emotional arousal and valence will better capture those predictions and that the predictions made based on sex-typed individuals' readiness to process all information in terms of their gender schema, which are more concerned with conscious motivations, will be best captured in the self-report measures of emotional arousal and valence.

So far we have discussed the effect that the sex of a player's avatar will have on his or her emotional arousal and emotional valence; however, we have not discussed the impact that the salience of the SOTA will have on either of these variables. The salience of the SOTA is particularly important as there is reason to believe that none of the above effects will be seen unless the sex of a player's avatar is made salient to them.

Video games are complex stimuli containing a plethora of characteristics that can all affect an individual's emotional arousal and valence (audio, video, haptic feedback, etc.). According to the LC4MP, individuals are most affected by message features and content that are motivationally relevant to them (Lang, 2009; Fisher et al., 2018). There are a number of message features and content types that are universally motivationally relevant because they are tied to humans' evolutionary past (e.g., graphic depictions of violence, opposite-sex nudes, smiling babies, etc.). Much of the content in video games falls into this category of "survival needs" (e.g., explosions, enemies, weapons, hazardous environments, etc.) and because of this is likely prioritized over other content/features, such as the SOTA[1]. Due to the prioritization of survival-need-related content, the influence of other factors in a video game that could affect an individual likely go unnoticed by the brain because they are not as motivationally relevant. Put another way, when you are attempting to defeat a horde of hostile robots while simultaneously escaping an

[1]One of the core assumptions of the LC4MP is that the brain processes all stimuli as "real" regardless of whether they are mediated or not (Lang, 2009; Fisher et al., 2018). In other words, the brain reacts to an attacking tiger on TV the same way it reacts to a "real" attacking tiger. This means that "survival needs" in a video game will be prioritized and processed the same way they would in the "real world." Thus, just like in the real world if you are in a dangerous situation (e.g., a gunfight) what your body looks like is likely not top of mind. You may be hyper aware of your body in terms of its positioning and/or whether it's been injured, but you're not thinking about whether or not your body is biologically male/female. You are simply focused on keeping that body from getting hurt.

exploding space station, the sex of your avatar is likely the furthest thing from your mind.

Previous work by Coyle and Liben (2016) suggests that when the salience of the SOTA is low (i.e., players are not consciously aware of it) it has no effects on people, but that when the salience of the SOTA is high (i.e., players are consciously aware of it) it does have effects. Specifically, they found that avatars with low sex salience had no effects on either sex-typed or non-sex-typed individuals, and that avatars with high sex salience influenced sex-typed people, but had no effects on non-sex-typed people (Coyle and Liben, 2016).

In the context of the present study this means that although the SOTA could have an influence on sex-typed individuals' emotional arousal and valence, because of everything else going on in the game any effect that the SOTA has on their emotional arousal and valence is likely "washed out." However, if the sex of sex-typed players' avatars were made more salient to them (i.e., brought to the fore of their thoughts), then it is possible that it would affect their emotional arousal and valence in the manner predicted above. The idea is that when the salience of the SOTA is low, sex-typed players are not consciously aware of the sex of their avatars. If sex-typed players are not consciously aware of the sex of their avatars, then the SOTA is less likely to trigger gender schematic processing, and thus it is less likely to be motivationally relevant. However, when the salience of the SOTA is high, sex-typed players are consciously aware of the sex of their avatars. If sex-typed players are consciously aware of the sex of their avatars, it is likely to trigger gender schematic processing, and thus have motivational relevance. In other words, how salient the sex of sex-typed players' avatars is to them may determine whether or not the effects of the sex of their avatars on their conscious perceptions and embodied motivational processes of emotional valence and arousal are masked by the effects of the rest of a game's content. In the context of the present project this means that in addition to testing the effects of the SOTA on sex-typed and non-sex-typed individuals' conscious perceptions and embodied processes of emotional arousal and valence, the effects of the salience of the avatar's sex will also be tested.

Prior to formally laying out our research questions and hypotheses, we will briefly review the argument being made. Gender schema theory predicts that people will process information differently based on their sex-type. Specifically, that when the SOTA matches their gender identity for sex-typed people it will be schematic, and thus motivationally relevant; and, that when the SOTA does not match their gender identity it will be a-schematic, and thus not motivationally relevant. Additionally, the SOTA is neither schematic nor a-schematic for non-sex-typed people and thus has no motivational relevance to them. According to the LC4MP, motivationally relevant content features can affect individuals' conscious perceptions and embodied processes of emotional arousal and valence. Thus, the SOTA will differentially affect individuals' conscious perceptions and embodied processes of emotional arousal and valence based on their sex-type. Additionally, it is argued that in order for the SOTA to have any effects on individuals, regardless of their sex-type, it must be salient to them. If the sex of players' avatars is not salient to them, then the SOTA will have no effect on conscious perceptions and embodied processes of emotional arousal and valence. However, when the salience of the sex of players' avatars' is high, it will effect conscious perceptions and embodied processes of emotional arousal and valence based on the sex-type of the player.

The specific predicted effects for conscious emotional responses and less conscious embodied emotional processing are presented in the following hypotheses:[2]

H1: Participants' conscious (a) arousal and (b) valence will not differ significantly between low-salience male and low-salience female avatar conditions, regardless of sex-typing.

H2: Sex-typed participants' conscious (a) arousal and (b) valence will be higher for high-salience avatars of the same-sex vs. the opposite-sex.

H3: Non-sex-typed participants' conscious (a) arousal and (b) valence will not differ significantly between the high-salience avatars of both sexes.

H4: Participants' subconscious (a) arousal and (b) valence will not differ significantly between low-salience male and low-salience female avatar conditions, regardless of sex-typing.

H5: Sex-typed participants' subconscious a) arousal and b) valence will be higher for opposite-sex avatars than for same-sex avatars.

For non-sex-typed people it is unclear how the SOTA will affect their embodied motivational processes of emotional arousal and valence when the salience of the SOTA is high. On the one hand, previous research has suggested that player-avatar similarity can impact players' identification with their avatars (Trepte and Reinecke, 2010). When the SOTA is highly salient to non-sex-typed people, if its sex matches their biological sex, it may contribute to their feelings of player-avatar similarity and thus be motivationally relevant. If this was the case, then non-sex-typed people using same-sex avatars would lead to increased embodied processes of emotional arousal and valence. However, because non-sex-typed people do not generally process information in terms of their gender schema, it is unlikely that the sex of their avatar would have any impact on their conscious perceptions of emotional arousal and valence. But, it is also possible that for non-sex-typed individuals there will be no significant differences between embodied motivational processes of emotional arousal and valence. The reasoning is that either both the male and female avatars will be equally motivationally relevant, thus leading to no significant differences between either condition; or neither of the avatars (male or female) is motivationally relevant, and thus leads to no significant differences between the conditions. Therefore, we ask:

RQ1: How are non-sex-typed participants' embodied motivational processes of emotional arousal and emotional valence affected by an avatar with a highly salient sex?

[2]It should be noted that a number of the above predictions predict null effects; while it is not common practice to predict null effects in some academic disciplines, in the context of the present study, it was felt that the predictions of null effects were justified because of the study's focus on examining conscious and less conscious mental processes across multiple conditions and contexts. Specifically, that in order to most precisely and accurately describe the expected effects of the SOTA on participants' conscious and less conscious emotional arousal and valence across each of the different conditions, it was necessary for several of the hypotheses to predict null effects.

MATERIALS AND METHODS

In order to test the above hypotheses and answer the research questions, a mixed-design experiment was performed.

Design

The experiment conducted utilized a 2 avatar sex (female × male) × 2 salience of avatar sex (high × low) × 2 sex-type (sex-typed × non-sex-typed) mixed model factorial design. Avatar sex was a within-subject factor, and salience of avatar sex, sex-type, and order served as between-subject factors. Avatar sex consisted of two levels, male and female. Salience of avatar sex consisted of two levels, high and low. Sex-type consisted of two levels, sex-typed and non-sex-typed. The non-sex-typed level consisted of both androgynous and undifferentiated individuals. Previous research has shown that androgynous and undifferentiated individuals' responses to and processing of gender information is similar with few exceptions (Bem, 1981b; Markus et al., 1982). The order factor represents the order in which subjects experienced the stimuli (i.e., male avatar then female avatar or female avatar then male avatar). Subjects were randomly assigned to one of the two order conditions to control for any order effects, participant fatigue, and desensitization.

Power Analysis

To determine the necessary sample size, a power analysis for a repeated measures ANOVA with a within-between interaction, a Cohen's f of 0.18, an α of 0.05, an expected power of 0.80, three groups, two measurements, a correlation among repeated measures of 0.5, and a non-spherecity correction of 1 was conducted using GPower 3.1, which indicated a minimum sample size of 78 participants. A small effect size was chosen as previous research using psychophysiological measures has indicated that the effect size for content features on embodied processes of emotional arousal and valence tend to be small (Potter and Bolls, 2012).

Sample

A sample of 106 male and female students from a large southern university in the USA was used for the study. Participants were recruited using a research participant pool and received extra credit for their participation. Of the 106 participants, 13 were removed from the sample due to procedural issues during data collection, and another 12 were removed due to excessive artifacts in their skin conductance data, leaving a final sample size of 81 participants. The final sample used for analysis was predominately female (55.6%, $n = 45$; male 44.4%, $n = 36$) and white (66.7%, $n = 54$; African American 12.3%, $n = 10$; American Indian or Alaska Native 1.2%, $n = 1$; Asian 4.9%, $n = 4$; Other 14.8%, $n = 12$).

Stimulus

The stimulus used for the study was the roleplaying game (RPG) *The Elder Scrolls V: Skyrim* by Bethesda Game Studios (2011). *The Elder Scrolls V: Skyrim* is an action-RPG in which players explore a fantasy world defeating monsters, collecting magic items, and completing quests for experience points. In this study, participants played through the "Shimmermist Cave" dungeon. The Shimmermist Cave dungeon is a circular cave system that contains several non-human enemies, a few traps, and a few treasure chests; it is recommended for characters of level 18 or higher (Skyrim: Shimmermist Cave, 2018). Shimmermist Cave was chosen for this study for several reasons. First, it is circular and entirely self-contained; the last room of the dungeon connects back to the entrance area of the dungeon to create a loop. By being self-contained Shimmermist Cave allows participants to have relatively similar gameplay experiences. Second, Shimmermist Cave contains a number of treasure chests, which are important for the task participants were asked to complete in the gameplay portion of the experiment. For the gameplay portion, participants were asked to locate six treasure chests in Shimmermist Cave, one more than actually exists in the cave. This task was intended as a way to occupy participants for the full 15 min of the gameplay section; because the dungeon is circular, even if participants completed it in under 15 min, they ended up back at the beginning of the dungeon and could continue exploring the dungeon as they looked for the "sixth" treasure chest. Third, Shimmermist Cave contains only monster enemies. Using a dungeon that only contains monster enemies avoided introducing any potential confounds from encountering other humanoid avatars during gameplay. Additionally, the enemies in Shimmermist Cave scale to some degree to match the level of the player (Skyrim: Shimmermist Cave, 2018). In the current study players used a level 81 character and were made invincible (i.e., they could not be killed by enemies) in order to control for varying levels of gaming skill. Participants were not informed of their invincibility in order to maintain natural reactions to in-game events.

Procedure

Upon arriving at the laboratory, participants were greeted and given an informed consent form to complete. Participants were told that they were participating in preliminary research for a game developer that the university had partnered with and that the developer was interested in getting feedback on character models used in their games. They were also told that because the research was preliminary what they tested may or may be part of an existing game. This information was described on the informed consent form and given verbally to the participants. After completing the informed consent form, participants were taken to the data collection room. They were seated in front of a computer on which they completed a pre-test questionnaire that contained demographic questions, the Bem Sex Role Inventory (BSRI), and several other questions not analyzed as part of the present project. After participants had completed the pre-test questionnaire, the researcher prepped participants' skin for sensor placement and then placed sensors on participants for the collection of facial electromyography (fEMG) and skin conductance (SC) data. After all the sensors had been placed, the researcher gave participants a sheet listing the game's controls and provided them with instructions on how to play the game. Next, participants watched a nature video and a 2-min baseline was taken of their fEMG and SC. Following baseline collection, the researcher returned to the participants and gave them instructions for the gameplay portion of the experiment. After the instructions were given, participants began the gameplay portion. Participants' gameplay was recorded using a webcam and synced to their physiological data via the Acqknowledge software.

During the gameplay portion of the experiment participants played the action-RPG *The Elder Scrolls V: Skyrim* on a widescreen computer monitor with a mouse and keyboard and headphones. The gameplay portion of the experiment consisted of two gameplay sessions; one using a male avatar and one using a female avatar. The order of the sessions (i.e., male then female, or female then male) was determined by participants' randomly assigned condition. The procedure for both sessions was identical save for the SOTA the player used. In each session participants played *The Elder Scrolls V: Skyrim* for 15 min, during which they had to explore a cave that contained various traps, enemies, and treasures. Participants were tasked with the goal of locating six different treasure chests in the dungeon and instructed to keep playing until they located all six chests or the 15 min expired. The path through the cave was relatively linear and made a large loop (i.e., it wrapped back to the starting area eventually). After 15 min, the researcher paused the game and participants completed an online questionnaire that contained self-report measures for arousal and valence and several distractor questions to help maintain the cover story.

Following administration of the questionnaire, participants completed a second gameplay session. The second gameplay session was identical to the first session except participants used a different avatar. Which avatar participants used during the second gameplay session was determined by their randomly assigned condition (e.g., if a participant played through the first session as the male avatar they would then complete the second session using the female avatar). Following the second session, participants completed another online questionnaire identical to the first one. Once participants had completed two gameplay sessions and the two online questionnaires, the researcher removed the sensors from them, thanked them, and dismissed them.

After all data collection was completed, an email was sent to all participants that debriefed them about the deception used in the study. Specifically, it informed participants that (1) the purpose of the study was to determine the effects of the sex of the player's avatar on their emotional arousal and emotional valence, (2) that the study was not part of a partnership between the university and an undisclosed game developer, (3) and that the number of chests in the level was actually five. The email also offered participants the opportunity to have their data withdrawn from use should they so desire now that the deception had been revealed. No participants requested to withdraw their data.

Measures

Avatar Sex

The SOTA was conceptualized as whether an avatar is male or female. The SOTA was operationalized by using physical characteristics of the in-game models as well as data provided in the game about the avatars; specifically, whether the avatar was listed as male or female in the character creator. Avatar sex was manipulated by assigning participants to play *The Elder Scrolls V: Skyrim* using either a male or female avatar. In *The Elder Scrolls V: Skyrim* players can choose from a number of human races (e.g., Nord, Imperial, Redguard). For the present study the default male and female Imperial avatars were chosen. The Imperial race was chosen because it was the only race whose default male and female avatars did not feature face paint or other facial markings. The default male Imperial avatar is Caucasian with short black hair and a goatee (see **Supplementary Figure 1**). The default female Imperial avatar is Caucasian with shoulder length dirty-blonde hair and wears minimal makeup (see **Supplementary Figure 1**).

Salience of the Sex of the Avatar

The salience of the SOTA was conceptualized as the degree to which players are consciously aware of the sex of their avatars. The salience of the SOTA was operationalized as whether a player used a high-salience avatar or a low-salience avatar. The salience of the sex of a player's avatar was manipulated by equipping the avatar with different attire which obscured or emphasized the avatar's body shape. Evidence suggests that video game players determine whether an avatar is male or female based on a combination of social gender cues (e.g., hair length, gendered clothing) and how closely it conforms to the ideal male body shape or the ideal female body shape (Wade, 2012). In other words, one of the main ways that sex differences in video games are created is by emphasizing the differences that exist between male and female anatomy (e.g., breasts) and the presence of other gender cues (e.g., long hair).

In the high-salience condition the male and female avatars were equipped with the "ragged trousers" clothing item. The ragged trousers clothing item is a pair of well-worn, cloth, brown pants. When equipped to male avatars it leaves the wearer's upper torso exposed, and when equipped to female avatars a similarly styled shirt (i.e., ragged cloth) covers the upper torso. The game was modified so that the ragged trouser clothing item appeared identically on both the male and female avatars (i.e., it left the wearer's upper torso exposed). For male avatars this left them bare chested, and for female avatars it exposed a bikini-like bra (see **Supplementary Figure 2**). In the low-salience condition the male and female avatars were equipped with a full set of "ebony armor." The ebony armor item consists of a bulky set of black plate armor that covers an avatar's body completely save for the head. The ebony armor looks nearly identical on both the male and female avatars (see **Supplementary Figure 2**).

Sex-Type

Participant sex-type was conceptually defined as how strongly individuals identify with the gender associated with their biological sex (Bem, 1981b). Participant sex-type was determined using participants' scores on the short form of the BSRI and their self-reported biological sex[3]. Following procedures outlined

[3]Participants' gender was calculated using the "hybrid method" described in the *Bem Sex Role Inventory Professional Manual* (Bem, 1981a). Of the 81 participants the majority were categorized as feminine (50.6%, $n = 41$), followed by androgynous (23.5%, $n = 19$), undifferentiated (13.6%, $n = 11$), and masculine (12.3%, $n = 10$). The median masculinity score was 4.7 ($M = 4.8$, $SD = 0.82$) and the median femininity score was 5.3 ($M = 5.3$, $SD = 0.88$). Missing data were replaced using the series mean.

by Bem (1974, 1981a,b) participants were placed into one of three sex-type categories (i.e., sex-typed, non-sex-typed, or cross-sex-typed) based on their self-reported biological sex and their gender identity (i.e., masculine, feminine, androgynous, or undifferentiated) as determined by the BSRI[4]. Participants whose biological sex was reported as male or female and who were categorized as masculine or feminine by the BSRI, respectively, were categorized as sex-typed. Participants whose biological sex was reported as male or female and who were categorized as androgynous or undifferentiated by the BSRI were categorized as non-sex-typed. Participants whose biological sex was reported as male and categorized as feminine by the BSRI and participants whose biological sex was reported as female and categorized as masculine by the BSRI were both categorized as cross-sex-typed. Of the 81 participants 31 were sex-typed (38.3%), 30 were non-sex-typed (37%), and 20 were cross-sex-typed (24.7%).

Cross-sex-typed individuals were excluded from the analyses performed because none of the hypotheses proposed and tested included them. Research on the effect of cross-sex-typed people's gender schemas on their processing of information finds that it is inconsistent (Bem, 1981b). In some situations cross-sex-typed people process information in terms of their gender schemas and in other situations they do not (Bem, 1981b). Unlike sex-typed and non-sex-typed individuals who predictably process information in terms or not in terms of their gender schemas, cross-sex-typed individuals process information in terms of their gender inconsistently. Without being able to predictably determine when cross-sex-typed people would be processing information in terms of their gender schemas, and thus when the SOTA may or may not be motivationally relevant, no predictions could be made about how the SOTA or the salience of the SOTA would affect their conscious and less conscious emotional arousal and valence. Additionally, the distinct lack of consistency in the use of gender schematic processing among cross-sex-typed individuals prevents them from simply being grouped with sex-typed or non-sex-typed individuals who consistently use or do not use gender schematic processing.

Arousal

Arousal was conceptually defined as an indicator of the strength of activation in the motivational systems (Potter and Bolls, 2012). Conscious perceptions of arousal were operationalized as participants' self-reported scores on the arousal portion of the Self Assessment Manikin (SAM). The SAM is a validated 9-point pictorial scale used for assessing emotional arousal and valence (Lang, 1980; Bradley and Lang, 1994). For the arousal portion of the SAM, the scores range from 1 (low arousal) to 9 (high arousal). In addition to collecting participants' conscious perceptions of arousal, their subconscious processes of arousal as they unfolded across time were measured using physiological measures of arousal. Skin conductance has been found to be a good physiological indicator of arousal; thus, subconscious arousal was operationalized as participants' SC (Hopkins and Fletcher, 1994; Potter and Bolls, 2012). As SC increases arousal is said to increase, and as SC decreases arousal is said to decrease (Potter and Bolls, 2012). Skin conductance data were collected using a BioPac EDA 100C Electrodermal Activity Amplifier and disposable 8 mm Ag/AgCl electrodes. Participants' hands were cleaned with distilled water prior to electrode placement. Electrodes were placed on the palm of participants' left hand.

Valence

Valence was conceptualized as an indicator of which motivational system(s) are active (Potter and Bolls, 2012). Conscious perceptions of valence were operationalized as participants' scores on the valence portion of the SAM. The SAM is a validated 9-point pictorial scale for measuring emotional arousal and valence (Lang, 1980; Bradley and Lang, 1994). Valence scores on the SAM range from 1 (negative) to 9 (positive). In addition to collecting conscious perceptions of valence, participants' subconscious processes of valence as they unfolded across time were measured using physiological measures of valence. Subconscious valence was operationalized as facial muscle activity as indexed by fEMG. Increased muscle activity in the corrugator supercilii can indicate activation of the aversive system, and decreased muscle activity in the corrugator supercilii can indicate activation of the appetitive system (Cacioppo et al., 1986; Lang et al., 1993; Larsen et al., 2003). Facial electromyography data were collected using a BioPac EMG100C Electromyogram Amplifier and disposable 4 mm, Ag/AgCl floating electrodes. Prior to electrode placement, participants' skin was cleaned using a combination of makeup wipes and alcohol wipes and then conductive gel was applied. Electrode placement on the face followed the recommendations outlined in Potter and Bolls (2012) for fEMG data collection.

Time Spent Playing the Elder Scrolls V: Skyrim

In order to control for potential knowledge-based effects from previous experiences with *The Elder Scrolls V: Skyrim* participants were asked to indicate how many hours they had spent playing it in the last month on a 5-point Likert-type scale ranging from "0 to 10 h" to "41 or more hours." Due the age (i.e., 8 years old at the time of writing) and popularity of *The Elder Scrolls V: Skyrim* there is a high chance that participants had played it previously (The Elder Scrolls V: Skyrim, 2019). Thus, in order to gain a clearer idea of participants' current knowledge of the game we measured how much time they spent playing the game recently. Of the 81 participants the vast majority had played 10 or less hours of *The Elder Scrolls V: Skyrim* in the past 30 days (80.2%, $n = 65$). The remaining participants had played the game anywhere from 11–20 h (11.1%, $n = 9$) to 21–30 h (1.2%, $n = 1$) to 31–40 h (1.2%, $n = 1$) to 41 or more hours (6.2%, $n = 5$) in the last 30 days.

Apparatus

Physiological measures were collected using a BioPac MP150 system with heart rate, skin conductance, and electromyography

[4]Bem (1981b) argues that the BSRI possesses a "number of features" which make it ideal for identifying individuals' sex-types, and that the findings of previous research that has used the BSRI to determine participants' sex-types provide convergent validity for the use of the measure in this manner. Based on Bem's (1981b) arguments, as well as the fact that we are not aware of any other measure of sex-type we chose to use the BSRI following the procedures outlined by Bem (1981b).

modules attached. BioPac's AcqKnowledge 5.0 software was used to control the physiological data collection. Participants' gameplay was recorded using a webcam and synced to their physiological data using AcqKnowledge 5.0.

RESULTS

Physiological Data Editing and Reduction Procedures

Skin conductance data were collected at 20 Hz and then averaged over 1 s intervals across each 2-min baseline and each 15-min gameplay segment. Skin conductance data for the baselines and the gameplay segments were then down-sampled to 90 data points each, representing 10 s of gameplay. Following down-sampling, data were cleaned for artifacts. For SC, data were considered artifacts if a values were below 1. Artifacts were replaced with the next most likely neighbor. If 30% or more of a participant's data had to be replaced, their data were dropped from analysis (Potter and Bolls, 2012). The data from 12 participants were dropped from analysis due to excessive artifacts. Following data cleaning, change scores were calculated for each gameplay segment. Change scores (i.e., the change for a given score from the baseline) were calculated by first averaging each baseline from the 90 down-sampled data points from the 2 min of viewing the nature video, then subtracting that average from each of the 90 down-sampled gameplay segment data points. This process resulted in 90 SC change scores for each gameplay segment. All analyses of SC data were performed on the calculated change scores. Additionally, for all analysis of SC data, if Mauchly's Test of Sphericity was violated, significance results are reported as Greenhouse-Geisser tests.

Facial electromyography data (corrugator activity) was collected at 20 Hz. A Bandpass filter was applied to the data with a low frequency of 90 Hz and a high frequency of 500 Hz. Following application of the Bandpass filter, data were rectified. After the data were filtered and rectified, they were averaged over 1 s intervals across each 2 min baseline and each 15 min gameplay segment. Facial electromyography data for the baselines and the gameplay segments were then down-sampled down to 90 data points each, representing 10 s of gameplay. Following down-sampling, fEMG data were cleaned for artifacts. Artifacts were identified by looking at the range of responses within each individual for obvious outliers. Artifacts were replaced with the next most likely neighbor. If 30% or more of a participant's data had to be replaced, their data were dropped from analysis (Potter and Bolls, 2012). Following cleaning, change scores were calculated for each gameplay segment. Change scores were calculated by first averaging each baseline from the 90 down-sampled data points from the 2 min of viewing the nature video, then subtracting that average from each of the 90 down-sampled gameplay segment data points. This process resulted in 90 fEMG change scores for each gameplay segment. All analyses of fEMG data were performed on the calculated change scores. Additionally, for all analyses of fEMG data, if Mauchly's Test of Sphericity was violated, significance results are reported as Greenhouse-Geisser tests.

Tests of Hypotheses

H1

Hypothesis 1 stated that participants' conscious (1) arousal and (2) valence would not differ significantly between the low-salience male and low-salience female avatar conditions, regardless of sex-type. To test both parts of this hypothesis, two separate two-way mixed design ANOVAs were calculated, one for arousal and one for valence.

A two-way mixed design ANOVA was calculated comparing participants' self-reported arousal scores for the low-salience male avatar and the low-salience female avatar. The SOTA (male × female) was entered as a within-subjects factor, and participant sex-type (sex-typed × non-sex-) was entered as a between-subjects factor. Missing values were excluded listwise. The main effect of the SOTA was not significant [$F_{(1, 24)} = 0.000215$, $p = 0.988$, $\eta_p^2 = 0.000009$]. The main effect of sex-type was also not significant [$F_{(1, 24)} = 0.238$, $p = 0.630$, $\eta_p^2 = 0.010$]. Lastly, the interaction of the SOTA and sex-type was not significant [$F_{(1, 24)} = 0.515$, $p = 0.480$, $\eta_p^2 = 0.021$]. Therefore, neither the SOTA nor a participants' sex-type had a significant effect on self-reported arousal in the low-salience condition (see **Table 1**).

A two-way mixed design ANOVA was calculated comparing participants' self-reported valence scores for the low-salience male avatar and the low-salience female avatar. The SOTA (male × female) was entered as a within-subjects factor, and participant sex-type (sex-typed × non-sex-typed) was entered as a between-subjects factor. Missing values were excluded listwise. The main effect of the SOTA was not significant [$F_{(1, 24)} = 0.031$, $p = 0.861$, $\eta_p^2 = 0.001$]. The main effect of sex-type was also not significant [$F_{(1, 24)} = 0.948$, $p = 0.340$, $\eta_p^2 = 0.038$]. Lastly, the interaction of the SOTA and sex-type was not significant [$F_{(1, 24)} = 0.331$, $p = 0.861$, $\eta_p^2 = 0.014$]. Therefore, neither the SOTA nor a participants' sex-type had a significant effect on self-reported valence in the low-salience condition (see **Table 1**).

The results of both two-way mixed design ANOVAs suggest that participants' conscious (1) arousal and (2) valence did not

TABLE 1 | Means and standard deviations for self-reported arousal and valence for low-salience condition.

Condition	*M*	*SD*
AROUSAL		
Male Avatar		
Sex-typed ($n = 16$)	5.5625	2.22017
Non-sex-typed ($n = 10$)	4.9000	2.18327
Female Avatar		
Sex-typed ($n = 16$)	5.2500	1.98326
Non-sex-typed ($n = 10$)	5.2000	1.98886
VALENCE		
Male Avatar		
Sex-typed ($n = 17$)	5.1176	1.40900
Non-sex-typed ($n = 9$)	5.6667	2.29129
Female Avatar		
Sex-typed ($n = 17$)	5.0000	2.09165
Non-sex-typed ($n = 9$)	5.8889	2.08833

TABLE 2 | Means and standard deviations for self-reported arousal and valence for sex-typed participants in the high-salience condition.

Condition	*M*	*SD*
AROUSAL		
Same-sex ($n = 14$)	5.9286	2.64471
Opposite-sex ($n = 14$)	5.3571	2.95107
VALENCE		
Same-sex ($n = 14$)	6.0000	2.03810
Opposite-sex ($n = 14$)	5.7143	1.77281

TABLE 3 | Means and standard deviations for self-reported arousal and valence for non-sex-typed participants in the high-salience condition.

Condition	*M*	*SD*
AROUSAL		
Same-sex ($n = 20$)	5.6500	2.41214
Opposite-sex ($n = 20$)	5.5500	2.41650
VALENCE		
Same-sex ($n = 19$)	5.7895	2.32329
Opposite-sex ($n = 19$)	5.6842	2.05623

significantly differ between the low-salience male avatar and low-salience female avatars regardless of sex-type. These findings are in-line with the predictions made by Hypothesis 1.

H2

Hypothesis 2 stated that sex-typed participants' conscious (1) arousal and (2) valence would be higher for high-salience avatars of the same-sex vs. high-salience avatars of the opposite sex. To test both parts of this hypothesis, two separate one-way ANOVAs were calculated, one for arousal and one for valence.

A one-way ANOVA was conducted comparing sex-typed participants' self-reported arousal for high-salience same-sex avatars to their self-reported arousal for high-salience opposite-sex avatars. Player-avatar sex match (same-sex × opposite-sex) was entered as a within-subject factor. Missing values were excluded listwise. There was no significant effect of player-avatar sex match on self-reported arousal [$F_{(1, 13)} = 2.019$, $p = 0.179$, $\eta^2 = 0.134$]. This suggests that SOTA had no significant impact on self-reported arousal for sex-typed participants in the high-salience condition (see **Table 2**).

A one-way ANOVA was conducted comparing sex-typed participants' self-reported valence for high-salience same-sex avatars to their self-reported valence for high-salience opposite-sex avatars. Player-avatar sex match (same-sex × opposite-sex) was entered as a within-subject factor. Missing values were excluded listwise. There was no significant effect of player-avatar sex match on self-reported valence [$F(_{1,13}) = 0.331$, $p = 0.575$, $\eta^2 = 0.025$]. This suggests that SOTA had no significant impact on self-reported valence for sex-typed participants in the high-salience condition (see **Table 2**).

Together, the results of the two one-way ANOVAs suggest that for sex-typed participants in the high-salience condition the SOTA did not significantly affect their conscious (1) arousal or (2) valence. These findings are counter to the predictions made by Hypothesis 2.

H3

Hypothesis 3 stated that non-sex-typed participants' conscious (1) arousal and (2) valence would not differ significantly between the high-salience avatars of both sexes. To test both parts of this hypothesis, two separate one-way ANOVAs were calculated, one for arousal and one for valence.

A one-way ANOVA was calculated comparing non-sex-typed participants' self-reported arousal for high-salience male avatars to their self-reported arousal for high-salience female avatars. The SOTA (male × female) was entered as a within-subjects factor. Missing values were excluded listwise. There was no significant effect of SOTA on self-reported arousal [$F_{(1, 19)} = 0.053$, $p = 0.821$, $\eta^2 = 0.003$]. This suggests that the SOTA had no impact on self-reported arousal for non-sex-typed participants in the high-salience condition (see **Table 3**).

A one-way ANOVA was calculated comparing non-sex-typed participants' self-reported valence for high-salience male avatars to their self-reported valence for high-salience female avatars. The SOTA (male × female) was entered as a within-subjects factor. Missing values were excluded listwise. There was no significant effect of SOTA on self-reported valence [$F_{(1, 18)} = 0.100$, $p = 0.755$, $\eta^2 = 0.006$]. This suggests that the SOTA had no impact on self-reported valence for non-sex-typed participants in the high-salience condition (see **Table 3**).

The results of both one-way ANOVAs suggest that non-sex-typed participants' conscious (1) arousal and (2) valence did not differ significantly between the high-salience male avatar and high-salience female avatar. These findings provide some evidence for the predictions made by Hypothesis 3.

H4

Hypothesis 4 predicted that participants' subconscious (1) arousal and (2) valence would not differ significantly between low-salience male and low-salience female avatar conditions, regardless of sex-typing. To test both parts of this hypothesis, two 2 (avatar sex) × 2 (sex-type) × 90 (time) repeated measure ANOVAs were calculated, one for SC and one for corrugator activity.

A 2 (avatar sex) × 2 (sex-type) × 90 (time) repeated measures ANOVA was calculated comparing participants' SC for the low-salience male avatar to their SC for the low-salience female avatar. The SOTA (male × female) and time were both entered as within-subjects factors. Participant sex-type (sex-typed × non-sex-typed) was entered as a between-subjects factor. The main effect of SOTA was not significant [$F_{(1, 25)} = 0.000309$, $p = 0.986$, ${\eta_p}^2 = 0.000012$]; see **Supplementary Table 1**. The main effect of sex-type was significant [$F_{(1, 25)} = 4.494$, $p = 0.044$, ${\eta_p}^2 = 0.152$]. Non-sex-typed participants' SC ($M = 1.869$, $SE = 0.631$) was significantly higher than sex-typed participants' SC ($M = 0.184$, $SE = 0.484$) when using the low-salience male and female avatars (see **Supplementary Table 2**). The interaction of SOTA and sex-type was not significant [$F_{(1, 25)} = 1.296$, $p =$

0.266, $\eta_p^2 = 0.049$]. The interaction of time and sex-type was not significant [$F_{(89, 2,225)} = 0.922$, $p = 0.477$, $\eta_p^2 = 0.036$] see **Figure 1**. The interaction of SOTA and time was not significant [$F_{(89, 2,225)} = 0.693$, $p = 0.631$, $\eta_p^2 = 0.027$]; see **Figure 2**. The interaction of SOTA, sex-type, and time was not significant [$F_{(89, 2,225)} = 0.643$, $p = 0.669$, $\eta_p^2 = 0.025$]; see **Figure 3**. These results suggest that SOTA and any of the interactions between the SOTA, participant sex-type, or time had no significant impact on participants' less conscious arousal. Additionally, these results suggest that participants' less conscious arousal for low-salience avatars differed depending on their sex-type such that non-sex-typed participants had significantly higher less conscious arousal while using the low-salience avatars than sex-typed participants.

A 2 (avatar sex) × 2 (sex-type) × 90 (time) repeated measures ANOVA was calculated comparing participants' corrugator activity for the low-salience male avatar to their corrugator activity for the low-salience female avatar. The SOTA (male × female) and time were both entered as within-subjects factors. Participant sex-type (sex-typed × non-sex-typed) was entered as a between-subjects factor. The main effect of SOTA was not significant [$F_{(1, 25)} = 0.156$, $p = 0.696$, $\eta_p^2 = 0.006$]; see **Supplementary Table 1**. The main effect of sex-type was not significant [$F_{(1, 25)} = 0.086$, $p = 0.771$, $\eta_p^2 = 0.003$]; see **Supplementary Table 2**. The interaction of SOTA and sex-type was not significant [$F_{(1, 25)} = 0.552$, $p = 0.465$, $\eta_p^2 = 0.022$]. The interaction of time and sex-type was not significant [$F_{(89, 2,225)} = 0.689$, $p = 0.692$, $\eta_p^2 = 0.027$]; see **Figure 4**. The interaction of SOTA and time was not significant [$F_{(89, 2,225)} = 0.843$, $p = 0.589$, $\eta_p^2 = 0.033$]; see **Figure 5**. The interaction of SOTA, sex-type, and time was not significant [$F_{(89, 2,225)} = 0.862$, $p = 0.571$, $\eta_p^2 = 0.033$]; see **Figure 6**. These results suggest that the SOTA; participant sex-type; or any interactions of SOTA, participant sex-type, and time had no significant effect on participants' less conscious valence.

Taken together, the results of the two 2 (avatar sex) × 2 (sex-type) × 90 (time) repeated measures ANOVAs suggest that participants' less conscious (1) arousal and (2) valence did not significantly differ between the low-salience male and low-salience female avatar conditions, regardless of sex-type. Additionally, these analyses revealed that non-sex-typed participants' and sex-typed participants' less conscious arousal did significantly differ while using a low-salience avatar (of either sex), such that non-sex-typed participants experienced greater arousal than sex-typed participants while using low-salience avatars. These findings are partially in line with the predictions made by Hypothesis 4.

H5

Hypothesis 5 stated that sex-typed participants' subconscious (1) arousal and (2) valence would be higher for opposite-sex avatars than for same-sex avatars. To test both parts of this hypothesis, two 2 (player-avatar sex match) × 90 (time) repeated measure ANOVAs were calculated, one for SC and one for corrugator activity.

A 2 (player-avatar sex match) × 90 (time) repeated measure ANOVA was conducted comparing sex-typed participants' SC for high-salience same-sex avatars to their SC for high-salience opposite-sex avatars. Player-avatar sex match (same-sex × opposite-sex) and time were entered as a within-subject factors. The main effect of player-avatar sex match was not significant [$F_{(1, 13)} = 0.162$, $p = 0.694$, $\eta_p^2 = 0.012$]. Additionally, the interaction of player-avatar sex match and time was not significant [$F_{(89, 1,157)} = 1.182$, $p = 0.325$, $\eta_p^2 = 0.083$]. These results suggest that the SOTA had no impact on less conscious arousal for sex-typed participants in the high-salience condition (see **Supplementary Table 3** and **Figure 7**).

A 2 (player-avatar sex match) × 90 (time) repeated measure ANOVA was conducted comparing sex-typed participants' corrugator activity for high-salience same-sex avatars to their corrugator activity for high-salience opposite-sex avatars. Player-avatar sex match (same-sex × opposite-sex) and time were entered as within-subject factors. The main effect of player-avatar sex match was not significant [$F_{(1, 13)} = 1.126$, $p = 0.308$, $\eta_p^2 = 0.080$]. Additionally, the interaction of player-avatar sex match and time was not significant [$F_{(89, 1,157)} = 0.999$, $p = 0.413$, $\eta_p^2 = 0.071$]. These results suggest that the SOTA had no impact on less conscious valence for sex-typed participants in the high-salience condition (see **Supplementary Table 3** and **Figure 8**).

Together, the results of the two 2 (player-avatar sex match) × 90 (time) repeated measure ANOVAs indicate that the SOTA did not significantly impact less conscious (1) arousal and (2) valence for sex-typed participants in the high-salience condition. These findings run counter to the predictions made by Hypothesis 5.

RQ1

Research Question 1 asked how non-sex-typed participants' embodied motivational processes of (1) emotional arousal and (2) emotional valence would be affected by an avatar with a highly salient sex. In order to test both parts of this research question, two 2 (avatar sex) × 90 (time) repeated measure ANOVAs were calculated, one for SC and one for corrugator activity.

A 2 (avatar sex) × 90 (time) repeated measure ANOVA was calculated comparing non-sex-typed participants' SC for the high-salience male avatar to their SC for the high-salience female avatar. The SOTA and time were both entered as within-subjects factors. The main effect of SOTA was not significant [$F_{(1, 19)} = 1.969$, $p = 0.177$, $\eta_p^2 = 0.094$]. The interaction effect of SOTA and time was also not significant [$F_{(89, 1,691)} = 0.834$, $p = 0.520$, $\eta_p^2 = 0.042$]. Therefore, the SOTA does not appear to have an impact on less conscious arousal of non-sex-typed participants in the high-salience condition (see **Supplementary Table 4** and **Figure 9**).

A 2 (avatar sex) × 90 (time) repeated measure ANOVA was calculated comparing non-sex-typed participants' corrugator activity for the high-salience male avatar to their corrugator activity for the high-salience female avatar. The SOTA and time were both entered as within-subjects factors. The main effect of SOTA was not significant [$F_{(1, 19)} = 1.155$, $p = 0.296$, $\eta_p^2 = 0.057$]. The interaction effect of SOTA and time was also not significant [$F_{(89, 1,691)} = 0.927$, $p = 0.473$, $\eta_p^2 = 0.047$]. Therefore, the SOTA did not appear to have an impact on the less conscious valence of non-sex-typed participants' in the high-salience condition (see **Supplementary Table 4** and **Figure 10**).

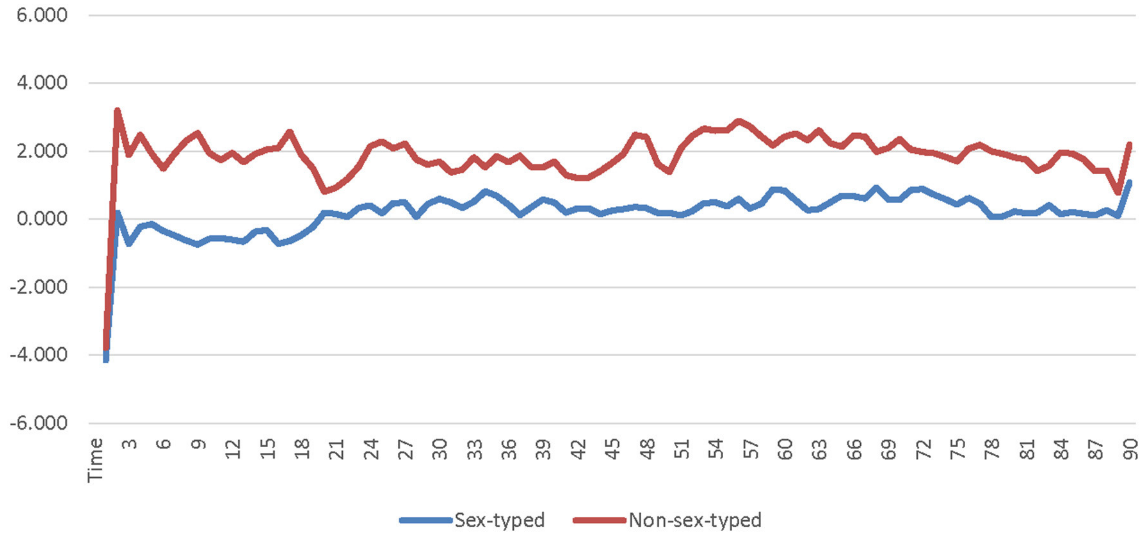

FIGURE 1 | Sex-type by time interaction effect on skin conductance for the low-salience condition. This graph depicts the estimated marginal means for the interaction effect of sex-type by time on skin conductance in the low-salience condition.

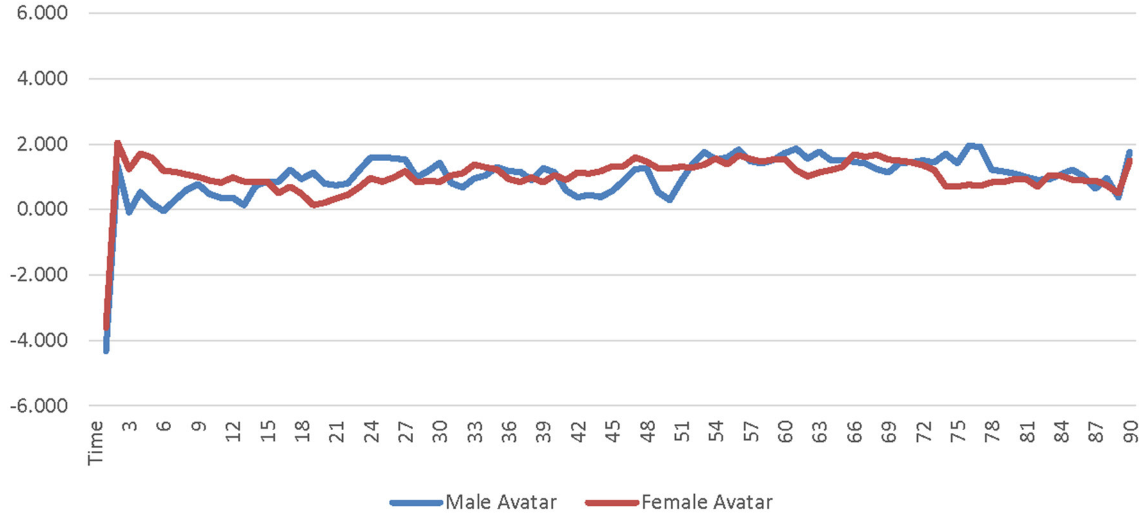

FIGURE 2 | Avatar sex by time interaction effect on skin conductance for the low-salience condition. This graph depicts the estimated marginal means for the interaction effect of avatar sex by time on skin conductance in the low-salience condition.

Together, the results of the two 2 (avatar sex) × 90 (time) repeated measure ANOVAs suggest that for non-sex-typed participants in the high-salience condition, neither their subconscious arousal nor their subconscious valence were influenced by the SOTA.

DISCUSSION

The objective of this study was to investigate the effects of the SOTA, salience of the SOTA, and participant sex-type on less conscious embodied emotional arousal and valence and consciously perceived emotional arousal and valence. It was predicted that the SOTA would have a threshold effect on conscious and less conscious arousal and valence such that when the salience of the SOTA was low the SOTA would have no significant effect on individuals' conscious and less conscious emotional arousal and valence, regardless of their sex-type (H1, H4); but, when the salience of the SOTA was high the SOTA would have significant effects on individuals' conscious and less conscious emotional arousal and valence based on their sex-type (H2, H3, H5, RQ1). Specifically, it was predicted that when the salience of the SOTA was high, sex-typed individuals' conscious and less conscious emotional arousal and valence would differ depending on the SOTA (H2, H5), and that non-sex-typed

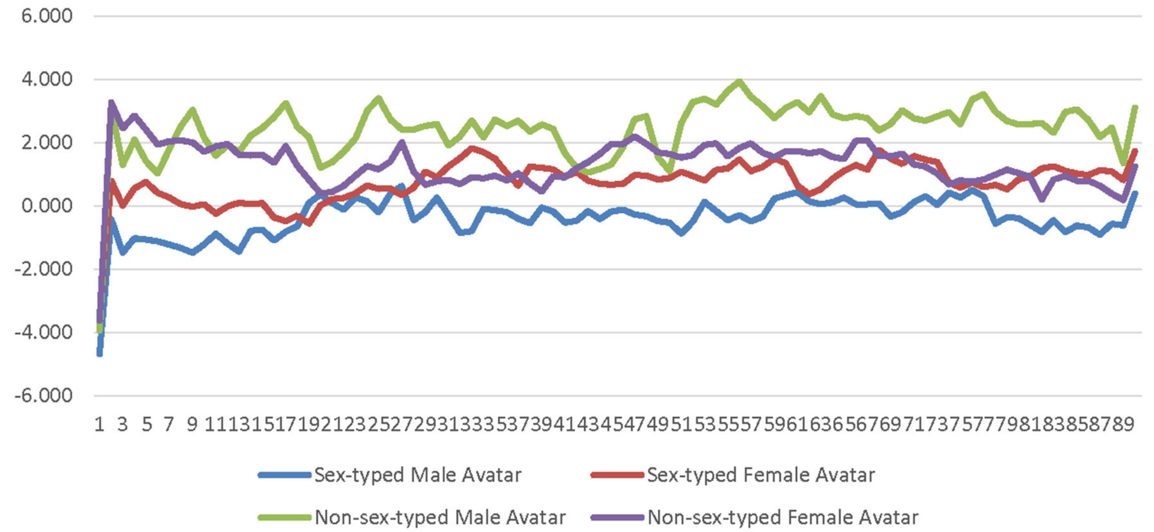

FIGURE 3 | Sex-type by avatar sex by time interaction effect on skin conductance for the low-salience condition. This graph depicts the estimated marginal means for the interaction effect of sex-type by avatar sex by time on skin conductance in the low-salience condition.

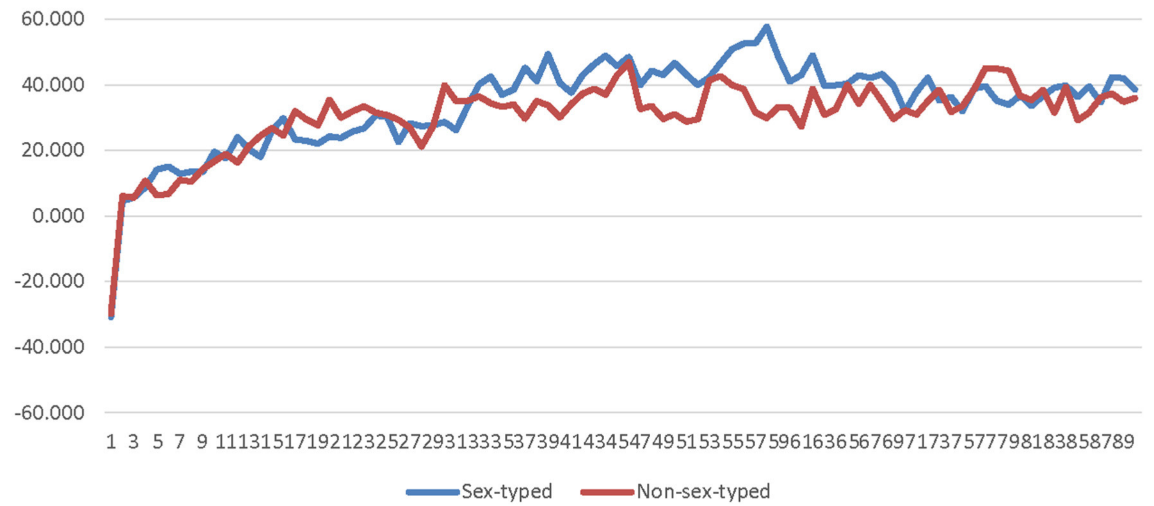

FIGURE 4 | Sex-type by time interaction effect on corrugator activity for the low-salience condition. This graph depicts the estimated marginal means for the interaction effect of sex-type by time on corrugator activity in the low-salience condition.

individuals' conscious emotional arousal and valence would not differ, regardless of the SOTA (H3). No specific predictions were made regarding the effects of the SOTA when the salience of the SOTA was high on non-sex-typed individuals' less conscious emotional arousal and valence (RQ1).

The results of the analyses conducted to test these predictions were almost entirely non-significant. Further interpretation of the non-significant findings is difficult because the analyses were underpowered. Despite having a sample that met the recommendations of the power analysis (i.e., the power analysis indicated the minimum necessary sample size was 78 and our final sample was 81) the number of participants in the individual cells was relatively small (e.g., there were only 14 sex-typed participants in the high-salience condition), and thus it is unclear whether the non-significant results are due to the small cell sizes or because no effect actually exists. Despite this there are still useful insights to be learned from the results of this study.

Contrary to the prediction that there would be no differences between sex-typed and non-sex-typed participants' less conscious emotional arousal when the salience of the SOTA was low (H4), it was found that non-sex-typed participants' SC was significantly higher than sex-typed participants' when using low-salience avatars. The effect size associated with this finding is large, which is surprising because based on previous research on the salience of the SOTA, it was expected that sex-typed

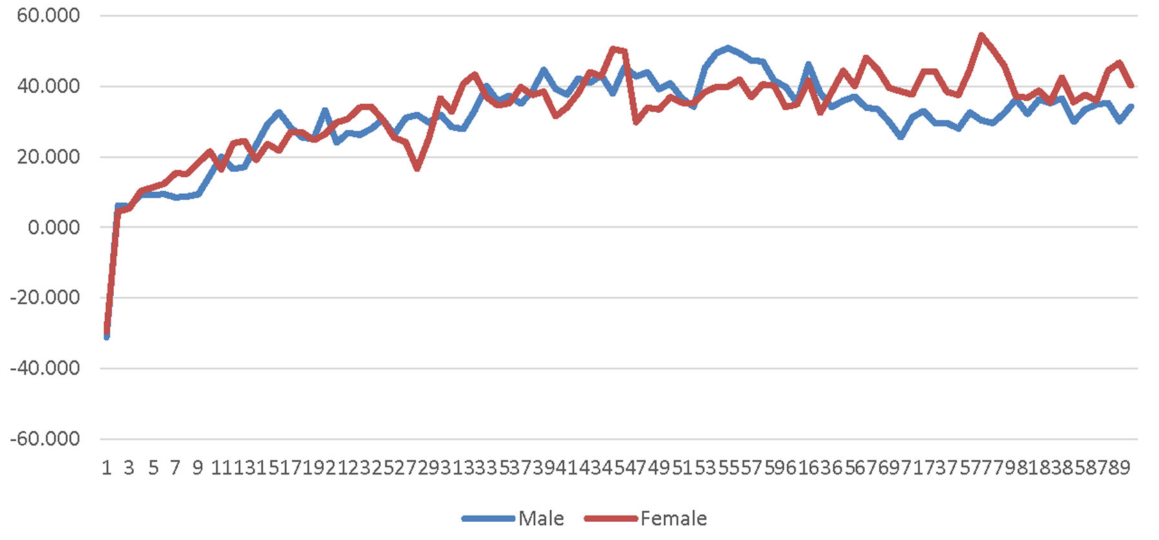

FIGURE 5 | Avatar sex by time interaction effect on corrugator activity for the low-salience condition. This graph depicts the estimated marginal means for the interaction effect of avatar sex by time on corrugator activity in the low-salience condition.

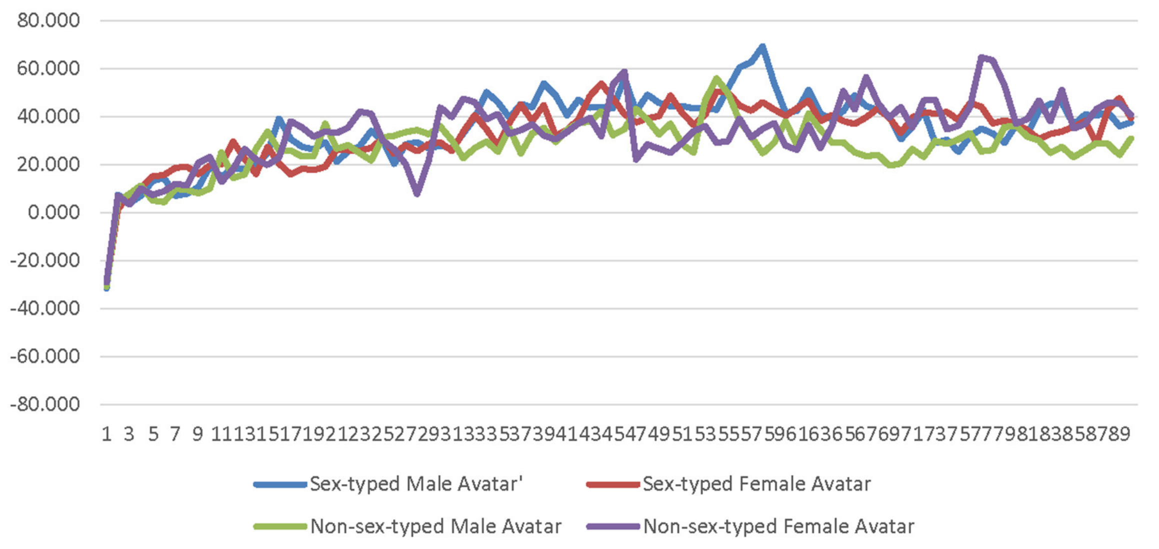

FIGURE 6 | Sex-type by avatar sex by time interaction effect on corrugator activity for the low-salience condition. This graph depicts the estimated marginal means for the interaction effect of sex-type by avatar sex by time on corrugator activity in the low-salience condition.

and non-sex-typed participants' responses to low sex-salience avatars would not differ (Coyle and Liben, 2016). However, in contrast to this previous research the findings of this study suggest individuals' sex-type may influence their responses to low sex-salience avatars in certain ways. Additionally, SC is an indicator of the strength of the activation of the motivational systems (i.e., arousal; Potter and Bolls, 2012). Sex-typed participants' SC was lower when using low-salience avatars compared to non-sex-typed participants', suggesting that low-salience avatars may be more motivationally relevant to non-sex-typed individuals than sex-typed individuals. According to GST, sex-typed individuals are much more likely to process information in terms of their gender schemas (Bem, 1981b). Because the low-salience avatars lacked explicit gender-cues, they may have been a-schematic to sex-typed participants, and thus less motivationally relevant, which in turn resulted in sex-typed participants' SC for low-salience avatars being lower than non-sex-typed participants'. In other words, it might not be that non-sex-typed individuals find low-salience avatars more motivationally relevant than sex-typed individuals, but that low-salience avatars have such little motivational relevance to sex-typed individuals that their physiological reactions to low-salience avatars are lower than those of non-sex-typed individuals.

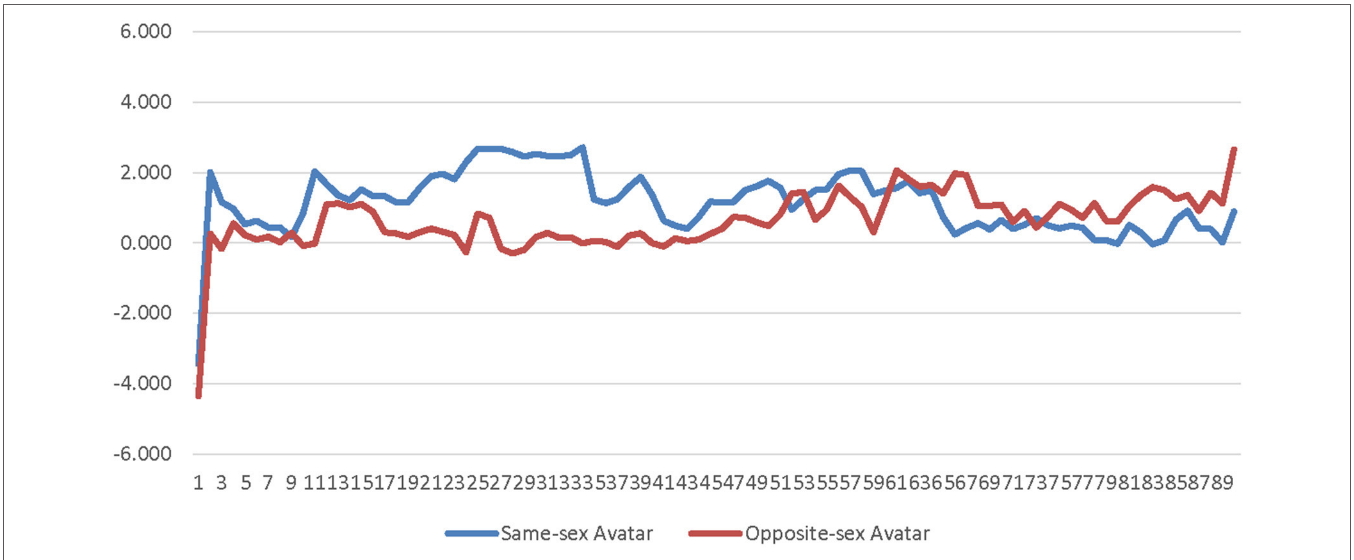

FIGURE 7 | Avatar sex by time interaction effect on skin conductance for sex-typed participants in the high-salience condition. This graph depicts the estimated marginal means for the interaction effect of avatar sex by time on skin conductance for sex-typed participants in the high-salience condition.

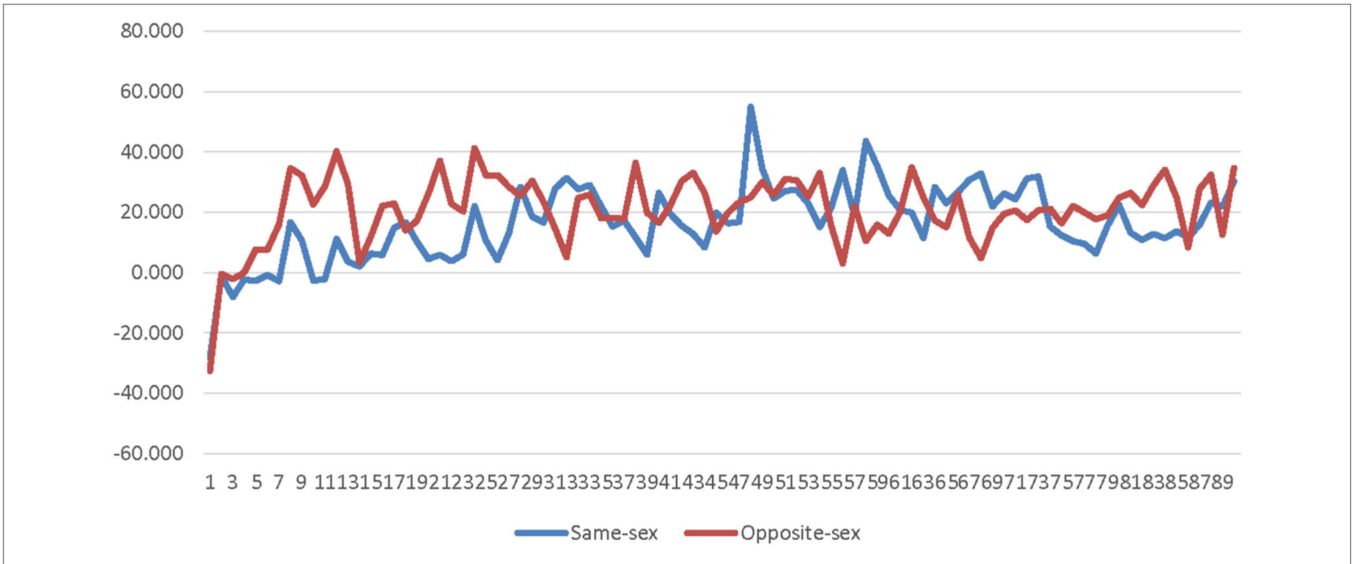

FIGURE 8 | Avatar sex by time interaction effect on corrugator activity for sex-typed participants in the high-salience condition. This graph depicts the estimated marginal means for the interaction effect of avatar sex by time on corrugator for sex-typed participants in the high-salience condition.

Limitations

The present study has several limitations that should be kept in mind when interpreting its results.

First, as previously mentioned, the analyses of the study were underpowered. There are a number of reasons that may have caused the analyses to be underpowered despite having a sample size that met the requirements of the previously conducted power analysis.

One possibility is that the effect size of the SOTA on conscious and less conscious emotional arousal and valence is much smaller than initially predicted. The original power analysis was conducted for a small effect size (Cohen's f of 0.18; Cohen, 1988); however, it is possible that the effect of the SOTA on conscious and less conscious emotional arousal and valence is much smaller. If this was the case, then it is possible that an effect might be found with a larger sample size. However, the majority of the effect sizes for the non-significant findings in the study were either small or below small, which suggests that the effect of the SOTA on conscious and less conscious emotional arousal and valence may be so small as to simply be inconsequential regardless of the sample size. In other words, while increasing the sample size may increase the study's statistical power, it would not likely change the results in a meaningful way.

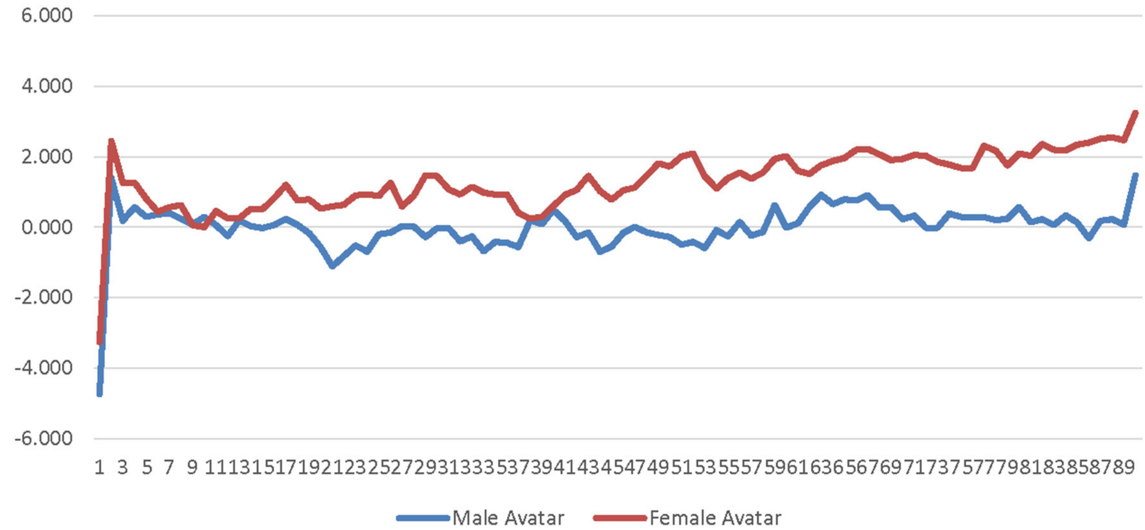

FIGURE 9 | Avatar sex by time interaction effect on skin conductance for non-sex-typed participants in the high-salience condition. This graph depicts the estimated marginal means for the interaction effect of avatar sex by time on skin conductance for non-sex-typed participants in the high-salience condition.

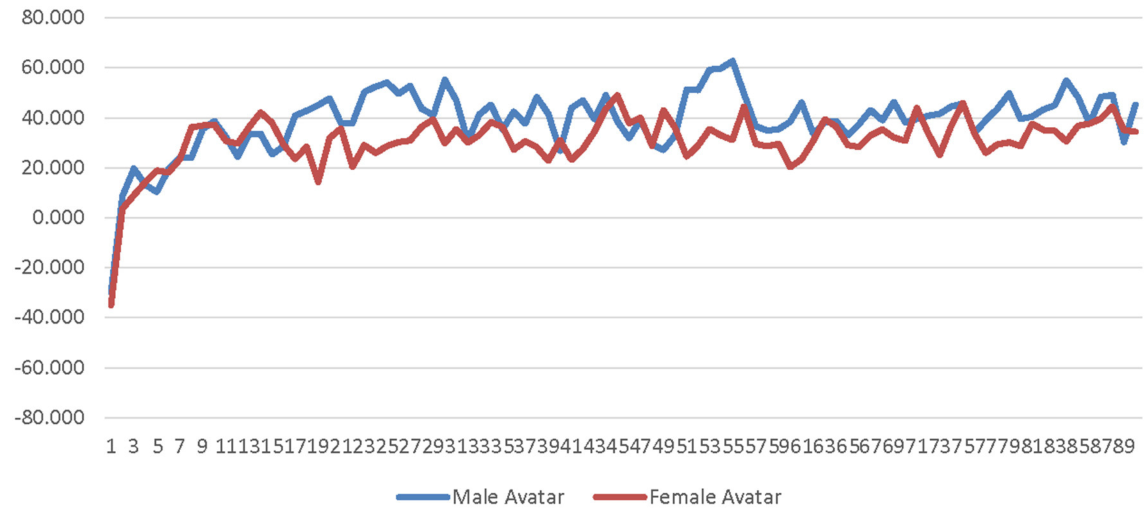

FIGURE 10 | Avatar sex by time interaction effect on corrugator activity for non-sex-typed participants in the high-salience condition. This graph depicts the estimated marginal means for the interaction effect of avatar sex by time on corrugator for non-sex-typed participants in the high-salience condition.

Another factor that potentially led to the analyses being underpowered was the use of the short form of the BSRI. According to the *Bem Sex Role Inventory Professional Manual* the short form of the BSRI tends to classify more people as androgynous and feminine than the long form due to the social desirability of the feminine items retained on the short form (Bem, 1981a). Because sex-type is determined based on individuals' biological sex and gender identity (Bem, 1981b), this can lead to more individuals being categorized as non-sex-typed and cross-typed when using the short form of the BSRI than when using the long form (Bem, 1981a). The short form of the BSRI used in this study may have led to an increased number of participants being categorized as non-sex-typed and cross-sex-typed, which would directly impact the size of the cells used for the analyses because they were based on participants' sex-type and salience condition (i.e., it may have led to non-sex-typed cells being larger and sex-typed cells being smaller because participants who would be categorized as sex-typed by the long form were categorized as non-sex-typed or cross-typed by the short form). Thus, the use of the short form of the BSRI may have potentially contributed to the small cell sizes and caused the analyses to be underpowered. The short form of the BSRI was chosen over the long form as a matter of practicality. It consists of only 30 items compared to the long form, which consists of 60 items; thus, the short form was chosen in the interest of keeping experimental sessions under an hour to avoid participant fatigue (Bem, 1981a).

Another issue that may have contributed to the analyses being underpowered was the unanticipated number of participants classified as cross-sex-typed (e.g., biological female with a masculine gender identity). According to the *Bem Sex Role Professional Manual*, cross-sex-typed individuals normally only make up a small percent of individuals in a given sample (12% of males and 12% of females; Bem, 1981a). Based on those percentages and the number of male and female participants in the final sample for this study, it was expected that approximately 8–10 participants would be classified as cross-sex-typed. However, while the percent of female participants classified as cross-sex-typed was as expected (11%, $n = 5$), the number of cross-sex-typed males in the present sample was well above 12%. Of the 36 male participants, 41% ($n = 15$) were classified as cross-sex-typed. Even accounting for how the short form of the BSRI increases the number of cross-sex-typed classifications, this is still an unexpectedly high number of cross-sex-typed individuals. Thus, of the 81 participants in the final sample, 20 participants were classified as cross-sex-typed. Because cross-sex-typed participants were excluded from analyses, the high number of cross-sex-typed individuals in the sample may have negatively impacted the cell sizes. Future studies may want to consider the use of a screener questionnaire in order to avoid having too many participants of one sex-type.

A second limitation of this study is that no manipulation check was carried out for the salience of the SOTA. The purpose of this experiment was to investigate potential effects of a common intrinsic feature of avatars, their sex. This feature can objectively vary for avatars based on avatar design. This variance in avatar design makes features that define the SOTA more or less visible or explicit as an intrinsic feature of the avatar used to play a game. This variance, defined by intrinsic features of an avatar, was manipulated in this experiment. There has been some past discussion of the necessity of manipulation checks in experiments on media processes and effects (O'Keefe, 2003; Tao and Bucy, 2007). These authors advance the argument that manipulation checks on independent variables in experiments are not appropriate when the independent variable is an intrinsic feature of the media stimulus that is manipulated based on production/design of the stimulus. Based on these arguments and because we manipulated concrete intrinsic features of our stimuli (e.g., the avatars' attires) we did not conduct a manipulation check. However, although the armor used in the low-salience condition was very similar for both male and female avatars it did not fully eliminate secondary sex traits, and thus could have influenced the results of our study. Future research should consider conducting a manipulation check to confirm salience of the SOTA was successfully manipulated.

A third limitation of this study is that we did not control for any non-salience-based effects of the outfits the avatars wore (i.e., the armor and the rags). Previous research into the Proteus Effect has found that avatar characteristics, like their attire, can influence how their users feel and behave (Yee and Bailenson, 2007; Ratan et al., 2020). These studies would suggest that the armor worn by the low-salience avatars could cause participants in the low-salience condition to feel more powerful/strong and that the rags used in the high-salience condition may have caused participants to less powerful/weak. Feeling more or less powerful could potentially have affected participants conscious and less conscious feelings of arousal, and thus influenced the results. Future research should conduct pre-tests of the avatars used as stimuli in order to control for any non-salience-based effects on the dependent variables.

A fourth limitation of the study is that the sample used for the study was a volunteer sample drawn from a student participant pool. Generalizing the findings of this study to other populations should be done cautiously as previous research has found that student samples can differ from non-student samples in important ways (Peterson, 2001).

A fifth and final limitation is that participants encountered significant lag during certain sections of game while playing it, even though the game's graphics settings had been properly set for the hardware capabilities of the computer it was played on. The lag participants experienced may have caused frustration, which may have influenced conscious and less conscious emotional arousal and valence. Future studies should use more powerful computers or consider using a dedicated gaming console for the gameplay portion of the study in order to ensure a smooth experience for participants.

Implications and Future Research

The results of this study found that participants' sex-type had a large effect on their less conscious arousal in response to low-salience avatars, such that non-sex-typed participants' less conscious arousal was significantly higher when using these avatars than sex-typed participants. This suggests that game developers may want to consider the salience of the SOTA when creating their games. Because individuals' less conscious arousal is indicative of how strongly their motivational systems (i.e., the appetitive and the aversive systems) are active, variation in less conscious arousal caused by the salience of the SOTA could potentially impact the way they experience a game. Thus, developers that are seeking to ensure that their game is experienced similarly by all players may want to avoid using low-salience avatars. Instead, developers may want to design avatars that are androgynous (i.e., have both explicit masculine *and* feminine cues) or abstract. Future research should explore more deeply the way that sex-type impacts individuals' conscious and less conscious responses to avatars with low sex-salience in order to determine the exact nature of this relationship.

Additionally, the present project had a number of limitations that constrained the insights that could be drawn from its results. However, a brief glance at the directionality of the means associated with the analyses conducted suggests that with adequate statistical power the results may have differed in many ways from our initial predictions. Therefore, conducting a replication of the study with a larger sample could provide important insights into the effects of the SOTA, the salience of the SOTA, and sex-type on players' embodied emotional processing of video games and their conscious emotional responses to the gaming experience.

As video games continue to grow in popularity and people spend increasingly more time with their avatars it, becomes important for us to understand how avatars can affect players' processing of and responses to video games. Studies such as the present one play an important role in providing a foundation upon which future studies of the effects of avatars on players' processing and responses to games can build and expand.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The Human Research Protection Program at Texas Tech University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

DP wrote the manuscript, designed and ran the experiment, conducted the analysis, and interpreted the results. PB acted as academic advisor for the project, contributed to the abstract and introduction, and assisted with the data analysis and interpretation. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.659547/full#supplementary-material

REFERENCES

Bem, S. L. (1974). The measurement of psychological androgyny. *J. Consult. Clin. Psychol.,* 42, 155–162. doi: 10.1037/h0036215

Bem, S. L. (1981a). Bem *Sex-Role Inventory: Professional Manual*. Palo Alto, CA: Consulting Psychologists Press.

Bem, S. L. (1981b). Gender schema theory: a cognitive account of sex typing. *Psychol. Rev.* 88, 369–371. doi: 10.1037/0033-295X.88.4.369

Bethesda Game Studios (2011). The *Elder Scrolls V: Skyrim*. Bethesda Softworks.

Bradley, M. M., and Lang, P. J. (1994). Measuring emotion: the self-assessment manikin and the semantic differential. *J. Behav. Ther. Exp. Psychiatry* 25, 49–59. doi: 10.1016/0005-7916(94)90063-9

Bradley, M. M., and Lang, P. J. (2007). "Emotion and motivation," in *The Handbook of Psychophysiology*, eds J. Cacioppo, L. G. Tassinary, and G. G. Bernston (Cambridge, UK: Cambridge University Press), 581–607. doi: 10.1017/CBO9780511546396.025

Cacioppo, J. T., Petty, R. E., Losch, M. E., and Kim, H. S. (1986). Electromyographic activity over facial muscle regions can differentiate the valence and intensity of affective reactions. *J. Pers. Soc. Psychol.* 50, 260–268. doi: 10.1037/0022-3514.50.2.260

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences, 2nd Edn.* Mahwah, NJ: Lawrence Erlbaum Associates Inc.

Coyle, E. F., and Liben, L. S. (2016). Affecting girls' activity and job interests through play: the moderating roles of personal gender explicitness and game characteristics. *Child Dev.* 87, 414–428doi: 10.1111/cdev.12463

Entertainment Software Association (2019). *The 2019 Essential Facts About the Computer and Video Game Industry*. Available online at: https://www.theesa.com/wp-content/uploads/2019/05/ESA_Essential_facts_2019_final.pdf

Fisher, J. T., Keene, J. R., Huskey, R., and Weber, R. (2018). The limited capacity model of motivated mediated message processing: taking stock of the past. *Ann. Int. Commun. Assoc.* 42, 270–290. doi: 10.1080/23808985.2018.1534552

Fujioka, Y. (2005). Emotional TV viewing and minority audience: how Mexican Americans process and evaluate TV news about in-group members. *Commun. Res.* 32, 566–593. doi: 10.1177/0093650205279210

Greenwald, M. K., Cook, E. W., and Lang, P. J. (1989). Affective judgment and psychophysiological response: dimensional covariation in the evaluation of pictorial stimuli. *J. Psychophysiol.* 3, 51–64.

Hopkins, R., and Fletcher, J. E. (1994). "Electrodermal measurement: particularly effective for forecasting message influence on sales appeal," in *Measuring Psychological Responses to Media Message*s, ed A. Lang (Mahwah, NJ: Lawrence Erlbaum Associates, Inc.), 113–132.

Lang, A. (2009). "The limited capacity model of motivated mediated message processing," in *Media Processes and Effects,* eds R. L. Nabi and M. B. Oliver (Thousand Oaks, CA: Sage), 193–204.

Lang, A., Potter, F., and Bolls, P. (2009). "Where psychophysiology meets the media: taking the effects out of mass media research," in *Media Effects: Advances in Theory and Research,* J. eds Bryant and M. B. Oliver (New York, NY: Taylor and Francis), 185–206.

Lang, P. J. (1980). "Behavioral treatment and bio-behavioral assessment: computer applications," in *Technology in Mental Health Care Delivery Systems*, eds J. B. Sidowski, J. H. Johnson, and T. A. Williams Norwood, NJ: Ablex Publishing, 119–137.

Lang, P. J., Greenwald, M. K., Bradley, M. M., and Hamm, A. O. (1993). Looking at pictures: affective, facial, visceral, and behavioral reactions. *Psychophysiology* 30, 261–273. doi: 10.1111/j.1469-8986.1993.tb03352.x

Larsen, J. T., Norris, C. J., and Cacioppo, J. T. (2003). Effects of positive and negative affect on electromyographic activity over zygomaticus major and corrugator supercilii. *Psychophysiology* 40, 776–785. doi: 10.1111/1469-8986.00078

Lim, S., and Reeves, B. (2009). Being in the game: effects of avatar choice and point of view on psychophysiological responses during play. *Media Psychol.* 12, 348–370. doi: 10.1080/15213260903287242

Lonergan, C., Craighead, B., and Weber, R. (2018). "Hardwired to play: an evolutionary, neurophysiological approach to video game research," in *Evolutionary Psychology and Digital Games,* eds J. Breuer, D. Pietschmann, B. Liebold, and B. P. Lange (New York, NY: Routledge), 49–60. doi: 10.4324/9781315160825-4

Markus, H., Crane, M., Bernstein, S., and Siladi, M. (1982). Self-schemas and gender. *J. Pers. Soc. Psychol*. 42, 38–50.

Martin, C. L., and Halverson, C. F. Jr. (1981). A schematic processing model of sex typing and stereotyping in children. *Child Dev.* 52, 1119–1134. doi: 10.2307/1129498

Martin, C. L., Ruble, D. N., and Szkrybalo, J. (2002). Cognitive theories of early gender development. *Psychol. Bull.* 128, 903–933. doi: 10.1037/0033-2909.128.6.903

O'Keefe, D. J. (2003). Message properties, mediating states, and manipulation checks: claims, evidence, and data analysis in experimental persuasive message effects research. *Commun. Theory* 13, 251–274.

Peterson, R. A. (2001). On the use of college students in social science research: insights from a second-order meta-analysis. *J. Consumer Res.* 28, 450–461. doi: 10.1086/323732

Potter, R. F., and Bolls, P. (2012). *Psychophysiological Measurement and Meaning: Cognitive and Emotional Processing of Media*. New York, NY: Routledge. doi: 10.4324/9780203181027

Raney, A. A., and Bryant, J. (2019). "Entertainment and enjoyment as media effect," in *Media Effects: Advances in Theory and Research, 4th Edn,* eds M. B. Oliver, A. A. Raney, and J. Bryant, (New York, NY: Routledge), 324–341. doi: 10.4324/9780429491146-21

Ratan, R., Beyea, D., Li, B. J., and Graciano, L. (2020). Avatar characteristics induce users' behavioral conformity with small-to-medium effect sizes: a meta-analysis of the proteus effect. *Media Psychol.* 23, 651–675. doi: 10.1080/15213269.2019.1623698

Shapiro, S., MacInnis, D. J., and Park, C. W. (2002). Understanding program-induced mood effects: decoupling arousal from valence. *J. Advertis.* 31, 15–26. doi: 10.1080/00913367.2002.10673682

Skyrim: Shimmermist Cave (2018). "Skyrim: Shimmermist Cave," in *The Unofficial Elder Scrolls Pages*. Available online at: https://en.uesp.net/wiki/Skyrim:Shimmermist_Cave

Tao, C. C., and Bucy, E. P. (2007). Conceptualizing media stimuli in experimental research: psychological versus attribute-based definitions. *Human Commun. Res*. 33, 397–426. doi: 10.1111/j.1468-2958.2007.00305.x

The Elder Scrolls V: Skyrim (2019). "The Elder Scrolls V: Skyrim," in *Wikipedia: The Free Encyclopedia*. Available online at: https://en.wikipedia.org/wiki/The_Elder_Scrolls_V:_Skyrim

Trepte, S., and Reinecke, L. (2010). Avatar creation and video game enjoyment: effects of life-satisfaction, game competitiveness, and identification with the avatar. *J. Media Psychol. Theor. Methods Appl.* 22, 171–184. doi: 10.1027/1864-1105/a000022

Wade, L. (2012). "Sexual dimorphism in World of Warcraft," in: *Sociological Images*. Available online at: https://thesocietypages.org/socimages/2012/07/14/gendered-fantasy-sexual-dimorphism-in-world-of-warcraft/

Yee, N., and Bailenson, J. (2007). The proteus effect: the effect of transformed self-representation on behavior. *Hum. Commun. Res.* 33, 271–290. doi: 10.1111/j.1468-2958.2007.00299.x

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BRIEF RESEARCH REPORT
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How Do Video Games Elicit Guilt in Players? Linking Character Morality to Guilt Through a Mediation Analysis

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Research has consistently found that committing immoral actions in video games is capable of eliciting feelings of guilt in players. This study aimed to investigate the mediating role of theoretically-relevant psychological mechanisms: Perceived morality of the player-controlled character and self-attribution of virtual behavior. Based in psychological and communication theory, we derived a model that links these variables to character portrayal and guilt. A between-subjects experiment manipulated the portrayal of the player-controlled character (immoral vs. moral) and measured the mediating variables and self-reported guilt. The hypothesized model was tested using a path model. Data were generally consistent with hypotheses. Controlling an immoral character reduced perceived character morality. Perceived character morality positively predicted self-attribution of character behavior and negatively predicted guilt. Self-attribution positively predicted guilt but self-attribution and perceived character morality did not interact. Our findings suggest novel directions for continued research into how game features elicit emotional responses in players.

Keywords: narrative, morality, self-serving bias, attribution, guilt

INTRODUCTION

Engaging in immoral actions in virtual settings, such as video games can lead players to feel guilt (Hartmann and Vorderer, 2010; Hartmann et al., 2010; Lin, 2011; Weaver and Lewis, 2012; Grizzard et al., 2014, 2017; Mahood and Hanus, 2017). Guilt is typically defined as a self-conscious emotion, which requires the activation of higher-level cognitive appraisal processes (Tangney et al., 2007; de Hooge, 2008). Guilt results when a person has violated a moral or social norm and attributes responsibility for the violation to the self (i.e., an internal attribution; e.g., I did this because I wanted to; Weiner, 2018). Absent a moral violation, guilt would not be expected to occur. Moreover, external attributions (e.g., "I did this because I was forced to") would be expected to reduce feelings of responsibility and guilt (see O'Donnell, 2005; Klimmt et al., 2006; Tangney et al., 2007; de Hooge, 2008; Hartmann and Vorderer, 2010; Hartmann et al., 2010; Weiner, 2018).

Virtual actions, by definition, lack real-world consequences. Moreover, games and their rule-based systems provide players with an external factor other than the self to which they might attribute their behaviors. Such external attributions should prohibit the elicitation of guilt (see Bartel, 2015). Yet, past research (Hartmann and Vorderer, 2010; Hartmann et al., 2010; Lin, 2011; Weaver and Lewis, 2012; Grizzard et al., 2014, 2017; Mahood and Hanus, 2017) that finds a relationship between such actions and guilt suggests that some players (a) perceive their virtual actions to be morally consequential, and (b) attribute responsibility for that consequentiality to themselves. Specific mechanisms that explain these phenemona have been theorized but remain untested. Thus, the current paper aims to bridge the gap by examining the role of character portrayal and perceptions of a character's morality/immorality as antecedents of guilt. Specifically, we test a causal model that links features of video game play (e.g., the character's narrative portrayal) to guilt through perceptions of the character's morality. We simultaneously examine how character portrayal influences self-attribution of character behavior and any moderating impact this would have on the generation of guilt. Thus, the specific model tested in the current study unites psychological understandings of guilt elicitation (i.e., immoral behaviors must be attributed to the self in order to elicit guilt) with common features of video game play (i.e., the experience of role-playing as a specific character). It also tests current theory regarding the interaction between character morality and player perceptions (see Bartel, 2015). In so doing, the current paper and its findings provide (a) empirical evidence for psychological theories of guilt and game studies theories of video game experience and (b) demonstrates a method to reliably alter player's perceptions of their in-game experience (i.e., the manipulation of a player character's portrayal).

CHARACTER PORTRAYAL, GUILT, AND PERCEIVED MORALITY OF CHARACTER

Several variables seem capable of eliciting guilt in games, including the attributes of the player-character (i.e., the character/avatar controlled by the player), the morality of virtual behaviors, and the attributes of non-player-characters (NPCs; i.e., those virtual agents who interact with the player-character). Controlling a player-character who is immoral elicits higher levels of guilt than controlling a player-characters who is moral (Hartmann and Vorderer, 2010; Hartmann et al., 2010; Mahood and Hanus, 2017). Committing less moral behaviors results in greater guilt than more moral behaviors (Mahood and Hanus, 2017). Finally, committing aggression against humanized NPCs results in greater guilt than committing aggression against dehumanized NPCs (Lin, 2011). These findings suggest that factors which positively or negatively influence the perceived morality of an action in the "real world" have similar effects in the virtual world (O'Donnell, 2005; Klimmt et al., 2006). The most common manipulation from past research seems to be attributes of the player-character, and so for the current paper, we focus on this manipulation and hypothesize the following:

Hypothesis 1: Character portrayal (manipulated moral vs. immoral) will influence perceptions of the character's morality.

Hypothesis 2: Perceived character morality will negatively predict guilt.

Hypothesis 3: Perceived character morality will mediate the relationship between character portrayal and guilt.

PERCEIVED MORALITY OF CHARACTER, SELF-ATTRIBUTION, AND GUILT

The attribution literature defines attributions in terms of their internal and external nature (Heider, 1958; Kelley, 1967; Weiner, 2018). Internal attributions are those that relate to the purposeful desires and motivations of an individual, whereas external attributions are those that relate to the environment that an individual finds themselves in. As stated earlier, recognition that one's behavior has violated a moral or social norm is insufficient to elicit guilt. Guilt responses require an internal attribution of the cause of the behavior and a perception of one's actions as volitional.

External attributions reduce feelings of guilt (see Tangney et al., 2007; de Hooge, 2008; Weiner, 2018), and video games have several features that should allow players to make external attributions for their immoral behaviors (Bartel, 2015). First, narrative video games place players into an artificial world governed by a rule-based system, which should allow a player to make an external attribution for their behavior (Klimmt et al., 2006). Second, players' in-game behaviors are mediated through the character or avatar they are controlling. The perception of an avatar as a separate entity from oneself (see Banks, 2015; Grizzard and Ahn, 2017) should allow for an external attribution of behavior. Finally, a general bias related to internal and external attributions—the *self-serving bias* (Miller and Ross, 1975)—should also reduce guilt. This bias relates to humans attributing desirable outcomes to themselves and undesirable outcomes to external factors (see Miller and Ross, 1975; see also for update, Weiner, 2018). Conceptualizing virtual immoral actions as undesirable suggests that internal attributions would be reduced for players who control an immoral character and internal attributions would be enhanced for players who control a moral character.

Hypothesis 4: Perceived character morality will positively predict self-attributions.

Combining self-attributions with past findings regarding the ability of virtual immoral actions to elicit guilt (Hartmann and Vorderer, 2010; Hartmann et al., 2010; Mahood and Hanus, 2017) suggests a potential moderation effect. Bartel (2015) argued that players will only feel guilt for their immoral virtual behaviors if they attribute the cause of such behaviors to the self. This proposition suggests that the effect of perceived character morality on guilt will be moderated by self-attribution, such that self-attributions increase the strength of the relationship.

Hypothesis 5: Self-attribution will moderate the effect of perceived character morality on guilt.

METHOD

Participants

Study participants ($N = 101$) were recruited to from communication classes at a large, public university in the northeastern United States (40 women, 61 men, $M_{age} = 19.84$, $SD = 3.08$), and received extra credit for their participation. Participants were treated in accordance with the ethical standards of the American Psychological Association and all procedures were evaluated by an institutional review board.

Design and Procedure

Participants were randomly assigned to play a video game as a character with either an immoral ($n = 52$) or a moral ($n = 49$) character portrayal. Participants first read a mock webpage that manipulated the morality of the character. They then played the game, and following play were asked to rate the key variables using self-report measures.

Stimuli

Heavy Rain, a PlayStation 3/4 game about catching a serial killer, was selected as the stimulus. It was selected because (1) it is an interactive narrative game which allows for manipulation of the player-character's morality and (2) Scott Shelby, one of the playable characters in this game is a morally ambiguous character who can be easily manipulated to appear good or evil. A mock webpage was used to manipulate Shelby's portrayal. In the moral character portrayal, Shelby was described as a private detective hired by a victim's family to stop the Origami Killer. In the immoral character portrayal, Shelby was described as the Origami Killer who was simply pretending to be a private detective in order to cover his tracks. The different portrayals were controlled for length and structure.

Participants completed the game chapter "Sleazy Place." In the chapter, Shelby interviews the mother of one of the killer's victims. Following questioning, the mother begins to cry. A result of our manipulation is that both conditions played the exact same game with the same characters and in-game results, with the only difference being the perceived motivations of the character. Gameplay lasted ∼7 min. The stimulus was played through a PlayStation 4 with 32-inch VIZIO 1,080 p 120 Hz (native) screen. Participants were seated approximately half a meter from the screen. The default sound system from the television was used.

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Measures

Character moral portrayal was dummy-coded (1 = immoral, 0 = moral).

Perceived morality of game character was measured with a single item: "Is Scott a good guy or a bad guy?". The item was rated on a 7-point semantic-differential scale ranging from 1 *bad* to 7 *good*. An independent-samples *t*-test indicated that participants in the immoral condition perceived their character to be less moral ($M = 2.17$, $SD = 1.49$) than participants in the moral condition ($M = 5.18$, $SD = 1.11$), $t(99) = -11.45$, $p < 0.001$. The effect size associated with this difference is large (Cohen's $d = -2.29$) and suggests that the manipulation was powerful for eliciting differential perceptions of the player character's morality.

Self-attributions of virtual behavior was measured using 7-point Likert-type responses to four items: "The actions my character committed represent me as a person," "The actions I committed as Scott Shelby were an expression of my true inner feelings, attitudes, and beliefs," "I felt in control of Scott Shelby's actions," and "I felt personally responsible for the virtual actions that I committed in the game." To assess the statistical validity of the scales, we used confirmatory factor analysis (CFA). The five self-attribution items were tested in a CFA with a single latent factor. The model fit the data well, $\chi^2(df = 2) = 3.73$, $p = 0.16$, CFI = 0.98, RMSEA = 0.09 (90% CI: 0.00,.24), SRMR = 0.05, and were averaged to create a composite. Internal consistency of the scale was judged to be acceptable as Cronbach's alpha approached 0.70 ($\alpha = 0.68$) and McDonald's omega—a more robust estimate of internal consistency (see Hayes and Coutts, 2020) −0.70 ($\omega = 0.70$).

Guilt was measured using a 6-item guilt scale with 11-point Likert-type response scale ranging from 0 = *not at all* to 10 = *extremely*. A CFA on the items resulted in an acceptable fit: $\chi^2(df = 9) = 44.65$, $p < 0.001$, CFI = 0.94, RMSEA = 0.20, SRMR = 0.04. We note that although RMSEA is elevated here, small *df* models can have artificially large RMSEAs (see Kenny et al., 2015, who recommend not calculating RMSEA for small *df* models). Given the other model fit indices (CFI, SRMR) suggest good to excellent fit, we created a composite by averaging across the six items ($\alpha = 0.95$; $\omega = 0.95$; Hartmann and Vorderer, 2010; Hartmann et al., 2010).

Analysis

We tested the hypotheses in a path model in AMOS using maximum likelihood estimation. Indirect effects were assessed through 5,000 bootstrap samples with bias-corrected 95% confidence intervals. The interaction term in the model was created after mean-centering the two variables that composed it. See **Figure 1** for the model and the results of the model test.

RESULTS

Hypotheses Testing

Data were consistent with Hypothesis 1. The character portrayal manipulation (dummy-coded 1 = immoral, 0 = moral) had a significant effect on perceived character morality. The player character was perceived as more moral when the moral character portrayal was associated with him.

Data were also consistent with Hypothesis 2. Perceived character morality had a negative effect on guilt. The more immoral the player character was perceived to be, the more guilt the player felt following game play.

Data were inconsistent with Hypothesis 3. The indirect effect of condition was non-significant ($p = 0.092$).

Data were consistent with Hypothesis 4. The more moral the player character was perceived to be, the more players attributed

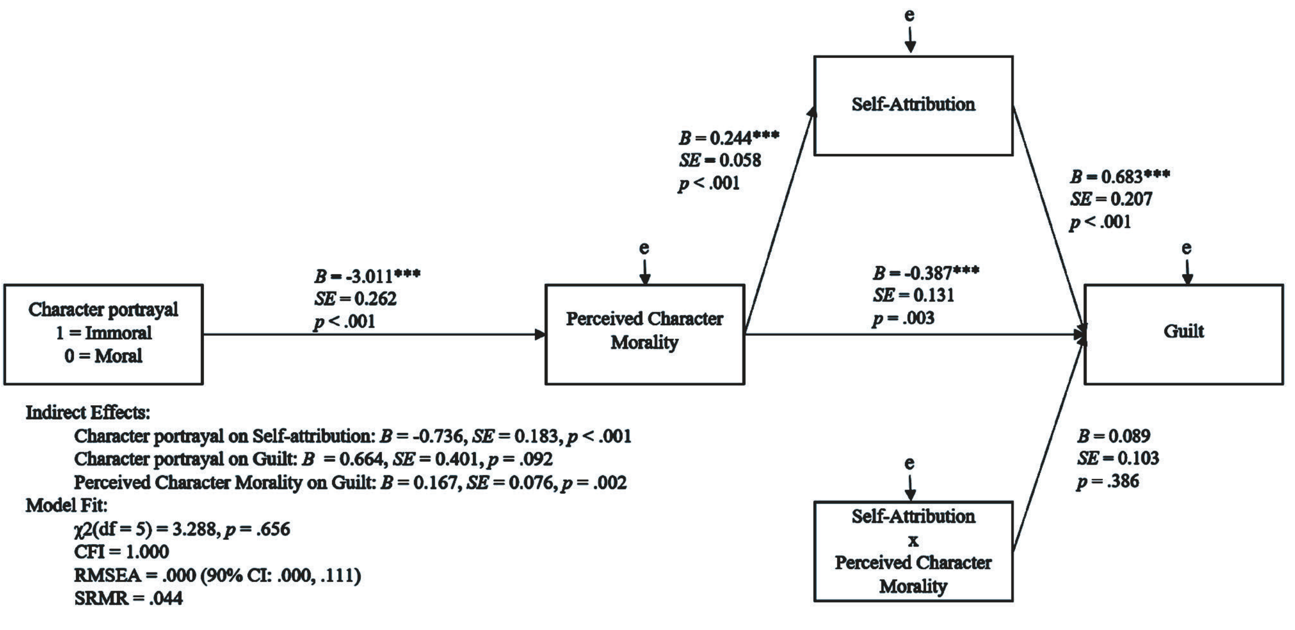

FIGURE 1 | Path model examining the hypotheses of the current study (***$p < 0.001$).

the character's behaviors to themselves. In addition, the indirect effect of condition on self-attribution was mediated through perceived character morality.

Data were inconsistent with Hypothesis 5. Although the direct path from self-attribution to guilt was significant, the interaction of self-attribution and perceived character morality was non-significant. This indicates that the more the players attributed the character's behavior to themselves the more guilt they felt regardless of the perceived morality of the character. It is important to note that the indirect effect of perceived character morality on guilt through self-attribution was significant. Together these findings suggest that perceptions of a character impact moral emotions mediated through self-attribution. One reason we may not have found a significant moderation could result from the narrative ending of the game play session. In both sessions, the player character causes the mother of a murder victim to recall a painful episode, which results in her crying. Our findings indicate that the more the participant attributed the actions of the character to themselves, the more guilt they felt regardless of the character's perceived morality. This finding makes sense when one considers that the ending was an undesirable and potentially guilt-inducing result that was magnified by the characters role (i.e., the significant results of Hypothesis 2) but not the attribution of the character's behavior to the self (i.e., the non-significant interaction term).

DISCUSSION

The goal of the current study was to examine psychological mechanisms through which immoral virtual actions influence guilt following video game play. Results suggest that a character's portrayal can have a significant impact on the perception of a character as moral and in turn the guilt elicited from immoral virtual actions. In addition, our findings demonstrate that a self-serving attributional bias can occur in virtual settings. Behaviors by a desirable virtual other are attributed to the self to a greater extent than behaviors by an undesirable virtual other. Our findings make several contributions to the literature on video game behaviors and the elicitation of guilt.

First, our findings begin to build and test a serial causal model of how player characters are interpreted and experienced by players. This model links video game attributes to player responses in a novel way. We found that players accurately perceive the morality of their player character and that these perceptions have direct impacts on guilt and the attribution of the character's behavior to the self. Future research should continue to explore these effects by manipulating aspects of the character's portrayal and examining other person perception attributes. For example, does controlling a character portrayed as powerful lead to feelings of competence for the player in the same way that controlling a character portrayed as immoral led to feelings of guilt? How might attributes of non-player characters impact these relationships? Would a player feel less guilty controlling an immoral character if NPCs were even less moral (see the character interdependence hypothesis; Grizzard et al., 2020)? These questions could be answered by applying our design and logic to other variables.

Second, our study provides a useful methodological observation. Our findings validate techniques for manipulating video game stimuli in a methodologically sound manner that maximizes internal validity and minimizes costs. Past studies (see Hartmann et al., 2010) have manipulated character portrayal by modifying a game's code. This approach is useful, but costly and time-consuming. We were able to achieve similar effects as this past work through simpler means: Creating a character biography that portrayed the character as moral or immoral. Our findings show that this type of exo-game manipulation (see Grizzard and Ahn, 2017) can be applied to some degree of success in a laboratory setting. By manipulating the character's backstory, we were able to induce variance in a theoretically meaningful way (a) without compromising internal validity by utilizing two separate games and (b) without having to engage in costly and time-consuming programming.

Our findings thus contribute to research on the emotions elicited by game play (see Grizzard and Francemone, 2018) by explicitly testing the implicit mechanisms described in previous research and theory (Klimmt et al., 2006; Hartmann et al., 2010; see Bartel, 2015). In addition, we provide nuance to the assumption that a player must attribute immoral actions to themselves to elicit guilt. This hypothesis provided by Bartel (2015) was partially consistent with our results. We found a significant effect of self-attribution on guilt. However, the findings were not entirely consistent with this theoretical explanation, as the interaction of self-attribution and character morality was non-significant and perceived character morality had a direct impact on guilt. Future research will need to test this logic in more detail.

LIMITATIONS

The current work has several limitations which must be addressed in future research. First, our convenience sample of young adults may limit the generalizability of our findings. It is unclear whether the effects observed here would differ for children or older adults, who may have less/more developed moral identities. Second, our findings should be replicated using other games. In the current study, the ambiguity of the stimulus allowed us to create clearly moral and immoral perceptions. Would such perceptions be possible with less ambiguous stimuli? For example, could a clear hero be portrayed as immoral and a clear villain be portrayed as moral through use of our manipulation? In a similar vein, would it be possible to alter the morality of a truly ambiguous character (e.g., a Dexter Morgan-type character who engages in evil deeds to punish those who are more evil)? Finally, consistent with feedback during the review process, some modifications were made to our statistical tests. These modifications did not alter the interpretation of findings, but they do result in the statistical model being more *post-hoc* than a priori. Thus, future research should consider our findings as tentative but promising.

CONCLUSION

Video game behavior seems capable of eliciting moral emotions such as guilt. This paper explored the potential mediators of this process, particularly perceptions of character morality and attribution of in-game behaviors. The findings extend previous research and suggest future directions related to self-attribution processes. Self-attributions of virtual behavior seems to intensify guilt. Future research should continue to explore the causal mechanisms implied by theoretical models of emotion-elicitation in video game settings.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Institutional Review Board at University at Buffalo. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

REFERENCES

Banks, J. (2015). *Object, Me, Symbiote, Other: A Social Typology of Player-Avatar Relationships. First Monday* 20:5433. doi: 10.5210/fm.v20i2.5433

Bartel, C. (2015). Free will and moral responsibility in video games. *Ethics Inform. Technol.* 17, 285–293. doi: 10.1007/s10676-015-9383-8

de Hooge, I. E. (2008). *Moral Emotions in Decision Making: Towards a Better Understanding of Shame and Guilt* (Doctoral dissertation). Tilburg University, Tilburg, The Netherlands.

Grizzard, M., and Ahn, C. (2017). "Morality & personality: perfect and deviant selves," in *Avatar, Assembled: The Social and Technical Anatomy of Digital Bodies,* ed J. Banks (New York, NY: Peter Lang Publishing), 117–126.

Grizzard, M., and Francemone, C. J. (2018). "Research on the emotions caused by video games demands integration," in *Video Games: A Medium That Demands Our Attention,* ed N. D. Bowman (New York, NY: Routledge), 60–73. doi: 10.4324/9781351235266-4

Grizzard, M., Francemone, C. J., Fitzgerald, K., Huang, J., and Ahn, C. (2020). Interdependence of narrative characters: implications for media theories. *J. Commun.* 70, 274–301. doi: 10.1093/joc/jqaa005

Grizzard, M., Tamborini, R., Lewis, R. J., Wang, L., and Prabhu, S. (2014). Being bad in a video game can make us morally sensitive. *Cyberpsychol. Behav. Soc. Netw.* 17, 499–504. doi: 10.1089/cyber.2013.0658

Grizzard, M., Tamborini, R., Sherry, J. L., and Weber, R. (2017). Repeated play reduces video games' ability to elicit guilt: evidence from a longitudinal experiment. *Media Psychol.* 20, 267–290. doi: 10.1080/15213269.2016.1142382

Hartmann, T., Toz, E., and Brandon, M. (2010). Just a game? Unjustified virtual violence produces guilt in empathetic players. *Media Psychol.* 13, 339–363. doi: 10.1080/15213269.2010.524912

Hartmann, T., and Vorderer, P. (2010). It's okay to shoot a character: moral disengagement in violent video games. *J. Commun.* 60, 94–119. doi: 10.1111/j.1460-2466.2009.01459.x

Hayes, A. F., and Coutts, J. J. (2020). Use omega rather than Cronbach's alpha for estimating reliability. But.... *Commun. Methods Meas.* 14, 1–24. doi: 10.1080/19312458.2020.1718629

Heider, F. (1958). *The Psychology of Interpersonal Relationships*. Hoboken, NJ: John Wiley & Sons, Inc. doi: 10.1037/10628-000

Kelley, H. H. (1967). "Attribution theory in social psychology," in *Nebraska Symposium on Motivation,* ed D. Levine (University of Nebraska Press), 192–238.

Kenny, D. A., Kaniskan, B., and McCoach, D. B. (2015). The performance of RMSEA in models with small degrees of freedom. *Sociol. Methods Res.* 44, 486–507. doi: 10.1177/0049124114543236

Klimmt, C., Schmid, H., Nosper, A., Hartmann, T., and Vorderer, P. (2006). How players manage moral concerns to make video game violence enjoyable. *Communications* 31, 309–328. doi: 10.1515/COMMUN.2006.020

Lin, S. F. (2011). Effect of opponent type on moral emotions and responses to video game play. *Cyberpsychol. Behav. Soc. Netw.* 14, 695–698. doi: 10.1089/cyber.2010.0523

Mahood, C., and Hanus, M. (2017). Role-playing video games and emotion: how transportation into the narrative mediates the relationship between immoral actions and feelings of guilt. *Psychol. Popul. Media Cult.* 6, 61–73. doi: 10.1037/ppm0000084

Miller, D. T., and Ross, M. (1975). Self-serving biases in the attribution of causality: fact or fiction? *Psychol. Bull.* 82, 213–225. doi: 10.1037/h0076486

O'Donnell, T. (2005). Executioners, bystanders and victims: collective guilt, the legacy of denazification and the birth of twentieth-century transitional justice. *Legal Stud.* 25, 627–667. doi: 10.1111/j.1748-121X.2005.tb00687.x

Tangney, J. P., Stuewig, J., and Mashek, D. J. (2007). Moral emotions and moral behavior. *Annu. Rev. Psychol.* 58, 345–372. doi: 10.1146/annurev.psych.56.091103.070145

Weaver, A. J., and Lewis, N. (2012). Mirrored morality: an exploration of moral choice in video games. *Cyberpsychol. Behav. Soc. Netw.* 15, 610–614. doi: 10.1089/cyber.2012.0235

Weiner, B. (2018). The legacy of an attribution approach to motivation and emotion: a no-crisis zone. *Motiv. Sci.* 4, 4–14. doi: 10.1037/mot0000082

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What Type of Body Shape Moves Children? An Experimental Exploration of the Impact of Narrative Cartoon Character Body Shape on Children's Narrative Engagement, Wishful Identification, and Exercise Motivation

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Background: The incorporation of narratives helps to enhance children's engagement in active video games (AVGs), thus increasing moderate-to-vigorous physical activity (MVPA). Specific narrative elements, such as the visual representation of the characters' body shape, have been rarely manipulated to explore their role in modulating children's narrative engagement (NE) and exercise motivation.

Objective: To investigate the effects of character body shape manipulation (overweight/obese, average, or athletic slim) on children's narrative immersion (NI), NE, wishful identification (WI), as well as their mediating effect on AVG and PA motivation.

Methods: Children ages 8–12 years old (N = 87) were randomly assigned to watch a 15-min animated video (designed for an existing AVG) in which the main characters had an overweight/obese, or average*, or athletic slim body shape (all other elements were identical). Children's NI, NE, WI, and AVG and physical activity (PA) motivation were then assessed.

Results: Controlling for social desirability, the analysis indicated that participants with a BMI of greater than the 75th percentile had a significantly higher NI, NE, WI, and PA motivation when video characters were set to the overweight/obese condition, than they did for video characters set to the average or athletic slim conditions. On the other hand, children of equal or less than the 75th percentile exposed to the average character body condition had a greater NE, WI, and PA motivation than overweight/obese or athletic slim conditions. A mediation analysis with structural equation modeling indicated that NE mediated the effect between character body shape and AVG and PA motivation.

Conclusion: Narrative cartoon characters that mirror the target participant's body shape can increase NE, which in turn mediates AVG and PA motivation. Content producers should identify optimal strategies in character body shape design to

encourage children of different weight status to participate in PA with engaging stories to maximize health narratives' persuasive potentials.

*The term average in this sense is not in reference to the national average body weight, but rather an average of the body weights represented in conditions A and C.

Keywords: body shape, character, narrative, story, children, active video game, physical activity, animation

INTRODUCTION

Entertainment media narratives have great potential in shaping children's perceptions and behavior (Strasburger et al., 2013). Characters are a primary component of persuasive media narratives (Lu et al., 2012a). Thus, it is crucial to effectively present these characters in order to maximize the persuasive goals and induce behavioral change in children (Lu et al., 2012a). With the current childhood obesity epidemic (Wang et al., 2020), it is even more important to examine how the body shapes of media characters should be presented to children when the goal is to encourage them to maintain or lose weight.

In this context, the "ideal body shape" of media characters portrayed in media is conveyed to children across different developmental stages and may be a motivational factor in altering their own body shapes (Harrison, 2000b; Field et al., 2005). On the other hand, these portrayals may also lead to the stigmatization of obesity (Latner et al., 2007). Therefore, it is critical to examine various types of mediated representation of bodies and their potential influence on children. Most mediated body studies have focused on existing characters in mass media narratives (Baker and Raney, 2007; Northup and Liebler, 2010; Tzoutzou et al., 2020). Some altered the character weight featured in transient media clips such as an advertisement to study its effect on children's perception of the health quality of the product (Castonguay et al., 2019). Few studies have experimentally manipulated the visual representation of the characters' body shape or weight status in an existing narrative, or a story, which permeates media content.

As a crucial element in narrative persuasion, characters, especially their body shapes, have an important role to motivate or deter children to exercise. For children with overweight or obesity, the goal of a persuasive narrative would be for their weight loss, resulting in a body shape of healthy body weight. How should the characters' body shape look in the narratives for them? Research so far has not provided a consistent answer to this question. The tailoring theories suggest that creating characters that look similar to the actual self, i.e., overweight/obese for overweight/obese children, may improve motivation to increase PA for better health outcome (Kreuter et al., 2013). On the other hand, the potential effects of observing or acting as overweight/obese characters may have adverse effects on the players. In addition, self-perception theory suggests that people rely on external cues (e.g., a game character) to infer their internal states (e.g., attitudes and emotions) and behave in accordance with the inference (Bem, 1972). From a Proteus effect perspective (Yee and Bailenson, 2007), watching an overweight or obese character in a narrative may cause the audience to be less likely to exercise while a character of ideal weight might do the opposite. For example, a recent study has suggested that showing children athletic slim and toned characters, or an ideal self-image, would motivate them to have better active video game (AVG) performance (Li et al., 2014).

Thus, the question remains: What type of body shape moves children? This study aims to address this question through an experimental study of character body shape manipulation in an animated narrative series among 8–12-year-olds.

LITERATURE REVIEW

This section will review a series of interdisciplinary literature. We will first situate this study in the larger public health context of the importance of reducing child obesity in terms of both adverse physical and psychological effects, a goal that this study shares. Then we will discuss the disappointing results of engaging children in physical activity (PA) and the potential benefits of AVG in increasing PA. In the next section, we will discuss how children do not play with AVGs for a long enough duration to have an impact and the potential positive impact of narrative that captures the child's attention with interesting plots and extraordinary characters in PA promotion via AVGs as well as reviewing several potential mediators of the narrative effect such as narrative immersion (NI), narrative engagement (NE), and wishful identification (WI). We also explore gender differences in the psychological effects of being overweight and obese. Children may have emotional responses to the body images of the cartoons that lead to dissatisfaction and potentially a decrease in motivation to participate in PA. Last but not least, we will review the visual representation of mediated character's body shapes and the effect of children's exposure to these body shapes.

Child Obesity, Physical Activity, and Active Video Games (AVGs)

In the United States, approximately 16.6% of children are overweight, and an additional 18.5% of children are considered obese (Fryar et al., 2018; National Center for Chronic Disease Prevention and Health Promotion, 2019). Childhood obesity (CO) has many negative influences on the developmental trajectory. It continues into adulthood (Whitaker et al., 1997), shortens lifespan (Danaei et al., 2009), increases multiple cancer risks (National Cancer Institute, 2017), impedes functional ability (Li et al., 2008), and diminishes quality of life (Swallen et al., 2005). Children with overweight or obesity are more likely to experience various psychosocial problems, such as aggressive and disruptive behavior (Puder and Munsch, 2010), and are more likely to be victims of bullying and teasing (Schwimmer et al., 2003).

Physical activity (PA) helps to prevent childhood obesity and has significant psychological benefits on children with obesity, including improvement in emotional well-being, self-perception, and self-confidence (Estabrooks et al., 2008; Katzmarzyk et al., 2015; Romero-Pérez et al., 2020). United States PA guidelines recommend 60+ min of age-appropriate, enjoyable, mostly moderate, or vigorous daily PA (MVPA) for children (U.S. Department of Health and Human Services, 2018). Yet, few children meet the guidelines (National Physical Activity Plan, 2014). The majority of PA interventions (e.g., home, school, or community-based), have yet to achieve sufficient engagement from children (Metcalf et al., 2012; Thivel et al., 2018). The study seeks to identify child-friendly PA interventions that are both engaging and sustainable.

An alternative PA intervention to promote exercise comes in the form of exercising using AVGs, also known as exergames, which are video games that require movements that mimic "real-life" exercise (Bailey and McInnis, 2011). Unlike traditional PA, AVGs gamify the component of exercise via various gaming consoles (e.g., *Wii Sports Resort*, *Xbox Kinect Adventures*). Children are more likely to associate AVG and exercise with fun and engaging gaming experiences. AVGs have been demonstrated to motivate children to engage in moderate-to-vigorous PA (Hwang et al., 2019; Williams and Ayres, 2020). Previous systematic reviews have found that AVG use significantly increases duration of vigorous PA among children (Lu et al., 2013; Gao and Chen, 2014) and AVGs have a small to medium effect of on BMI reduction (van't Riet et al., 2016).

Narratives for PA Promotion via AVGs

Despite their seemingly engaging qualities, AVGs are less likely to be played for a long periods of time (Graves et al., 2010; Lyons et al., 2011). A potential reason for this reduced long-term engagement is that AVGs seldom incorporate narratives (Lu and Kharrazi, 2018) and are then perceived to be less enjoyable than sedentary games.

The use of narrative could be a solution to this problem. Narratives, defined as two more events occurring in succession (Rimmon-Kenan, 2003), have been identified as an integral component of the player experience and motivation (Bateman, 2006; Yee, 2016). The addition of a narrative to existing AVGs may increase user motivation and ultimately lead to increased PA (Lu, 2015; Sousa et al., 2020).

Not all narratives elicit the same motivational effects in children. Previous studies found that narratives with interesting plots, including cliffhangers, and extraordinary characters are capable of promoting PA engagement in children aged 8–12 years (Lu et al., 2016b). In another study, children preferred the narrative cartoon as opposed to non-narrative cartoon and reported enjoyment of the story and exercise (Davis et al., 2016). Children in the 8–12-year age group, across all weight, race, and gender groups, also preferred a fantasy genre of dystopian science fiction (Lu et al., 2019). Indeed, the most popular reading topic among boys and girls is the science fiction genre (Sturm, 2003).

Most of the previous studies on obesity combating narratives have targeted the 8–12-year age group. Without intervention, children with obesity in this age group are highly likely to become obese young adults (Whitaker et al., 1997). Therefore, examining outcomes in a high-risk population is especially important (Foster et al., 2010). Interventions have had effects primarily among the people with overweight and obesity (McMurray et al., 2000). Implementing narrative AVGs in higher-risk groups should result in greater positive outcomes (Ledoux et al., 2010). Children younger than eight have cognitive limitations in responding to survey questionnaires or interview questions (Borgers et al., 2000). Children older than 12 have entered early adolescence and will be subject to many physical, mental, emotional, and social changes that may require different intervention strategies (Centers for Disease Control and Prevention (CDC), 2010).

Narratives Immersion, Narrative Engagement, and Wishful Identification: Mediation Effects

Researchers have found that narratives Immersion, NE, and WI are potential mediators that improve or deteriorate the narrative effect. NI was adapted from the term "narrative transportation" (Green and Brock, 2000), which originally was defined as the story's ability to "transport" audiences to a different world. Due to the highly interactive and immersive qualities of videogames, the term "NI" was coined to describe the involving nature of videogames among children. We have also found that children had a better understanding of the term "NI" than "narrative transportation" in our interaction with them over the research sessions. The NI has been found to underlie the stories' motivating effect in PA (Sousa et al., 2020).

Narrative engagement, a relevant concept to narrative transportation/immersion, is based on the notion that NE is a process of constructing mental models of narrative events (Busselle and Bilandzic, 2009). While NE tends to be highly correlated with narrative transportation/immersion, it includes four additional dimensions of NE: narrative understanding, attentional focus, emotional engagement, and narrative presence (Busselle and Bilandzic, 2009). Both narrative immersion and engagement may be associated with narrative health persuasion outcomes, e.g., increasing children's motivation to exercise. Therefore, narrative immersion and engagement may mediate the effect of the character body shape manipulation on children's exercise motivation.

Wishful identification, defined as the desire to become or mimic actions of characters in the narrative (Hoffner, 1996), may influence exercise motivation as well when the narrative character's body shape has been changed. Due to the desirability of athletic slim characters, a child may have a higher WI with athletic slim characters, who represent societal ideals. This corresponds to the self-perception theory (Bem, 1972) that argues that children may rely on the character's body shape to infer their internal states and behave according to the inference. Seeing athletic slim characters may therefore encourage children to behave as them by exercising regularly. On the other hand, according to tailoring literature, children with overweight or obesity are more likely to identify with characters that look like themselves and thus would perceive these characters and the stories to be more relevant to themselves as well as have higher WI with them (e.g., want to act like the overweight or obese characters). A study of AVG has found that customized avatars with idealized body shapes (as opposed to realistic features) decreased the players' AVG performance (Koulouris et al., 2021).

In other words, seeing characters similar in body shape for children with overweight/obesity may enhance the perceived self-relevance, enabling them to become more immersed in a narrative, resulting in a higher WI with the characters. On the other hand, seeing characters engaging in PA in a body shape that the children wish to resemble, may also enable them to be more engaged with the narrative and having a higher WI. Either way, the increased engagement with narratives and WI has the potential to motivate them to participate in higher PA to combat obesity. More research is needed to determine whether similar or aspirational body shapers are more likely to encourage children to engage in PA.

The Visual Representation of Media Characters' Body Shapes and the Effects of Exposure to Them

The visual components of the video narratives added to AVGs, such as the body shape of characters, may affect AVG motivation and amount of time spent engaging in PA. Narratives, especially those with vivid imagery, may affect players' attention and adherence to health messages, such as encouraging PA (Baranowski et al., 2013), even more so than textual cues. However, this effect is dependent on the valence of emotional response users have to these images (Houts et al., 2006). One notable visual cue in narratives is the characters' body shape, which can potentially modify children's health-related outcomes (Common Sense Media, 2015).

The body shape of characters may also decrease motivation to engage in PA as well. The body shape is an inextricable aspect of contemporary American media, partially due to the prominence of character-based stories, and can contribute to negative psychological effects (Puhl et al., 2013), which can lead decreased time spent exercising (Han et al., 2018). The portrayal of overweight characters in American media often perpetuates stigmatization of obesity, thus negatively affecting overweight/obese children (Puhl et al., 2013). In adolescent targeted media, such as cartoons, movies, and books, children deemed overweight characters to be unattractive, less loving, less physically healthy, and less intelligent; children tended to classify such characters as "bad" (Ata and Thompson, 2010). Thus, the explicit body shape of the character depiction may provide implicit messages and associations concerning the quality of the character to children.

The body shape, media representation, and subsequent associations of the characters in media differs by gender as well. In cartoons, female characters were four times more likely to be depicted as underweight; overweight female characters were more likely to be presented as unintelligent or unhappy (Latner et al., 2007). For men, over the past 30 years, action figures have grown substantially in muscle size, correlating with decreased body esteem and an increase in depression in male audiences (Barlett et al., 2008; Martins and Harrison, 2012). Being exposed to characters that are predominantly athletic slim (for women) or muscular (for men) instead of characters with a variety of body shapes can lead to unsatisfactory body self-perception and a lack of self-esteem in both boys and girls (Barlett et al., 2008). For both genders, positive traits, such as being referred to as "good looking" were addressed toward slim characters (Tzoutzou et al., 2020).

The portrayals of the ideal body shape in both genders could lead to internalization, which causes body dissatisfaction and even lead to a decrease in motivation to participate in PA. A previous study demonstrated that people are especially susceptible to internalizing media messages about the idealized body shape, as determined by an internalization score. Those who were presented with a high internalization score were more likely to report higher body dissatisfaction (Dye, 2016). The body dissatisfaction, reinforced by ideals presented in media, can further manifest in a lower health-related quality of life, including physical ability and a decrease in motivation to participate in PA. Such detrimental effects may extend to adulthood. For example, in a self-reported adult study, exercise avoidance motivation was influenced by weight stigma and contributed to the negative correlations between body weights and PA (Han et al., 2018). Furthermore, a positive discrepancy between reported and actual self-figure was inversely related to health-related quality of life (Petracci and Cavrini, 2013).

For younger girls specifically, the internalization of the appearance ideals conveyed through characters, as represented in conversations with friends and criticism by peers, was significantly related to body dissatisfaction (Jones et al., 2004), which, as previously mentioned, can result in decreased PA motivation. Boys also suffer body dissatisfaction based on comparisons with friends, comments by peers, and their own body shape (de Vries et al., 2019). Furthermore, children's media also perpetuate internalization of obesity stigmatization and the media use for both genders has been found to be correlated with a more negative attitude toward girls and boys with overweight and obesity and demonstrated the negative internalizing role an idealized depiction of both genders plays (Latner et al., 2007).

The negative effects of internalization are further highlighted through the narrative persuasion theory, which states that narratives can have an impact on beliefs, behaviors, and attitudes (Green and Brock, 2002). Accordingly, a narrative promoting certain body images or ideals may also shape the behaviors and beliefs of the audience. For both boys and girls, the amount of time engaging with idealistic images predicted low self-esteem and participation in diets to lose weight (Harrison, 2000a). Although this exposure to idealized images can motivate both genders to improve their body shapes, along with the effects of low self-esteem and body desirability produced by such exposure, there may also be undesirable aspects to body shape improvement, including unhealthy mechanisms for weight loss (Harrison, 2000a). In addition, as postulated by the social cognitive theory, learning occurs in a social context with a dynamic and reciprocal interaction of the person, environment, and behavior (Bandura, 1986), observational learning can occur from a model (Schunk and DiBenedetto, 2020) from a narrative. If these narratives provide a model that perpetuates unattainable, yet desirable body shapes, and unhealthy mechanisms to achieve said body, audiences who emulate this model may adopt these unhealthy behaviors. The negative effect on self-image and perception is also physically damaging as it can result in reduced motivation to engage in PA, ultimately demonstrating that body shape of various media figures has a key impact on self-perception (Petracci and Cavrini, 2013; Rideout, 2015).

Therefore, building upon previously research, we plan to create a narrative in which the visual components, specifically the body shape of the characters, resemble the viewer with a goal to increase PA. More specifically, to explore the influence of the variation of narrative character's body shape on 8–12-year-old children's exercise motivation (AVG and PA motivation), we manipulated the character's body shape and examined their NI (Lu et al., 2012b), NE (Busselle and Bilandzic, 2009), and WI (Hoffner, 1996) that may be affected by manipulation of character body shape and explored how these factors may influence children's motivation to exercise as a result of watching this animated narrative.

Due to the fact that WI is based on the notion that the character's body shape matches that of the children, we divided the participants into two groups: children with a BMI greater than the 75th percentile vs. a BMI equal or less than the 75th percentile. Therefore, we could compare the effects of the different character body conditions on children of different weigh classes. The 75th percentile BMI marker is also correlated with onset of certain conditions, such as asthma and heightened allostatic load (Davis et al., 2007), which added further clinical relevance to this division.

We hypothesized that presenting the children with characters with similar character body shapes would ultimately enhance NI, NE, and WI, all of which in turn will increase PA and AVG play motivation.

MATERIALS AND METHODS

Narrative Development

To investigate the effect of character body shape on the aforementioned outcomes, we presented children aged 8–12 with a single animated narrative video in which we had varied the body shapes of the main characters to three conditions (overweight/obese, average, and athletic slim). These three conditions were chosen to represent a graded scale of the body shape spectrum presented in media narratives, from the idealized body shape to characters that more closely resemble the overweight/obese population our research team works with. As part of a pilot study, children were presented with sample images of potential characters representing each condition and asked for their opinion. From their answers, we noted that the expression "thin" should be avoided and therefore chose "athletic slim" to avoid a negative connotation for children of the body shape. Furthermore, a team of research assistants were also interviewed about the perception of body shapes of three different conditions and contributed to the current naming convention.

A professional media production company, FableVision, was hired to create a 15-min animation about a dystopian Sci-Fi narrative, *Ataraxia*, that incorporated AVGs in the plotline. In *Ataraxia,* the plot concerns a dystopian future in which a twin brother and sister, who can absorb and take away people's pain, are kidnaped by an evil dictator to create an army of indestructible soldiers. During the *Ataraxia* narrative, the player character, who grows up with the twins, begins to develop superpowers through exergaming and must train to hone their powers to aid in saving the twins and saving Ataraxia from various villains. The *Ataraxia* series was later developed into a six-season 72-episode animated series.

During the animation production, the production team created multiple layers of different animation panels to allow various modifications of different elements. This allowed for varying each element of a character (i.e., body shape independent of any other alterations such as hair color, background settings). With this approach, three different character types based solely on body shape (all other elements were kept equal) were created by a single animator to ensure a consistent visual style: overweight/obese (condition A), average (condition B), and athletic slim (condition C; see **Figure 1**). The audio was also kept identical across the conditions.

Recruitment

We partnered with a charter school and eight different youth centers in the Greater Boston Area. Site coordinators helped to distribute information sheets to the parents of 8–12-year-old children attending afterschool activities. Research assistants (RAs) also placed posters/flyers with a brief overview of the study on stationary bulletin boards in the school and at the centers.

Regardless of the recruitment method, interested parents completed a screening questionnaire either online or in person, including parent contact information and basic demographic and physical information regarding their child. If they completed the questionnaire in person, it was then returned to their afterschool coordinators, who later passed them to the research team. All parents and children also completed consent and assent forms to participate in this project.

All data collection took place between January 8, 2019 and June 17, 2019. Inclusion criteria included the following: children who were between 8 and 12 years, able to speak and understand English, and able to complete the protocol. Exclusion criteria included the following: children who did not speak English, who had an intellectual disability (preventing them from understanding the narrative video), or who had a physical disability (preventing them from participating in AVGs).

After RAs obtained completed consent and assent forms from the site coordinators, they visited the sites to conduct further assessments of the children. The children's height and weight were measured by the RAs two times: height

FIGURE 1 | Image stills taken from the narrative trailer for each of the three body shape conditions. Produced by FableVision Studios for Northeastern University. Reproduced with permission from Northeastern University.

(to the nearest 0.1 cm) using a ShorrBoard (Weight and Measure, LLC, Olney, MD, United States) and weight (to within 0.1 kg) using a SECA scale (SECA Inc., Chino, CA, United States). A third measurement was taken if there was more than a 0.2 cm (height) or a 0.2 kg (weight) difference between the first two measurements. Afterward, the demographic information previously provided was confirmed. Body mass index was calculated using the mean of height and weight measurements (BMI; kg/m^2) and using the CDC growth charts (Kuczmarski et al., 2000). The children were then randomly assigned to watch one of three animation clips: one-third assigned to condition A, one-third to condition B, and one-third to condition C. The height and weight assessment, randomization, and actual data collection were within 1–2 weeks to ensure the timeliness and accuracy of the measurements.

Procedure

To ensure children provided us with their unfiltered opinions, we used as the primary data collection site the media classrooms of their afterschool facility, where they usually gather to watch TV or play video games. Before watching the video, children were directed away from their afterschool activities and invited into the room to sit in chairs pre-arranged in front of a high-definition TV set. They were then told that the study was about their opinions of an animation movie created to encourage them to exercise more. They were told that the RAs would ask them for their opinions in a questionnaire that they would complete and that there was no right or wrong answer to the questions. The RAs told them that they should feel free to express themselves confidentially in the questionnaires. They were also reminded that they could stop their participation at any time. Children were then placed in groups of 4–15, depending on the room size, time of the visit, the afterschool program's schedule, and the child participant's availability.

Questionnaires and Scales

After watching the animation clip, children were handed hard copies of questionnaires consisting of the following: a demographic questionnaire (age, sex, race, and ethnic background) and a psychological survey questionnaire measuring NI (Lu et al., 2012b), NE (Busselle and Bilandzic, 2009), WI (Hoffner, 1996), AVG motivation (a five-item scale developed for this project), PA motivation (Kendzierski and DeCarlo, 1991), and social desirability (SD) (Reynolds and Paget, 1983).

The NI scale (Lu et al., 2012b) was adapted from the original 11-item transportation scale (Green and Brock, 2000). One item ("I had a vivid image of [character name]") was removed because the original scale was about transportation via textual media. Thus the original narrative transportation scale has been adapted into a "NI" scale, which captures all of the essential information of the original one to measure children's response to visual narrative media (Lu et al., 2012b). The remaining 10-items had then been repeatedly implemented with children in a series of studies among children (Lu et al., 2012b, 2016a; Sousa et al., 2020). Through the children's feedback during the study sessions, the RAs documented their questions about the questions and explained to them the meaning of the questions to ensure the scale to be child friendly for a better understanding. As a result, this effort resulted in the original scale language being modified slightly to the NI scale to ensure children's understanding while retaining the original meaning.

Given children's limited understanding of the Likert scales and the typical field practice in psychology (Mellor and Moore, 2013), we have also reduced the choice options from 7-point to 5-point, with 1 = disagree, 3 = neutral, and 5 = agree. Sample questions for NI include "I was completely involved in the story while watching it" and "I wanted to find out how the story ended" (Cronbach's $\alpha = 0.544$ initially and later = 0.610 after removal of two additional reversed-coded items, elaborated later).

Similarly, the 12-item NE scale was also adapted from the original study with adults (Busselle and Bilandzic, 2009) to be used for children. Minor changes were implemented to ensure that the questions were understood. Sample questions for NE include "I understood the story" and "I understood the characters," with 1 = disagree, 3 = neutral, and 5 = agree (Cronbach's $\alpha = 0.695$).

The 3-item wishful identification (WI) scale was adapted without any modification as it was originally developed for children (Hoffner, 1996) with a 5-point scale. Sample questions for WI included "I would like to do the kinds of things he/she does in the story" and "He/she is the sort of person I want to be like," with 1 = disagree, 3 = neutral, and 5 = agree (Cronbach's $\alpha = 0.750$).

The assessment of AVG play motivation (AVGM) is based on a 5-item scale developed for this project. The scale assessed the degree of children's willingness to play an AVG if the story is included as its plot. Sample questions include "I intended to play this AVG" and "I plan to exercise through this AVG," with 1 = disagree, 3 = neutral, and 5 = agree (Cronbach's $\alpha = 0.792$).

The PA motivation (PAM) employed a 16-item scale adapted from the validated exercise enjoyment scale (Kendzierski and DeCarlo, 1991), Sample questions include "(1=) (PA) is no fun at all" versus (5=) (PA) is a lot of fun;" and "(1=) (PA) is not at all exciting (=1)" vs. "(5=) (PA) is very exciting" (Cronbach's $\alpha = 0.883$).

The 9-item SD scale (Reynolds and Paget, 1983) was used to measure the importance of social approval in children. This variable was included because we wanted to control for demand characteristics and ensure that the children were not answering the questionnaires in a way to appease the researchers. Statements such as "I am always kind" and "I tell the truth every single time" were presented in an agree/disagree gradient scale, with 1 = disagree, 3 = neutral, and 5 = agree (Cronbach's $\alpha = 0.841$).

As children completed the paper copies of questionnaires, RAs observed their attention to the questionnaire completion and answered questions from them. They also took notes of children who simply answered all questions without reading them (e.g., selecting "1" or "5" for all questions on multiple pages or completing the questions in extremely short period of time (e.g., finishing over 50 questions in less than 3 min), which suggested the lack of validity for these answers. After children have completed the questionnaires, children were given a $25 gift card for their participation, thanked, and brought back to their afterschool activities. The RAs then collected the questionnaires and entered them into the database. All data entries were triple checked to ensure accuracy. The questionnaires from those less attentive participants were identified and later removed for analysis.

RESULTS

Statistical Analysis

To compare the perceptions of conditions A, B, and C by children of different weight status, we dichotomized our participant population using the 75th percentile of BMI, which also happened to have resulted in a median split of the total sample as a cut-off point. The Shapiro–Wilk and Levene's tests were applied for normality and homogeneity, respectively. All variables presented a normal and/or homogeneous distribution and were analyzed using parametric tests. Characteristics of the sample were compared between the group ≤ 75 and >75 BMI percentile with an independent t-test. The Cronbach's Alphas were calculated for all of the scales (reported in section "Materials and Methods").

Since the Cronbach's Alpha of NI was relatively low (0.544), we then conducted a factor analysis for NI and after excluding two items ("When I was watching the story, other activity going on in the room around me was on my mind." and "After the story ended, I found it easy put it out of my mind."), the new Cronbach's Alpha was 0.610. Nevertheless, due to the high correlation between NI and NE ($r = 0.716$, $p < 0.001$), which was routinely observed over our child sample (Lu et al., 2012b, 2016a; Sousa et al., 2020), we decided to examine both variables as outcomes of narrative persuasion, but only include NE in the mediation analysis. The scales were thus all averaged for additional analysis.

General linear models with two factors (two-way ANOVA) were ran for each outcome. BMI percentile ($\leq$75th/$>$75th) was added as fixed factor, and Condition as a random factor (conditions A, B, and C, were coded as 1, 2, and 3, respectively). When interactions were found ($p < 0.05$), pairwise comparisons were applied to further identify the differences. The hypothesis of sphericity was verified by Mauchly test, and when violated, the degrees of freedom were corrected by the Greenhouse–Geisser estimates.

Structural equation modeling (SEM) was conducted using Mplus 7 (Muthén and Muthén, 2018) with maximum likelihood estimation. Given the relatively small sample size in relation to the number of individual variables (Bollen, 1989), we did not adopt a latent variable model. Instead, a path model using manifest variables was developed to examine the mediating role of NE and WI of the effect of character body shape manipulation (IV) and children's BMI percentile (IV) on children's AVG (DV) and PA motivation (DV). We used Hu and Bentler's (1999) criteria for model fit indices. More specifically, to indicate a good model fit, both Comparative Fit Index (CFI) and Tucker Lewis index (TLI) should be 0.96 or higher; the root mean square error of approximation (RMSEA) should be 0.06 or lower; the standardized root mean square residual (SRMR) should be 0.08 or lower. All path coefficients reported later were standardized estimates, which were indicative of effect sizes (Muthén and Muthén, 2018).

The statistical significance level was set at 5% ($p < 0.05$). The independent t-test, and ANOVA models showed a power of analysis of 79% or higher considering a moderate effect size and the final sample size (n = 87). All non-SEM statistical procedures were carried out using the Statistical Package for the Social Sciences (SPSS) 26 (IBM Corp, 2020) and GraphPad Prism 8.4.2 (GraphPad Software, 2020).

Demographic Information

Data was originally collected from 96 children. Of them, nine children were identified as improperly answering questions (giving the same rating to each of the questionnaire questions throughout or too fast in answering all questions) and were therefore removed from data analysis, resulting in 87 participants.

The participants' average age was 9.8 (SD = 1.26); 55% were boys, and 45% were girls. The participants were racially diverse, with 32.2% of children identifying as Hispanic or Latino, 28.7% as African American, 10.3% as Caucasian, 9.2% as mixed race, 5.7% as Asian, and 13.8% of participants identifying as American Indian/Alaska Native or of Other race. As indicated in **Table 1**, participants were divided by a median split of a BMI percentile of 75. No differences were identified for age (p = 0.919), sex (p = 0.831), race (p = 0.170), and SD (p = 0.458) for children in different BMI percentile groups across the three conditions. The key differences between the ≤75th BMI percentile or >75th BMI percentile, as expected, were participant weight, BMI, and BMI percentile (ps < 0.001).

A two-way between-subject multivariate analysis of variance indicated a significant Condition effect, $F(10,154) = 2.418$, $p = 0.011$; Wilks' $\Lambda = 0.747$, and a borderline significant interaction effect between BMI percentile and Condition on the combined dependent variables, $F(10,154) = 1.702$, $p = 0.085$; Wilks' $\Lambda = 0.811$. To investigate the impact of each effect on the individual outcome variables, a univariate F-test using an alpha level of 0.05 was performed. The general linear model identified an interaction effect (BMI percentile × Condition) for NE ($F = 4.58$; $p = 0.013$; $\eta_p^2 = 0.102$), WI ($F = 5.85$; $p = 0.004$; $\eta_p^2 = 0.126$), and PA motivation ($F = 3.17$; $p = 0.047$; $\eta_p^2 = 0.073$). Pairwise comparisons found that condition A resulted in higher NE and WI among children of >75th BMI percentile than children of ≤75th BMI percentile (ps < 0.029). Condition B resulted in higher NE and PA motivation in children of ≤75th BMI percentile than those in >75th BMI percentile ($p < 0.05$). Among children in ≤75th BMI percentile, condition B showed higher NE, WI, AVG play motivation than conditions A and C (ps < 0.05). Condition C also resulted in a lower PA motivation than condition B. As for children in >75th BMI percentile, condition A resulted in higher NI, NE, WI, and PA Motivation than conditions B and C, and borderline higher AVG motivation than condition C (p = 0.064). See **Table 2** for details. Similar results were obtained when controlling for SD and would not be double presented for space conservation.

In terms of the structural equation modeling analysis, **Figure 2** presents the original hypothesized model examining the mediating role of NE and WI of the effect of condition of three types of character body shape manipulation (IV) and children's BMI percentile (IV) on children's AVG (DV) and PA motivation (DV). For the 3-type character body shape manipulation IVs, two dummy variables (X1 and X2) were created with the "athletic slim" group as a reference group. The model ($\chi_{18}{}^2 = 104.37$, $p < 0.01$) fits were good (CFI/TLI > 0.96, RMSEA < 0.06, SRMR < 0.08). Both the overweight/obese condition and the average condition (compared to the athletic thin condition)

TABLE 1 | Participant demographics and social desirability results (N = 87).

	≤75th BMI percentile (*n* = 44)			**>75th BMI percentile (*n* = 43)**			***p***
	Condition A (overweight/obese) (*n* = 11)	**Condition B (average) (*n* = 21)**	**Condition C (athletic slim) (*n* = 12)**	**Condition A (overweight/obese) (*n* = 13)**	**Condition B (average) (*n* = 18)**	**Condition C (athletic slim) (*n* = 12)**	
Age, mean (*SD*)		9.8 (1.3)			9.8 (1.2)		0.919
Weight (kg)		33.8 (6.7)			48.7 (10.3)		<0.001
BMI, kg/m^2, mean (*SD*)		16.6 (1.5)			23.0 (3.7)		<0.001
BMI percentile, mean (*SD*)		43.5 (22.2)			91.6 (6.3)		<0.001
Sex (boy/girl, n)	8/3	12/9	5/7	9/4	11/7	3/9	0.831
Race (*n*)							0.170
Asian	2	0	0	1	2	0	
African American	1	5	3	5	4	7	
American Indian/Alaska Native	0	1	1	0	0	0	
Caucasian	4	3	0	2	0	0	
Hispanic or Latino	2	7	4	2	10	3	
Mixed	1	2	3	1	1	0	
Other	1	3	1	2	1	2	
Social desirability (*SD*)		3.3 (0.8)			3.4 (0.9)		0.458

TABLE 2 | Means of the main outcome variables per group (*N* = 87).

	Condition A (overweight/obese)	Condition B (average)	Condition C (athletic slim)
≤75th BMI percentile	***n* = 11**	***n* = 21**	***n* = 12**
Narrative immersion (NI)	3.39 (0.60)	3.42 (0.59)	3.12 (0.58)
Narrative engagement (NE)	3.19 (0.61)	3.74 (0.50)[#,a]	3.10 (0.54)
Wishful identification (WI)	3.09 (1.03)	3.86 (1.20)[a]	3.11 (1.04)
AVG play motivation (AVGM)	3.56 (1.16)	4.35 (0.82)[a]	3.35 (1.36)
PA motivation (PAM)	3.84 (0.69)	4.27 (0.68)[#]	3.57 (0.79)[b]
>75th BMI percentile	***n* = 13**	***n* = 18**	***n* = 12**
Narrative immersion (NI)	3.74 (0.47)[c]	3.15 (0.59)	3.13 (0.80)
Narrative engagement (NE)	3.73 (0.48)[*,c]	3.34 (0.68)	3.12 (0.77)
Wishful identification (WI)	4.41 (0.78)[*,c]	3.50 (1.02)	3.33 (1.33)
AVG play motivation (AVGM)	4.15 (0.93)[d]	3.96 (0.96)	3.35 (1.33)
PA motivation	3.93 (0.76)[c]	3.39 (0.90)	3.15 (0.66)

Pairwise comparisons: the different scores are marked with a superscript symbol.
[,#]Different between BMI percentile groups.*
[a]Higher than Conditions A and C. [b]Lower than Condition B. [c]Higher than Conditions B and C. [d]Borderline higher than Condition C.

were significantly associated with NE, which was significantly associated with both of the DVs. The indirect effects of the average body image condition (compared to the athletic thin condition) on AVG ($p = 0.019$) and PA motivation ($p = 0.046$) via NE were also significant. Since nearly all of the paths related to WI and the children's BMI percentile (IV) were non-significant, these two variables were removed from the mediation model, leaving the character body shape as the only IV and the NE as the only mediating variable. Participant age and sex were not significantly associated with the mediators and outcome variables in this model and thus excluded in the final model.

Figure 3 has the updated mediation structural equation model. The updated model ($\chi_9^2 = 67.48$, $p < 0.01$) has excellent goodness of fit indices (CFI/TLI > 0.98, RMSEA < 0.04, and SRMR < 0.06) and explains approximately 37 and 18% of the variances of children's AVG and PA motivation, respectively. In this model, the overweight/obese ($\beta = 0.262$, $p = 0.03$) and average ($\beta = 0.348$, $p = 0.002$) body image conditions were significantly associated with NE. The direct effects of NE on children's AVG motivation ($\beta = 0.553$, $p < 0.001$) and PA motivation ($\beta = 0.328$, $p < 0.01$) remained significant. While the indirect effects of the overweight/obese body image condition (compared to the athletic thin condition) on AVG ($p = 0.058$) and PA motivation ($p = 0.085$) via NE were marginally significant, the indirect effects of the average body image condition (compared to the athletic thin condition) on AVG ($p = 0.019$) and PA motivation ($p = 0.046$) via NE remained significant, indicating the robustness of this particular effect.

To check the robustness of the overall model, two-way interactions of SD with the condition variables were tested. These interaction coefficients were not significant and results overall remained similar.

DISCUSSION

To increase children's engagement in PA-inducing AVGs, we investigated the effects of manipulating the character body shape in an animated narrative on children's NI, NE, WI, AVG, and PA motivation.

We have found that the visual presentation of different character body sizes in a narrative impacted children's NE across different weight groups. Children with a higher than 75th BMI percentile had a significantly greater NI, NE, WI, and PA motivation in the overweight/obese (condition A) character condition than those who were in the average or athletic slim conditions (conditions B and C). On the other hand, children equal to or below the 75th BMI percentile had higher NE, WI, and AVG play motivation when the characters body shape was average (condition B) than in condition A (overweight/obese) or C (athletic slim). Furthermore, the overweight/obese character body shape (condition A) resulted in higher NE and WI among children with higher than 75th BMI percentile than those with 75th or less BMI percentile while condition while the average character body shape (condition B) resulted in higher NE and PA motivation in the 75th or less BMI percentile than those whose BMI percentile are 75th or higher. Last but not least, the NE had

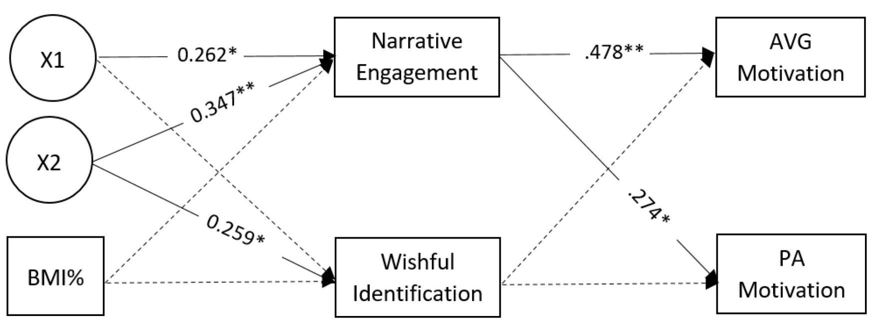

FIGURE 2 | Structural Equation Model for the relation between character body shape, children's BMI percentile, AVG motivation and PA motivation, with narrative engagement and wishful identification as the mediating variables. X1: the overweight/obese condition in reference to athletic slim condition. X2: the average condition in reference to athletic slim condition. All paths' estimates are standardized. For the sake of simplicity, the direct and indirect paths from the IVs to the DVs as well as the correlations between the mediators and DVs are not shown. *$p < 0.05$; **$p < 0.001$.

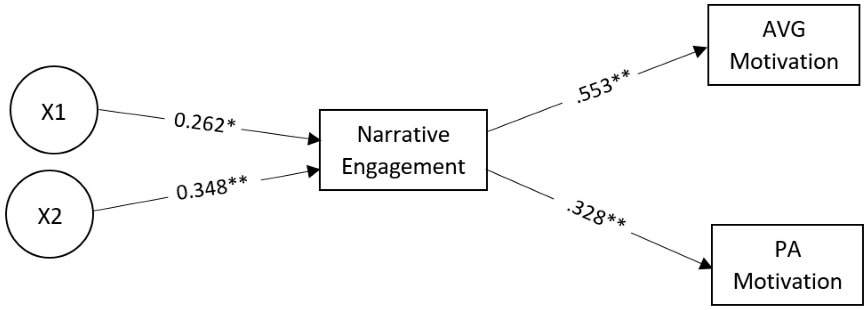

FIGURE 3 | Structural Equation Model for the relation between character body shape and AVG motivation and PA motivation, with narrative engagement as the mediating variable. All paths' estimates are standardized. X1: the overweight/obese condition in reference to athletic slim condition. X2: the average condition in reference to athletic slim condition. For the sake of simplicity, the direct and indirect paths from the IVs to the DVs as well as the correlations between the DVs are not shown. *$p < 0.05$; **$p < 0.001$.

a stable and significant mediating effect between the character body manipulation and the AVG play motivation and physical activity motivation.

In the mediation model, the NE repeatedly demonstrates the capability of narratives to translate the power of entertainment to health behavior change. We have consistently demonstrated the importance of the engaging factor, that is, a health intervention, be it in the form of narrative media or not, must be engaging to have the potential to induce health behavior change. On the other hand, this also suggested the psychological crux of successful narrative health intervention for children. A narrative message must be fully understood, grabbing children's attention, capturing their emotion, and drawing them into the narrative world.

Wishful identification yielded no significant mediating path results. While this could be potentially attributed to the relatively small sample of the study, the result also suggests that children's engagement with a story may be more relevant to their motivation to exercise than their desire to become like the characters presented in the story. In addition, the original WI scale adopted in this study did not include items asking about the physical characteristics of the characters, incorporation of these items may alter the results.

While WI was not found to have significant effects on children's PA or AVG play motivation in this study, this concept can still be relevant to a child's engagement with the story and thus the relationship between WI and NE should be further explored. For example, children showed significantly higher WI with characters that looked like their own body shapes in both weight groups. Since these characters may already appear more similar to the children, the increased desire to be like the shape of those characters may not translate directly to exercise behaviors among the audience, despite the fact these characters themselves are engaged in physical activities in the animated story. On the other hand, when WI was higher, so was NE, which according to the mediation results did mediate AVG and PA motivation. A higher WI may contribute to higher NE as well as the health behavior intentions in an indirect fashion.

From a practical perspective, given the higher NE, NI, and WI presented when characters have body shapes that match the intended audience, when executing potential PA interventions among children population, media creators should be conscious of creating body shapes of various sizes if they are catering to diverse children body shapes. Creating the appropriate visual aspect of the character body shape could not only increase children's engagement with the story, but also motivate them to participate in the physical activities suggested and potentially enhance their adherence to the intervention. This way, children of all body shapes can have access to an engaging and relatable narrative.

Due to the importance of NE in PA intervention, and potential clinical use, further research is needed on how to best engage children of various backgrounds to ensure the narrative truly serves the entire child population. For example, while we have found that the children in our population were more likely to be engaged in stories with similarly sized characters, in the study design; however, we did not account for gender differences as our presented characters had one male and one female character, both of whom were presented in a similar fashion in each of the body shape conditions. As previously reviewed, the traditional gender representation in media is more likely to have women being represented as underweight and men presented as muscular (Barlett et al., 2008). Thus, the way the body shape differences are represented across different gendered characters still needs to be investigated in terms of their differing effects on NE and exercise motivation.

In addition, we have only presented the character's body shape in an initial segment of a long story, most of the effects observed here are based on the beginning status of the character body shape. Will there be a differential response when the characters' body shapes start to increase or decrease in accordance with children's exercise participation over different time intervals (Fox and Bailenson, 2009)? The dynamics of the characters' body shape change mirroring or opposite to the audience's own body shape during the narrative development deserve some additional exploration.

It is also interesting to observe that the athletic slim body type of cartoon characters did not appeal to children in either weight group with the 75th BMI percentile as the cutoff point. While dividing children's weight groups in a much more fine-tuned fashion may allow us to identify some children with less BMI percentile to engage with the athletic slim condition more, further examination of the data among the slim children proved otherwise; we could not identify a significant number of children who gave this condition higher ratings. This may have something to do with potentially visual and aesthetic fatigue with respect to children's long-term exposure to the stereotyped media characters' body shape presentation (Lemish and Johnson, 2019). Therefore, when they are presented with someone without the stereotyped body shape, the novelty of such visual presentation may be more welcome among them. An alternative explanation is that the increasing obesity epidemic, coupled with popular culture's influence on body ideals change over the past several decades, may also have already shifted the social and perceptual norms of a typical child. Though research in this area has been sparse.

This research project is not without limitations. The participants only watched 15 min of the narrative and did not watch the full six-season animated series over time. Thus, it is unclear if the results would be altered should the children have been exposed to more episodes and more viewing sessions. In addition, due to space and time constraints, we have only measured participants' response through survey questionnaires. Children did not actually play the AVG after watching the episodes. Thus, exercise motivation was determined based on self-report instead of objectively measured PA outcomes. More research is needed regarding the actual increase in AVG playtime instead of hypothetical change reported on paper. Our access to children was also constrained by the schedule of different afterschool activities in different classes, resulting in relatively limited sample size, which could contribute the borderline and lack of significant results. Similarly, although our participant base was racially diverse and relatively equally divided between boys and girls, the small sample size may preclude us from in-depth examination of specific racial and sex characteristics and differences.

Despite these limitations, this project found that narrative cartoon characters that mirror the target participant's body shape can increase NI, WI, and NE. NE in turn mediates the effect of character body shape manipulation on AVG and PA motivation. Such findings strongly suggests the importance of having relatable characters to increase children engagement with narrative health interventions. Future health narrative content producers should identify optimal strategies in character body shape design to encourage children of different weight status to participate in PA with engaging stories to maximize health narratives' persuasive potentials.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Northeastern University IRB. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

DA contributed to data analysis and wrote the first draft of the manuscript. CS participated in data analysis and results interpretation. AL designed the study, supervised the data collection, participated in data analysis, results interpretation, and supervised the study. All the authors contributed to the manuscript writing, read and approved the final version of the manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.653626/full#supplementary-material

Supplementary Table 1 | Shapiro–Wilk and Levene's tests results.

REFERENCES

Ata, R. N., and Thompson, J. K. (2010). Weight bias in the media: a review of recent research. *Obes. Facts* 3, 41–46. doi: 10.1159/000276547

Bailey, B. W., and McInnis, K. (2011). Energy cost of exergaming: a comparison of the energy cost of 6 forms of exergaming. *Arch. Pediatr. Adolesc. Med.* 165, 597–602. doi: 10.1001/archpediatrics.2011.15

Baker, K., and Raney, A. A. (2007). Equally super?: Gender-role stereotyping of superheroes in children's animated programs. *Mass Commun. Soc.* 10, 25–41. doi: 10.1080/15205430709337003

Bandura, A. (1986). *Social Foundations of Thoughtw and Action: A Social Cognitive Theory*. Englewood Cliffs, NJ: Prentice Hall.

Baranowski, T., Lu, A. S., Buday, R., Lyons, E. J., Schell, J., and Russoniello, C. (2013). Stories in games for health: more pros or cons? *Games Health J.* 2, 256–263. doi: 10.1089/g4h.2013.0052

Barlett, C. P., Vowels, C. L., and Saucier, D. A. (2008). Meta-analyses of the effects of media images on men's body-image concerns. *J. Soc. Clin. Psychol.* 27, 279–310. doi: 10.1521/jscp.2008.27.3.279

Bateman, C. (2006). *Game Writing: Narrative Skills for Videogames*. Newton, MA: Charles River Media.

Bem, D. J. (1972). Self-perception theory. *Adv. Exp. Soc. Psychol.* 6, 1–62.

Bollen, K. A. (1989). *Structural Equations with Latent Variables*. Hoboken, NJ: Wiley.

Borgers, N., de Leeuw, E., and Hox, J. (2000). Children as respondents in survey research: cognitive development and response quality. *Bull. Soc. Methodol.* 66, 60–75. doi: 10.1177/075910630006600106

Busselle, R., and Bilandzic, H. (2009). Measuring narrative engagement. *Media Psychol.* 12, 321–347. doi: 10.1080/15213260903287259

Castonguay, J., Bakir, A., and Blodgett, J. G. (2019). Adolescents' responses to cereal ads: an assessment of weight and gender. *J. Food Prod. Mark.* 25, 785–804. doi: 10.1080/10454446.2019.1678208

Centers for Disease Control and Prevention (CDC) (2010). *Child Development*. Atlanta, GA: Centers for Disease Control and Prevention (CDC).

Common Sense Media (2015). *Children, Teens, Media and Body Image: A Common Sense Media research brief*. San Francisco, CA: Common Sense Media.

Danaei, G., Ding, E. L., Mozaffarian, D., Taylor, B., Rehm, J., Murray, C. J., et al. (2009). The preventable causes of death in the United States: Comparative risk assessment of dietary, lifestyle, and metabolic risk factors. *PLoS Medicine* 6:e1000058. doi: 10.1371/journal.pmed.1000058

Davis, A., Lipsett, M., Milet, M., Etherton, M., and Kreutzer, R. (2007). An association between asthma and BMI in adolescents: results from the California Healthy Kids Survey. *J. Asthma* 44, 873–879. doi: 10.1080/02770900701752656

Davis, V., Mafra, R., Beltran, A., Baranowski, T., and Lu, A. S. (2016). Children's cognitive and affective responses about a narrative versus a non-narrative cartoon designed for an active videogame. *Games Health J.* 5, 114–119. doi: 10.1089/g4h.2015.0019

de Vries, D. A., Vossen, H. G. M., and van der Kolk-van der Boom, P. (2019). Social media and body dissatisfaction: Investigating the attenuating role of positive parent–adolescent relationships. *J. Youth Adolesc.* 48, 527–536. doi: 10.1007/s10964-018-0956-9

Dye, H. (2016). Does internalizing society and media messages cause body dissatisfaction, in turn causing disordered eating? *J. Evid. Inform. Soc. Work* 13, 217–227. doi: 10.1080/23761407.2015.1024572

Estabrooks, P. A., Fisher, E. B., and Hayman, L. L. (2008). What is needed to reverse the trends in childhood obesity? A call to action. *Ann. Behav. Med.* 36, 209–216. doi: 10.1007/s12160-008-9070-7

Field, A. E., Austin, S. B., Camargo, C. A., Taylor, C. B., Striegel-Moore, R. H., Loud, K. J., et al. (2005). Exposure to the mass media, body shape concerns, and use of supplements to improve weight and shape among male and female adolescents. *Pediatrics* 116, e214–e220. doi: 10.1542/peds.2004-2022

Foster, G. D., Linder, B., Baranowski, T., Cooper, D. M., Goldberg, L., Harrell, J. S., et al. (2010). A school-based intervention for diabetes risk reduction. *N. Engl. J. Med.* 363, 443–453. doi: 10.1056/NEJMoa1001933

Fox, J., and Bailenson, J. N. (2009). Virtual self-modeling: the effects of vicarious reinforcement and identification on exercise behaviors. *Media Psychol.* 12, 1–25. doi: 10.1080/15213260802669474

Fryar, C. D., Carroll, M. D., and Ogden, C. L. (2018). *Prevalence of Overweight, Obesity, and Severe Obesity Among Children and Adolescents Aged 2–19 years: United States, 1963–1965 through 2015–2016*. Hyattsville, MD: National Center for Health Statistics

Gao, Z., and Chen, S. (2014). Are field-based exergames useful in preventing childhood obesity? A systematic review. *Obes. Rev.* 15, 676–691. doi: 10.1111/obr.12164

GraphPad Software (2020). *GraphPad Prism version 8.4.2 for Windows*. San Diego, CA: GraphPad Software.

Graves, L. E., Ridgers, N. D., Atkinson, G., and Stratton, G. (2010). The effect of active video gaming on children's physical activity, behavior preferences and body composition. *Pediatr. Exerc. Sci.* 22, 535–546. doi: 10.1123/pes.22.4.535

Green, M. C., and Brock, T. C. (2000). The role of transportation in the persuasiveness of public narratives. *J. Pers. Soc. Psychol.* 79, 701–721. doi: 10.1037//0022-3514.79.5.701

Green, M. C., and Brock, T. C. (2002). "The mind's eye: transportation-imagery model of narrative persuasion," in *Narrative Impact: Social and Cognitive Foundations*, eds M. C. Green, J. J. Strange, and T. C. Brook (Mahwah, NJ: Lawrence Erlbaum Associates), 315.

Han, S., Agostini, G., Brewis, A. A., and Wutich, A. (2018). Avoiding exercise mediates the effects of internalized and experienced weight stigma on physical activity in the years following bariatric surgery. *BMC Obes.* 5:18. doi: 10.1186/s40608-018-0195-3

Harrison, K. (2000a). The body electric: Thin-ideal media and eating disorders in adolescents. *J. Commun.* 50, 119–143. doi: 10.1111/j.1460-2466.2000.tb02856.x

Harrison, K. (2000b). Television viewing, fat stereotyping, body shape standards, and eating disorder symptomatology in grade school children. *Commun. Res.* 27, 617–640. doi: 10.1177/009365000027005003

Hoffner, C. (1996). Children's wishful identification and parasocial interaction with favorite television characters. *J. Broadcast. Electr. Media* 40, 389–402. doi: 10.1080/08838159609364360

Houts, P. S., Doak, C. C., Doak, L. G., and Loscalzo, M. J. (2006). The role of pictures in improving health communication: A review of research on attention, comprehension, recall, and adherence. *Patient Educ. Couns.* 61, 173–190. doi: 10.1016/j.pec.2005.05.004

Hu, L. T., and Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Struct. Equat. Model. A Multidis. J.* 6, 1–55. doi: 10.1080/10705519909540118

Hwang, J., Lee, I. M., Fernandez, A. M., Hillman, C. H., and Lu, A. S. (2019). Exploring energy expenditure and body movement of exergaming in children of different weight status. *Pediatr. Exerc. Sci.* 31, 1–10. doi: 10.1123/pes.2019-0006

IBM Corp (2020). *Statistical Package for the Social Sciences (SPSS) V. 26*. Armonk, NY: IBM Corp.

Jones, D. C., Vigfusdottir, T. H., and Lee, Y. (2004). Body image and the appearance culture among adolescent girls and boys: an examination of friend conversations, peer criticism, appearance magazines, and the internalization of appearance ideals. *J. Adolesc. Res.* 19, 323–339. doi: 10.1177/0743558403258847

Katzmarzyk, P. T., Barreira, T. V., Broyles, S. T., Champagne, C. M., Chaput, J.-P., Fogelholm, M., et al. (2015). Physical activity, sedentary time, and obesity in an international sample of children. *Med. Sci. Sports Exerc.* 47, 2062–2069. doi: 10.1249/MSS.0000000000000649

Kendzierski, D., and DeCarlo, K. J. (1991). Physical activity enjoyment scale: two validation studies. *J. Sport Exerc. Psychol.* 13, 50–64. doi: 10.1123/jsep.13.1.50

Koulouris, J., Jeffery, Z., Best, J., O'Neill, E., and Lutteroth, C. (2021). "Me vs. super (wo) man: effects of customization and identification in a VR exergame," in *HI '20: Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (Honolulu HI: Association for Computing Machinery).

Kreuter, M. W., Farrell, D. W., Olevitch, L. R., and Brennan, L. K. (2013). *Tailoring Health Messages: Customizing Communication With Computer Technology*. New York, NY: Routledge.

Kuczmarski, R. J., Ogden, C. L., Grummer-Strawn, L. M., Flegal, K. M., Guo, S. S., Wei, R., et al. (2000). CDC growth charts: United States. *Adv. data* 314, 1–27.

Latner, J. D., Rosewall, J. K., and Simmonds, M. B. (2007). Childhood obesity stigma: association with television, videogame, and magazine exposure. *Body Image* 4, 147–155. doi: 10.1016/j.bodyim.2007.03.002

Ledoux, T., Hingle, M., and Baranowski, T. (2010). Relationship of fruit and vegetable intake with adiposity: a systematic review. *Obes. Rev.* 12, e143–e150.

Lemish, D., and Johnson, C. R. (2019). *The Landscape of Children's Television in the US & Canada*. New York, NY: The Center for Scholars and Storytellers.

Li, B. J., Lwin, M. O., and Jung, Y. (2014). Wii, myself, and size: the influence of proteus effect and stereotype threat on overweight children's exercise motivation and behavior in exergames. *Games Health Res. Dev. Clin. Appl.* 3, 40–48. doi: 10.1089/g4h.2013.0081

Li, Y., Dai, Q., Jackson, J. C., and Zhang, J. (2008). Overweight is associated with decreased cognitive functioning among school-age children and adolescents. *Obesity* 16, 1809–1815. doi: 10.1038/oby.2008.296

Lu, A. S. (2015). Narrative in exergames: thoughts on procedure, mechanism, and others. *Games Health J.* 4, 19–24. doi: 10.1089/g4h.2014.0090

Lu, A. S., Baranowski, T., Hong, S. L., Buday, R., Thompson, D., Beltran, A., et al. (2016a). The narrative impact of active video games on physical activity among children: a feasibility study. *J. Med. Internet Res.* 18:e272. doi: 10.2196/jmir.6538

Lu, A. S., Baranowski, T., Thompson, D., and Buday, R. (2012a). Story immersion of videogames for youth health promotion: a review of literature. *Games Health Res. Dev. Clin. Appl.* 1, 199–204. doi: 10.1089/g4h.2011.0012

Lu, A. S., Buday, R., Thompson, D., and Baranowski, T. (2016b). "What type of narrative do children prefer in active video games? An exploratory study of cognitive and emotional responses," in *Emotions, Technology, and Digital Games*, eds S. Tettegah and W.-H. Huang (London: Elsevier Publications).

Lu, A. S., Green, M. C., and Thompson, D. (2019). Using narrative game design to increase children's physical activity: exploratory thematic analysis. *JMIR Serious Games* 7:e16031. doi: 10.2196/16031

Lu, A. S., and Kharrazi, H. (2018). A state-of-the-art systematic content analysis of games for health. *Games Health J.* 7, 1–15. doi: 10.1089/g4h.2017.0095

Lu, A. S., Kharrazi, H., Gharghabi, F., and Thompson, D. (2013). A systematic review of health videogames on childhood obesity prevention and intervention. *Games Health J.* 2, 131–141. doi: 10.1089/g4h.2013.0025

Lu, A. S., Thompson, D., Baranowski, J., Buday, R., and Baranowski, T. (2012b). Story immersion in a health videogame for childhood obesity prevention. *Games Health Res. Dev. Clin. Appl.* 1, 37–44. doi: 10.1089/g4h.2011.0011

Lyons, E. J., Tate, D. F., Ward, D. S., Bowling, J. M., Ribisl, K. M., and Kalyararaman, S. (2011). Energy expenditure and enjoyment during video game play: differences by game type. *Med. Sci. Sports Exer.c* 43, 1987–1993. doi: 10.1249/MSS.0b013e318216ebf3

Martins, N., and Harrison, K. (2012). Racial and gender differences in the relationship between children's television use and self-esteem: a longitudinal panel study. *Commun. Res.* 39, 338–357. doi: 10.1177/0093650211401376

McMurray, R. G., Bauman, M. J., Harrell, J. S., Brown, S., and Bangdiwala, S. I. (2000). Effects of improvement in aerobic power on resting insulin and glucose concentrations in children. *Eur. J. Appl. Physiol.* 81, 132–139. doi: 10.1007/pl00013786

Mellor, D., and Moore, K. A. (2013). The use of Likert scales with children. *J. Pediatr. Psychol.* 39, 369–379. doi: 10.1093/jpepsy/jst079

Metcalf, B., Henley, W., and Wilkin, T. (2012). Effectiveness of intervention on physical activity of children: Systematic review and meta-analysis of controlled trials with objectively measured outcomes (EarlyBird 54). *BMJ* 345:e5888. doi: 10.1136/bmj.e5888

Muthén, L., and Muthén, B. (2018). *Mplus. The Comprehensive Modelling Program for Applied Researchers: User's Guide*, 7th Edn. Los Angeles, CA: Muthén & Muthén.

National Cancer Institute (2017). *Obesity and Cancer: Questions and Answers*. Bethesda, MD: National Cancer Institute.

National Center for Chronic Disease Prevention and Health Promotion (2019). *Childhood Obesity Facts*. Available online at: https://www.cdc.gov/obesity/data/childhood.html (accessed May 9, 2021).

National Physical Activity Plan (2014). *The 2014 United States Report Card on Physical Activity for Children & Youth*. Available online at: http://www.physicalactivityplan.org/reportcard/NationalReportCard_longform_final%20for%20web.pdf (accessed May 9, 2021).

Northup, T., and Liebler, C. M. (2010). The good, the bad, and the beautiful: beauty ideals on the Disney and Nickelodeon channels. *J. Child. Media* 4, 265–282. doi: 10.1080/17482798.2010.496917

Petracci, E., and Cavrini, G. (2013). The effect of weight status, lifestyle, and body image perception on health-related quality of life in children: a quantile approach. *Qual. Life Res.* 22, 2607–2615. doi: 10.1007/s11136-013-0358-0

Puder, J., and Munsch, S. (2010). Psychological correlates of childhood obesity. *Int. J. Obes.* 34, S37–S43.

Puhl, R. M., Peterson, J. L., DePierre, J. A., and Luedicke, J. (2013). Headless, hungry, and unhealthy: a video content analysis of obese persons portrayed in online news. *J. Health Commun.* 18, 686–702. doi: 10.1080/10810730.2012.743631

Reynolds, C. R., and Paget, K. D. (1983). National normative and reliability data for the revised children's manifest anxiety scale. *Sch. Psychol. Rev.* 12, 324–336. doi: 10.1080/02796015.1983.12085047

Rideout, V. (2015). *The Common Sense census: Media Use by Tweens and Teens*. San Francisco, CA: Common Sense Media Research.

Rimmon-Kenan, S. (2003). *Narrative Fiction: Contemporary Poetics*. London: Routledge.

Romero-Pérez, E. M., González-Bernal, J. J., Soto-Cámara, R., González-Santos, J., Tánori-Tapia, J. M., Rodríguez-Fernández, P., et al. (2020). Influence of a physical exercise program in the anxiety and depression in children with obesity. *Int. J. Environ. Res. Public Health* 17:4655. doi: 10.3390/ijerph17134655

Schunk, D. H., and DiBenedetto, M. K. (2020). Motivation and social cognitive theory. *Contemp. Educ. Psychol.* 60:101832. doi: 10.1016/j.cedpsych.2019.101832

Schwimmer, J. B., Burwinkle, T. M., and Varni, J. W. (2003). Health-related quality of life of severely obese children and adolescents. *JAMA* 289, 1813–1819. doi: 10.1001/jama.289.14.1813

Sousa, C. V., Fernandez, A. M., Hwang, J., and Lu, A. S. (2020). The effect of narrative on physical activity via immersion during active video game play in children: mediation analysis. *J. Med. Internet Res.* 22:e17994. doi: 10.2196/17994

Strasburger, V. C., Wilson, B. J., and Jordan, A. B. (2013). *Children, Adolescents, and the Media*. Albuquerque, NM: Sage.

Sturm, B. W. (2003). The information and reading preferences of North Carolina children. *Sch. Library Res.* 6, 1–17.

Swallen, K. C., Reither, E. N., Haas, S. A., and Meier, A. M. (2005). Overweight, obesity, and health-related quality of life among adolescents: the national longitudinal study of adolescent health. *Pediatrics* 115, 340–347. doi: 10.1542/peds.2004-0678

Thivel, D., O'Malley, G., and Aucouturier, J. (2018). "Exercise and childhood obesity," in *Pediatric Obesity*, ed. M. S. Freemark (Cham: Springer), 569–587.

Tzoutzou, M., Bathrellou, E., and Matalas, A.-L. (2020). Body weight of cartoon characters in children series is associated to food consumption, attractiveness, and physical activity engagement. *Int. J. Behav. Med.* 27, 707–716. doi: 10.1007/s12529-020-09911-7

U.S. Department of Health and Human Services (2018). *Physical Activity Guidelines for Americans*, 2nd Edn. Washington, DC.: U.S. Department of Health and Human Services.

van't Riet, J., Alblas, E., Crutzen, R., and Lu, A. S. (2016). "The effects of active videogames on BMI among young people: a meta-analysis," in *Handbook of Research on Holistic Perspectives in Gamification for Clinical Practice*, eds D. Novaák, B. Tulu, and H. Brendryen (Hershey, PA: IGI Global), 277–292. doi: 10.4018/978-1-4666-9522-1.ch013

Wang, Y., Beydoun, M. A., Min, J., Xue, H., Kaminsky, L. A., and Cheskin, L. J. (2020). Has the prevalence of overweight, obesity and central obesity levelled off in the United States? Trends, patterns, disparities, and future projections for the obesity epidemic. *Int. J. Epidemiol.* 49, 810–823. doi: 10.1093/ije/dyz273

Whitaker, R. C., Wright, J. A., Pepe, M. S., Seidel, K. D., and Dietz, W. H. (1997). Predicting obesity in young adulthood from childhood and parental obesity. *N. Engl. J. Med.* 337, 869–873. doi: 10.1056/nejm199709253371301

Williams, W. M., and Ayres, C. G. (2020). Can active video games improve physical activity in adolescents? A review of RCT. *Int. J. Environ. Res. Public Health* 17:669. doi: 10.3390/ijerph17020669

Yee, N. (2016). "The gamer motivation profile: what we learned from 250,000 gamers," in *CHI Play '16: Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play* (Austin, TX: Association of Computing Machinery), doi: 10.1145/2967934.2967937

Yee, N., and Bailenson, J. (2007). The proteus effect: the effect of transformed self-representation on behavior. *Hum. Commun. Res.* 33, 271–290. doi: 10.1111/j.1468-2958.2007.00299.x

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frontiers in Psychology

ORIGINAL RESEARCH
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Some Assembly Required: Player Mental Models of Videogame Avatars

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In playing videogames, players often create avatars as extensions of agency into those spaces, where the player-avatar relationship (PAR) both shapes gameplay and is the product of gameplay experiences. Avatars are generally understood as singular bodies; however, we argue they are functional and phenomenological assemblages—networks of social and technological components that are internalized by players as networks of knowledge about the avatar. Different PARs are based on different internalizations (i.e., mental models) for what an avatar is and why it matters. Toward illuminating nuances in PARs, we examine the content and structure of players' internalizations of avatars as evidenced by descriptions of those digital bodies. Secondary analysis of $N = 1,201$ avatar descriptions parceled them by PAR type (avatars as asocial Objects, psychologically merged extensions of Me, hybrid me/other Symbiotes, and authentically social Other). Aggregated descriptions for each PAR type were subjected to semantic network analysis to identify patterns in salient avatar components, and then qualitatively compared across the four PARs. Results indicate component clusters that are universal to PARs (demographics and body features), common to three of four PARs (time, appearance, clothing, and player agency), and idiosyncratic to specific PARs (significance, character narratives, game dynamics, liminality, and gratifications). Findings signal the importance of theoretically engaging avatars as assemblages both (a) influenced by player-avatar sociality and (b) that contribute (in part and whole) to antecedents, processes, and effects of gameplay.

Keywords: avatars, videogames, mental models, assemblage, semantic network analysis

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INTRODUCTION

In videogames, bonds between users and avatars are complex and multifaceted. Although much research has explored the psychological merging of player and avatar (i.e., identification), other evidence suggests that player-avatar relationships (PARs) span a range of sociality. This sociality is represented in four heuristic categories, in which players approach their avatars as (a) asocial "Object" orientations for challenge and competition (b) psychologically merged "Me" orientations for social play (c) hybrid "Symbiote" orientations toward identities and agency negotiations, or (d) authentically social "Other" orientations often marked by escapism (Banks, 1995). These categories are further informed by players' assessments of relational closeness with, anthropomorphic autonomy of, sense of control over, and critical concern for specific avatars (Banks and Bowman, 2016a; Banks et al., 2019).

Although this research shifts attention toward a dyadic (rather than monadic) approach to PARs (Banks, 1995), a preponderance of scholarship still characterizes avatars as monolithic entities—singular bodies with singular personas engaged in a singular manner akin to users' physical bodies (cf. Yee et al., 2008). Yet structurally and functionally, avatars are best understood as complex *assemblages* of discrete technological and anthropomorphizing components (Banks, 2018), and players' experiences of avatars may be correspondingly understood through the lens of mental models—dynamic cognitive structures representing the internalization of external phenomena (Craik, 1943). To examine the ways in which gamers variably internalize avatars, the current study examines a corpus of players' descriptions of favorite avatars to discover their form and content and to identify key similarities and differences across PAR types.

Players, Avatars, and Social Relations

The term "avatar" is appropriated from Hindu scripture (de Wildt et al., 2019). It is rooted in Sanskrit and is commonly translated to "incarnation" in English, where avatars are the representation of gods manifest on Earth for specific tasks through a variety of forms (Mukherjee, 2012). A clear example of this can be found in the *Dashavatara*, which recounts the 10 incarnations (*swaroop*) of Vishnu. As the Hindu god of preservation, Vishnu comes to Earth in various avatars, each aimed at thwarting a specific danger to humanity. For example, as the Kurma (the second incarnation), Vishnu adopted a half-tortoise, half-human avatar who balanced Mount Mandara on his shell during the "Samudra Manthan"—the churning of the oceans. As the Parashurama (sixth incarnation), Vishnu took the guise of an ax-wielding priest (Brahmin) who fought against a warrior class (Kshatriyas) misusing their power to oppress others. As the Gautam Buddha (ninth incarnation), Vishnu established a peaceful path for humanity in the foundation of Buddhism and the establishment of the Noble Eightfold Paths. In these examples, we can understand avatars as tangible embodiments of ephemeral forces that take forms commiserate with a given task.

Applied to digital worlds in videogames, avatars have been characterized as users' "casting off of the flesh" in shifting attention and intention away from physical worlds and toward digital worlds (a decarnation; Boellstorff, 2008).[1] As players' experiences in digital worlds are (to some extent) mediated by avatars, many approaches to study PARs presume that the former and the latter "psychologically merge" (Lewis et al., 2008, p. 515). Some suggest that PARs are "staggeringly simple: the player is the avatar and vice versa" (Mukherjee, 2012, para 8). This theorized merging relies, in part, on how players identify with (or as) their avatars, suggesting that when players step into their digital containers, they experience a "temporal shift in self-perception through adoption of valued properties [of another]" (Klimmt et al., 2009, p. 351). A polythetic model for player-avatar identification (Downs et al., 2019) contends that players can perceive variable levels of physical similarity, embodiment, value homophily, perspective-taking, and wishful identification with their on-screen avatar—none required but all contributing to felt identification.

However, this focus on monadic identification as the *de facto* way in which players engage their avatars does not permit for a broader consideration of the full range of possible PARs. For example, in many videogames players engage digital worlds through the diegetic lens of an established character—*another*, rather than themselves. Likewise, in digital experiences where players craft their own avatars, there is no requirement that avatars one-to-one represent players' corporeal self. Recognizing degrees of self-differentiation (rather than identification) between players and avatars permit reconsideration of how these relationships can be *authentically social*—that is, players can variably perceive avatars to be separate agents and form a social bond with them.

Bowen (1978) suggests that a key distinction between social relationships and dependent connections is that one (here, the player) must see the other (the avatar) as a distinct entity with its own subjectivity. For instance, the player creates a mage avatar: In play, the player enters a command into the system instructing the avatar to cast a spell; then, the avatar communicates back to the player that it does "not have enough mana" (see Kudenov, 2018). Here, player and avatar are exchanging information based on the native communicative abilities of each (see Banks and de Graaf, 2020). The player encodes meaning by pushing a button, the message is conveyed through the game medium, and the avatar decodes the message according to its programming; in turn, the avatar encodes a message according to its programming, the message is conveyed through the game's software to the game's supporting hardware and peripherals (i.e., computer speakers), and the player decodes it by interpreting the words. In these ways, if one rejects anthropocentric accounts of what counts as communication or meaning-making, player-avatar relations are inherently *functionally* social in that each entity is encoding and decoding messages as it engages the other. As such, variations in PARs are less about the formal dynamics of a relation and more about the extent to which the relation is *perceived* as social.

Player-Avatar Relationships

As argued here and in prior work (Banks, 1995; Banks and Bowman, 2015, 2016a,b; Banks et al., 2019), PARs can be broadly parceled as a function of sociality (from phenomenologically asocial to social) with four discrete relationship types forming along this continuum: avatar-as-Object, avatar-as-Me, avatar-as-Symbiote, and avatar-as-Other.

Avatar-as-Object

Anchored in the asocial, many players approach their on-screen with an Object orientation—seeing their avatar as a "toy," "tool," "puppet," or "object" existing merely for purposes of gameplay

[1]As noted in Bowman and Banks (2021), the terms avatar and character are often used interchangeably. That said, *avatar* refers broadly to a digital representation of the player in a gaming environment, while *characters* are a specific kind of avatar whose personality, appearance, and narrative trajectory is crafted by the game (i.e., an existing character). For this manuscript, we use *avatar* in a broad sense, except in specific instances where distinctions are important.

(Banks and Bowman, 2015). When seen as objects, avatars are engaged as mere tools with which to play the game such that players feel little emotional investment in them and experience little recognition of their legitimacy as characters (Banks and Bowman, 2016a,b). Players engaging avatars as objects are mostly focused on challenge and competition gameplay (Banks, 1995; noting these to be prominent videogame motivations, see Sherry et al., 2006; Yee, 2006), and likewise, enjoyment is mostly derived from players' abilities to succeed through their avatars (Klimmt et al., 2009; Oliver et al., 2016). Koles and Nagy (2016) found evidence that some gamers viewed their avatars as collectible objects, serving as indicators of status and personal accomplishment.

Avatar-as-Me

For some players, avatars are extensions of the players themselves—very much associated with notions of avatars as an agentic "extensions" or self "representations" of players (Banks and Bowman, 2015). Banks (2015) explained that these players tend to engage digital worlds in more or less the same ways that they engage physical worlds, as the on-screen avatar is carefully crafted to *literally* represent the player, although this representation can take several forms. With respect to sociality, these "Me" orientations cannot be construed as social relationships[2] because they largely represent a monadic or merged orientation: The player and the avatar are one and the same entity (perhaps the most literal application of the notion of an avatar)—Me orientations do not distinguish between themselves and the avatar (Ko and Park, 2020). Me orientations can be understood through various theories of the self, including social identity theory (Teng, 2017) and self-affirmation theory by Teng (2019).

Avatar-as-Symbiote

Although Object and Me orientations appear to dominate most study samples (see Bowman and Banks, 2021), some gamers have meaningful relations with avatars in a blended sense, seeing some of themselves in avatars but also seeing elements of a unique and authentic social other (Banks, 1995, 2013). These relations may be described as symbiotic—the avatar manifests an entanglement of self and other. Players who are working through interpersonal conflict—such as those questioning their gender identity, coping with disability, or working through aversive (potentially identity-threatening) experiences—are inclined to engage avatars as a sort of identity laboratories (Banks, 2013; cf. Nakamura, 1995; Turkle, 1995). Such Symbiote relations break from Me relations in that they ascribe more agency and personality to avatars as demi-persons, but still see them as anchored in the self. For example, whereas a Me-relation player might create an avatar that represents an idealized version of the self, a Symbiote-relation player would experience an avatar as a separate social entity that serves as an affective and behavioral exemplar (i.e., modeling possible selves; Markus and Nurius, 1986). Clark et al. (2018) found evidence of such hybrid identities in avatars created for exergames, in which players discussed a tension between presenting current and ideal body types (although others framed their avatar more as an Object to engaging exercise sans any further connection). In some cases, the Symbiote relationship can represent a stage of identity transference in which players begin to see themselves in their avatars or vice versa [Koles and Nagy, 2021; also suggested in Banks (2013)].

Avatar-as-Other

At the far end of the player-avatar sociality spectrum, there are gamers who label their avatar using terms (such as "partner" or "person;" Banks and Bowman, 2015) suggesting that avatars are authentic and self-differentiated social entities—not so different phenomenologically from friends. Although these relations are not limited to role players, Other orientations do tend to rely on headcanon (see McKnight, 2018)—an original narrative that aligns with the broader world narrative, situating it diegetically as having life histories, relationships, experiences, and goals. Such orientations are common in role-playing games, for example, where gamers are often tasked with helping another negotiation through a given quest or series of tribulations that are wholly contextualized within the gameworld. As these relations rely on engagement with canonical or original narratives, Other PARs are characterized by socioemotional motivations and needs (Banks, 1995) and so often engender feelings of relatedness with in-game characters (see Oliver et al., 2016). An autoethnographic account by de Wildt et al. (2019) provides several examples of the interpersonal intimacy common for players engaging their avatars as authentic social Others. Burgess and Jones (2018) found evidence of players feeling that their avatar "broke character" during gameplay—that the avatar had a distinct personality from the player, but often times were forced to act "out of character" by either the player's or the game designers' hands.

Avatars Are Assemblages in Practice and Perception

In considering how players experience these varied bonds with avatars, it is prudent to take a step back and reconsider the substance and functioning of what players are actually bonding with. We have defined an avatar as a body that extends agency and (sometimes) identity into a gamespace. Importantly, though, in the same way that human bodies are complex networks of tissues, structures, processes, and energy, so too are avatars complex assemblages of social and technological components (Steinkuehler, 2008; Giddings, 2009; Taylor, 2009; Banks, 2018). Put another way, an avatar is a coming together of elements existing in complex relations, convened by some agent (here, the player; Nail, 2017). For instance, their technological anatomy may include behavioral scripts, skill statistics, polygonal structures, and even glitches, while their anthropomorphizing (i.e., social) anatomy includes embodied features, modes of gesturing and

[2]In past work (e.g., Banks and Bowman, 2015), we have characterized the Me relation as "parasocial" in line with Lewis et al. (2008) characterization of psychologically merged relations as parasocial. However, in reflecting on some collegial critiques, we have since abandoned this notion because parasociality requires the relation to be one-way and imaginary, where we characterize PARs as functionally and actually social, where variations come not in whether or not they are dyadic but whether they are perceived as such.

movement, moral alliances, and character relationships. As these components constellate in the course of gameplay, the potential for players to connect with avatars emerges at the intersection of the parts and the whole (Banks, 2018).

Put more directly, avatars are not only operational assemblages but also *phenomenological assemblages*. That is, people experience avatars to some extent as collections of discrete elements such that players involved in different PARs may actually be having different relationships with different assemblages—and the nature of those assemblage relations may explain the gameplay motivations and gratifications known to emerge from different PARs.

Regarding technical and ludic components, evidence indicates that some players focus intensely on avatar statistics as they seek to empower an avatar (Ask, 2017) while others emphasize mechanics mastery toward achievements and the building of cultural capital through avatars (Korkeila and Hamari, 2020). Some work toward manipulating avatars to subvert normative gameplay (de Peuter, 2015) while others still exploit glitches to explore forbidden gameplaces or novel forms of play (Johnson, 2018). For anthropomorphizing social components, evidence indicates players have attachments to specific body parts like hair and feet (Banks, 2017) and may carefully attend to markers of gender-, race-, and sexuality-group identities (Martey and Consalvo, 2011). Sometimes personality and embodied components are more holistic or heuristic as when avatar characters are narratively framed as "good" or "evil" (Melenson, 2011) while others are more piecemeal as players assemble multimodal, symbolic representations of a character from tokens and visuals (Banks et al., 2018). Importantly, some technological components have patterned connections with other anthropomorphizing components, as when game functions and aesthetics influence avatar names (Hagström, 2008) or dictate that certain gameplay roles require avatars to wear certain types of clothing (e.g., healers often wear light cloth gear).

In addition to the assembled nature of avatars, it must be acknowledged that the avatar and player are, together, an assemblage (a cyborg of sorts; see Zylinska, 2002) and are situated within and across assembled spaces (i.e., the liminal gameplay environment). Because the boundaries of assemblages are often difficult to demarcate (see Latour, 2005), the bond with an avatar-as-assemblage—as it is subjectively experienced—may also incorporate components of the player and the environment, such as motivations and gratifications (e.g., Yee, 2006), gameworld and interface elements (e.g., Taylor, 2009), and gaming-culture norms and practices (e.g., Consalvo, 2007). These broad potentials for the constitution of avatars as phenomenal assemblages warrant careful inquiry into what, exactly, matters to players as the engage and understand avatars—in whole or in part—in and around games.

PARs as a Function of Mental Models

The subjective experience of avatar-assemblages is perhaps best understood through the lens of mental models (MMs). MMs are cognitive frameworks that represent a person's internalized knowledge about some external thing, consisting of knowledge "tokens" or quasi-pictorial representations; each token represents some discernible or abstract component of that thing, where the MM structure reflects one's understanding of the actual or possible structure of that thing (Johnson-Laird, 1989, 1995; see Rickheit and Sichelschmidt, 1999 for a review). The elements composing MMs are drawn from direct and indirect experiences (Seel and Strittmatter, 1989) such that MMs can be understood as a way of knowing a thing (such as an avatar) and that knowing guides how people approach new experiences (Craik, 1943) and think about possibilities (Johnson-Laird and Byrne, 2002).

If (as argued) avatars are functional and subjective assemblages and MMs are internalized knowledge structures representing a thing, then understanding player-avatar relations require attention to how players hold MMs for their avatars. By understanding how players internalize the avatar-assemblage, we may better understand how those internalizations contribute to and vary across PARs. Importantly, because MM content is causally linked to people's attitudes and intentions toward some social technologies (Banks, 2020), understanding this internalization may be key to understanding how PARs influence subjective experiences of play. Thus, we ask (RQ1) what is the content and structure of players' mental models for avatars in the four primary PARs?

MATERIALS AND METHODS

To address the posed research question, we conducted a secondary analysis of players' open-ended descriptions of their avatars from existing datasets in which participants were asked to both (a) describe their in-game avatars and (b) indicate which one of the four heuristic PAR types (Object, Me, Symbiote, and Other) best described their connection with this focal avatar. These open-ended responses were subjected to semantic network analysis to identify clusters of semantically and structurally related words as representative of assembled MM knowledge tokens.

Participants

Data were aggregated from N = 1,201 respondents from past research investigating PARs, including studies on (1) changes in character appearance (n = 482; World of Warcraft; Banks, 2017) (2) sense of place (n = 370, Fallout 76; Bowman et al., 2020) (3) memorable experiences with avatars (n = 309; various; unpublished data, see online supplements), and (4) military gamers (n = 52; various; Banks and Cole, 2016)—referred to as datasets 1–4 (DS1-4) Among these descriptions, most referred to World of Warcraft avatars (n = 591) and Fallout 76 (n = 367) as a function of DS1 and DS2's emphasis on those games as well as prevalence within the other datasets; these were followed by Guild Wars (n = 37), EVE Online (n = 20), Skyrim (n = 12), and other games (k = 96 other game titles named in n = 174 remaining player narratives; see OSF for complete list of games mentioned). Across all datasets in our secondary analysis, participants were M = 28.17 years old (SD = 8.67, range 18–74, median 26) and 73.7% male, 23.7% female, 1.2% nonbinary, and 1.4% not reporting. All data and analysis scripts for this project are shared freely *via* an Open Science Framework project folder at https://osf.io/8n9mp/.

Measures

Open-Ended Avatar Description

Because MMs are unobservable internalizations, they must be externalized—often most readily accomplished through narration (see Rickheit and Sichelschmidt, 1999). To elicit the internalization of players' avatar, the prior studies' participants were asked to describe an avatar, with slight language variations reflecting the individual studies themselves. DS1 is based on a request for participants to name a favorite avatar within the game and then to "describe that avatar." DS2 data resulted from eliciting a most-played avatar's name and then asked players to "describe [name]'s appearance." DS3 includes responses to requests to name their favorite avatar and then "offer a brief description of that avatar, in your own words." DS4 data resulted from requesting the name of a videogame that was important to the player, to then name a favorite avatar in that game, and then to "describe this avatar." As these datasets were drawn from discrete studies, the variation in language is acknowledged as a limitation of the current secondary analysis (in particular, DS2's attention to appearance over more general descriptions); however, all prompts are similar mental-model elicitations in that they work to externalize players' internalizations of their avatars.

Player-Avatar Relationship Type

All four datasets used a single categorical item to capture the heuristic PAR type for the specific, named avatar. Players indicated that "This avatar is merely an object on a screen" (Object; $n = 400$), "This avatar is me" (Me; $n = 277$), "This avatar and I are part of each other" (Symbiote; $n = 329$), or "This avatar is a separate being" (Other; $n = 195$).

Analytical Approach

In externalizing the avatar MM by responding to the elicitation, the description is engaged as a tool to infer the content of the MM. The description's words represent the content of the MM (i.e., knowledge tokens) and the structure (e.g., grammar and word co-location) represents the relations among the content elements; analyzing the semantic structure of a text allows for inferencing of the MM components that are accessible to a person as they narrate their understanding of the avatar (see Sowa, 1992). As argued by Banks (2020), examining content of MMs within and across individuals is a challenging affair because of the great variation among individual MMs—so much so that it is unlikely that there would be a "canonical form" by which cases could be compared (Woods, 1975, p. 16). This challenge is addressed by aggregating texts according to a feature of interest (here, PAR types) and constructing a semantic-network model for that corpus. In other words, we address the question of PAR-specific mental models by examining avatar descriptions aggregated by PAR-type, such that the unit of analysis is the relationship type rather than any one instance of it.

Prior to analysis (and to facilitate data sharing), elicited avatar descriptions were anonymized (replacing avatar name- and guild-mentions with NAME and GUILD) and were standardized for variations in language (e.g., MMO instead of MMORPG; see online supplements for all standardizations). Data were vetted to ensure valid descriptions of avatars versus an irrelevant response to the prompt (e.g., "I do not know") and matching of an avatar to the game (e.g., Mario does not appear in *Guitar Hero*). Data were then prepared for the semantic network analysis by removing all terminating punctuation (periods, exclamation points, and question marks) from within the response and ensuring a period at the end of the response such that the analysis software (Leximancer; Smith and Humphreys, 2006) would recognize the whole response as a single unit of analysis. Obvious misspellings were corrected to ensure they were similarly accounted for in analysis (e.g., charismatic to charismatic, mohawk to mohawk).

Avatar descriptions were parceled into four corpuses based on player's self-reported PAR type, resulting in $n = 400$ Object, $n = 277$ Me, $n = 329$ Symbiote, and $n = 195$ Other type-aligned descriptions. Each corpus was independently subjected to semantic network analysis per Leximancer's standard procedure: text processing (one sentence per block, merging word variants, and inclusion of name-like concepts), generation of concept seeds (removing words artificially injected by the prompt [e.g., "avatar"] and merging word classes [e.g., "brown" and "blue" as the object "color"]; see online supplements), generation of thesaurus, and generation of the concept map (i.e., semantic network map) based on the induced thesaurus (see OSF space for technical details of map generation; Leximancer, 2021 for analysis process details). This process resulted in four concept maps (one for each of the four PAR types) and accompanying catalog of data excerpts corresponding with each map's concept-clusters. The maps (presented in **Figures 1–4**) were interpreted with consideration for heat mapping (clusters toward the red end of the color spectrum include concepts with greater gravity in the overall aggregate model); this evaluation was synthesized with an interpretation of the ranked list of words comprising each concept and of the specific data excerpts from which the concept-clusters were derived (see online supplements for complete outputs.) This interpretive procedure resulted in the naming of concept-clusters and thick descriptions of their constituent data. Throughout, the counts provided refer to the number of "hits" (i.e., word instances) in the source data; they are offered for descriptive purposes, as indicators of relative prevalence within each PAR-specific map.

RESULTS

Aggregate Model for Avatars in Object Relations

The Object model comprised 10 clusters (**Figure 1**) interpreted as generally reflective of the following mental-model components (with cluster-comprising keywords in italics):

Centrality ($n = 203$)

The extent to which the avatar is the *main* vehicle by which they *play* the *game*, having spent the most *time* with, often

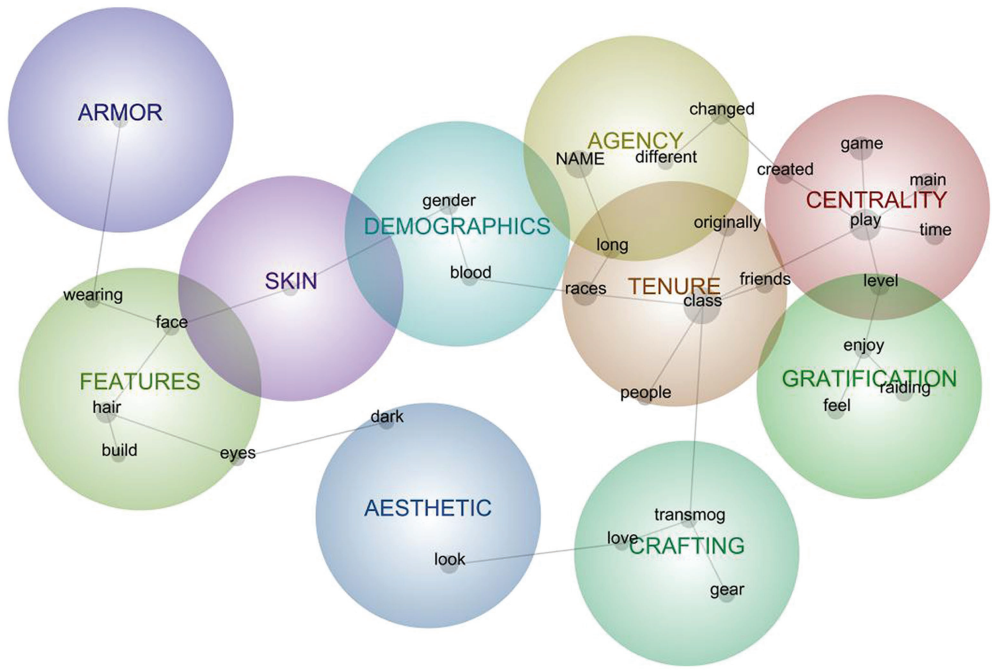

FIGURE 1 | Semantic network model for aggregated descriptions of avatars in Object relations.

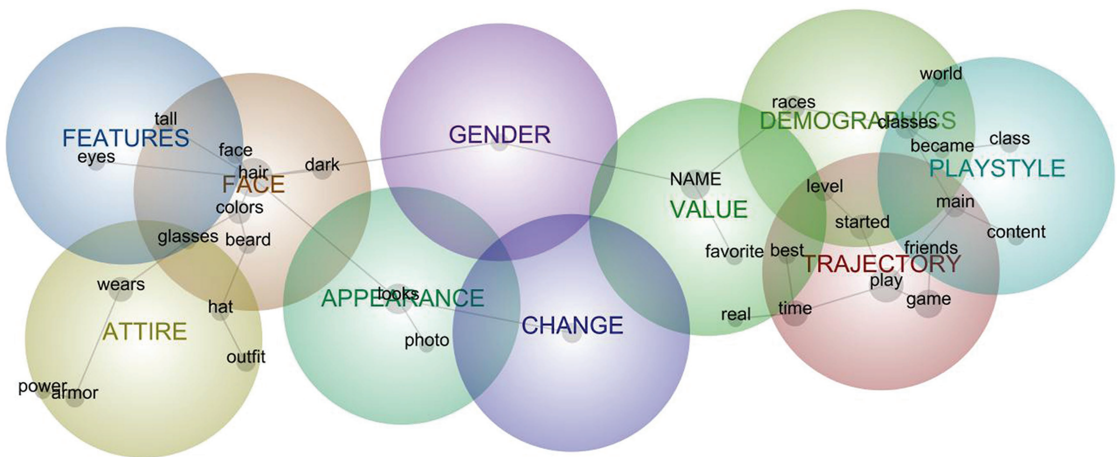

FIGURE 2 | Semantic network model for aggregated descriptions of avatars in Me relations.

created for a particular play purpose and often having the most advanced *level*. Sometimes, this centrality is a sort of specialness and sometimes, it is more utilitarian given the amount of time required to advance to higher levels: "It is the very first avatar that I have *created* and I have been *playing* him for as long as I have been *playing* [the *game*] I do not *play* any other avatars other than my *main* avatar."

Tenure (*n* = 196)

Having used the avatar for a *long* time, often as part of dedication to a *class* or alignment with a certain group of *people* (especially *friends*); often the avatar was the one *originally* created when starting to play the game (versus having been adopted later), as when "It's been my main for as *long* as I played [the game] … She is a hunter it's been my favorite *class* since then."

Agency (*n* = 130)

The history or ability to *change* the avatar (especially into a *different* expressed race, sex, clothing, or *name*) or taking up a resistance to *change* due to being well known or attached to those characteristics. Notably, descriptions suggest that despite sometimes frequent and dramatic changes that avatar is usually

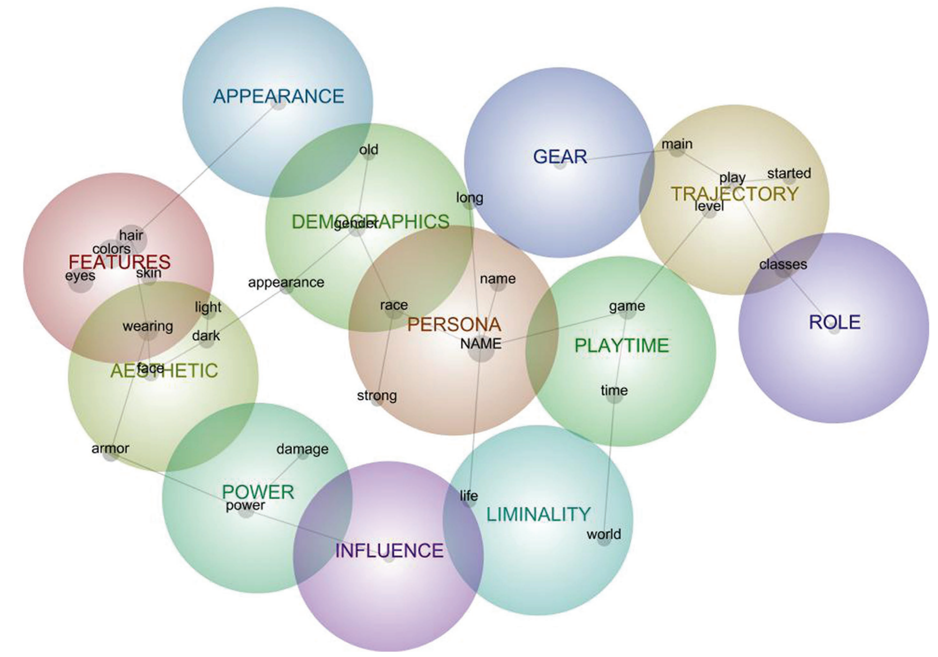

FIGURE 3 | Semantic network model for aggregated descriptions of avatars in Symbiote relations.

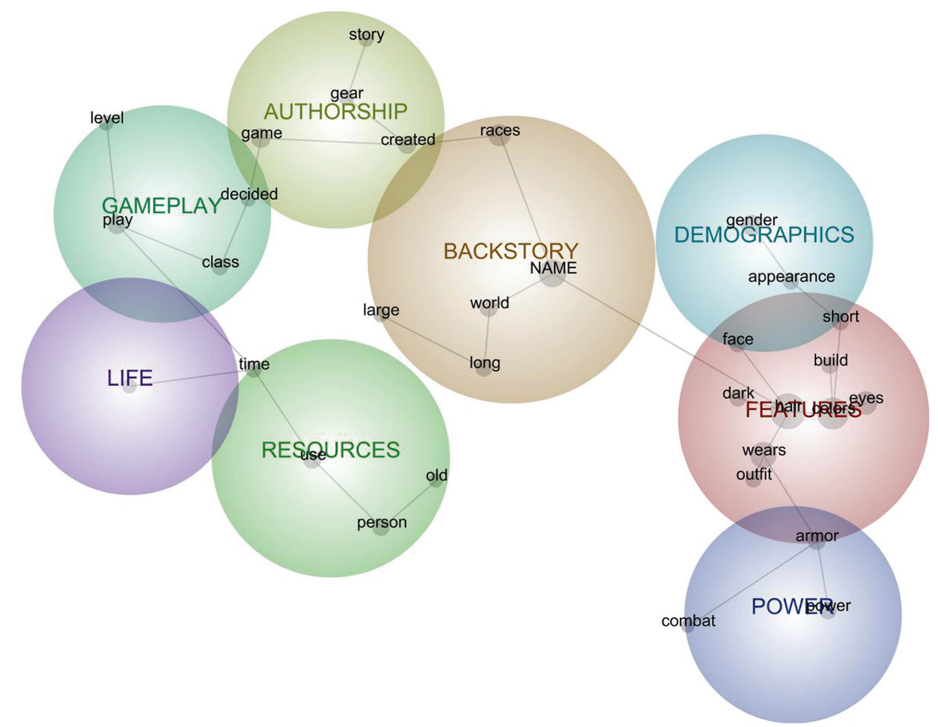

FIGURE 4 | Semantic network model for aggregated descriptions of avatars in Other relations.

still characterized as the same avatar. For instance, one player noted: "I do like to *change* her hair and face tattoo occasionally though I usually keep it black or white."

Features (n = 110)

Specific descriptions associated with hair, face, eyes, body type, or clothing, as with "Blonde *hair*, blue *eyes*, and medium *build*."

Although usually rote descriptions, they sometimes included motivations for avatars' design, such as "She is modeled after me" or combinations of descriptions with backstories, as one having "a slightly chubby *face* from a comfy few years in the vault."

Gratification (*n* = 75)

Entertainment characterized as *enjoyment* or *feelings* derived from gameplay experiences, most often connected to *raiding* experiences. Sometimes feelings were general or holistic (as in "the one I *feel* most comfortable playing" as a matter of class mechanics and experience) and sometimes more specific (e.g., "I *enjoy* the *feeling* that I am a holy warrior that protects the innocent from evil").

Crafting (*n* = 58)

The making of an avatar's appearance, through *transmogrification* (the WoW-specific practice of assigning an appearance to avatar *gear* while retaining its gameplay statistics), especially in ways that reflect aesthetics that players *love*. Although usually this crafting of gear appearance is described as a player activity ("I enjoy to find cool and unique transmog gear that makes me stand out…") it is sometimes attributed to avatars' preferences ("She likes to transmog mostly in rogue gear…").

Demographics (*n* = 57)

Membership in diegetic social groups—those that are specific to the gameworld, as with *gender* and race (specifically *blood* elf) or class specialization (i.e., WoW-common *blood*-named specs or abilities). These were most often rote descriptions of character features.

Aesthetic (*n* = 50)

Overall avatar *looks*, especially in terms of *dark* hair or *dark* aesthetics. For instance: "*Visually* my goal has been to combine the *dark* aspects of the warlock lore like spikes and chains and skulls with a more mystical look—candles, books, pointy hats, glowy runes, etc."

Armor (*n* = 38)

General references to gear, usually in its functional sense ("Dude in X-01 modified armor and legendary weapons.") but sometimes references to aesthetic sets ("In hulking classic DK armor…").

Skin (*n* = 21)

General references to an avatar's exhibited bodily color ("lavender *skin*") or tone ("with light *skin*") or attributes ("she is rotten and her *skin* is slowly decaying…").

Looking more closely at the relationships among these clusters, those most prevalent are related to tenure, centrality, agency, and gratification (i.e., together focusing on playing for long, playing well, and playing enjoyably), and they are all linked together, suggesting some degree of co-occurrence in player descriptions. The other six clusters represent less prevalent and more peripheral MM components, indicating that aesthetics or embodied features are secondary to gameplay in Object MMs. Even crafting (an otherwise creative endeavor) is linked with tenure through a connection to avatar "class" which suggested that even creative aesthetic authorship could be done in support of the diegetic combat role (see object attachments; Koles and Nagy, 2016, 2021).

Aggregate Model for Avatars in Me Relations

The Me model comprised 10 clusters (**Figure 2**) interpreted to depict the following mental-model components (with induced concept keywords in italics):

Trajectory (*n* = 114)

Narratives recounting avatars' persistence or evolution over *time*, most often conveying *play* activities (especially *starting* new ones or those having been important from the *start* of the player-avatar relation), the social importance to playing with *friends*, and the avatar's status as a *main* character for playing. In other words, this cluster represents an internalization of the avatar's origins and arc over a gameplay history—often in ways that entangled the avatar's arc with the player's arc. For instance, one player recounted that "He's been my *main* for several years … He was *starting* to do heroic but my job got crazy and I do not have the hours to put into raiding." Sometimes both avatar and player trajectories were also entangled with those of technologies, such as when, at the *time* EVE Online *started*, avatars were merely "kind of ugly" images and names, but one could more fully customize an avatar by shaping their skills.

Face (*n* = 84)

Features of the *face* and head, inclusive of *hair*, *beard, glasses*, and specific *colors* and tones thereof. Excerpts linked to this cluster were often descriptions comprising listed features, as with "well-kept *brown* hair and a respectably short *beard*" and "Asian female with *dark* skin, tattoos, *face* painted to look like a skull."

Demographics (*n* = 65)

Membership in diegetic social groups—those *race*, *class*, and *level* features that position avatars in relation to others in the game*world*. These features were often presented in list format ("Retribution paladin blood elf. High level. Fun to play.") but were sometimes also presented as situating the character in the game's narrative *world*, as with a monk who "wishes to rid the *world* of evil" or a young upper-class man "thrust into a *world* he never knew existed."

Appearance (*n* = 58)

Descriptions of the overall *look* of avatars ("tough *looking*"), similarity to self ("*looks* like me just dirtier"), or appreciation for the appearance ("*looks* awesome"). Of note, this clustering may be an artifact of the FO76 players having uploaded multiple images over time, so references to *photograph* were often suggestive of the "badge photo" were a specific kind of uploaded image.

Attire (*n* = 56)

The collection of clothing *worn* by the character, presented as the current or typical outfit and most often noting armor or hats. For instance: "Currently *wearing* the Firebreathers *outfit* with the Beer *Hat* Bottle Cap Glasses." As with the appearance cluster above, this cluster is heavily influenced by FO76 respondents in that they narrated highly customizable outfits and often juxtaposed them with more utilitarian *power armor* inherent to that game.

Value (*n* = 53)

Articulations of valuing avatars according to representative or gameplay significance, manifesting in two forms. The first is affect or attachment to the avatar or its features as a *favorite* among other possibilities, as with "one of my favorite gaming avatars I've ever inhabited it grew to embody me and my playing style." The second is *real*ness akin to legitimacy associated with *real* life ("a representation of my real life persona") or *real* value in gameplay ("this has been my only real avatar").

Playstyle (*n* = 33)

Particular affinity for, skill in, or utility of avatars' class as a matter of play style or activities. Often the playstyle relevance of the avatar was a matter of *becoming*—or becoming accustomed to or skilled in—as when an avatar was created ironically but "I grew a liking to as I got better gear and became better at the class." This cluster sometimes included references to the avatar's relevance with respect to a specific kind of *content*: solo, PvE, old, and new.

Features (*n* = 24)

Specific descriptions of avatar body characteristics, specifically constellated around eyes and height, as with "Brown hair, blue *eyes*, white, scruffy, *tall*, medium build."

Change (*n* = 19)

Extent to which the avatar has (not) changed over time. Some are artifacts of the FO76 longitudinal data collection (e.g., "Appearance has not changed."), while others are articulations that "I could not ever delete or change her" or that some characteristics are periodically changed ("long hair that changes color every few weeks").

Gender (*n* = 15)

Indication of avatar sex (usually a binary male or female) that was tied to an expression of gender identity. Generally, these are embedded in descriptions with other demographics, as with "A *female* Twi'lek" or "Depending on my mood [name] was a gender and androgynous, fully *male*, or fully *female* with a chest." Although keywords refer here to sex, keywords were embedded in more general constructions of avatar gender.

Looking more closely at the relationship among these clusters, two groupings emerge somewhat opposite each other: aesthetics and gameplay. The aesthetics grouping includes detailed and tightly networked facial features, flanked by clusters representing features, attire, gender, and appearance. The gameplay grouping is nearly mirrors that structure with a complex core cluster representing play trajectory that is flanked by playstyle and diegetic demographics. That these two groupings are linked by the value cluster suggests the avatar-as-Me's status as a favorite and its sense of realness could be core to that PAR, reflecting Me relations' tendencies to foster identification through both liking and self-reflection (Bowman et al., in press).

Aggregate Model for Avatars in Symbiote Relations

The Symbiote model comprised 12 clusters (**Figure 3**) interpreted as representing the following mental-model components (with induced concept keywords in italics):

Persona (*n* = 132)

The persona manifested by/in the avatar by design or emergence, with particular references to *names*, *race*, and the characteristic of *strength*. *Names* were drawn from famous authors, mathematical concepts, time periods, popular media characters, lore, or those used by players across games. In addition to descriptive references to *race*, avatar *race* was unpacked as a key personality feature, as when "Charr are a beast *race* in the game–militaristic as well" or how a race/class combination does not "seem particularly inclined toward shadow in the lore." *Strength* was invoked both as a descriptor for physiques ("very strong human male") as well as for player and avatar personality (the avatar *race* "most resembles how I see myself … I'm *strong*.")

Features (*n* = 121)

Specific descriptions of avatar body characteristics, specifically constellated around *hair*, *colors*, *eyes*, outfits *worn*, and *skin*. Some were straightforward ("she has shortish red *hair*, glasses, and fairly pale *skin*") while others gave commentary or background about specific features ("She exclusively wears heavy armor and weapons to emphasize her physical strength.").

Trajectory (*n* = 117)

Recounting avatars' persistence or evolution, most often conveying *play* activities—especially those that recount how the avatar or player *started*, the process of *leveling*, or how the avatar functioned as a *main*. Some stories situated the avatar within a narrative and/or franchise timeline: The avatar "was a bounty *hunter* that fought for the Rebellion in Star Wars Galaxies. I *played* Star Wars Galaxies from just after the New Game Enhancement patch August 2005 and several years afterwards." Other trajectories included how the avatar came to become the player's *main* avatar, sometimes from the outset of gameplay ("My *main* from when I *started* to today") and sometimes according to shifts in game content or social groups ("New main, rerolled holy paladin"). Avatar *level* was used as a benchmark for marking particular events, as with "eventually got to *level* 66 before switching servers."

Demographics (*n* = 79)

Membership in nondiegetic social groups—those that do not necessarily belong to the gameworld, as with *gender* and age—often reflected in the avatar's *appearance*. Specifically, avatars were often identified as *male* or *female* were described as being crafted in line with specific notions of masculinity and femininity, and often characterized as *old*—reflective of the character, player, or account age.

Time (*n* = 77)

How much *time* is spent in the *game* with the avatar, and how that *time* is spent. Generally, this included descriptions of how the avatar was engaged in gameplay ("spent most of his *time* either raiding Molten Core with groups or hitting the nascent PvP battlegrounds"), but also included indications of time as an investment ("increasing my avatar's power which would occupy all of my *time* in the *game* world"). In some cases, players referenced specific time periods ("There was a time when I would pull weekenders…") during which the avatar was specifically played.

Aesthetic (*n* = 74)

Overall avatar visual impression, especially in terms of *light* and *dark* impressions as manifested in *armor* and *face*. Armor was often describes as achieving a specific kind of style, as when a player assigned clothing such that it would "have a lot of attitude and be cool so he had a very serious but also expressive and edgy style to him." *Light*ness referred to the brightness or goodness of the aesthetic (e.g., adhering to the "dark or light side of the force"), to the depth or intensity of the aesthetic or feature ("a light scar"), or to the weight of the armor ("mostly wears light armors"). *Dark*ness generally referred to intensity, as with "*dark* red *face* tattoos" or "heavy *dark* makeup." References to face most often illustrated that part's contribution to the aesthetic, as evidence of a personality ("her *face* is scarred from battle damage and she's grubby") or aesthetic ("the left side being much *brighter* and the right side of the *face* much *darker*").

Liminality (*n* = 49)

Situatedness of avatars within/between *worlds* and as having/between *lives*. Players frequently depicted the avatar as having a particular narrative and history both within and across game and non-game *worlds* ("has family history that dates back 250 years in game *world* and about 15 years in the real *world*"), and as being in tension with their existence in the *world* of everyday *life* ("he represented a version of me that could get away with things I could not in the *real* world."). In tandem, the avatar was often positioned in relation to "real *life*." Sometimes there is a crossing of the diegetic boundary ("He exists mainly as a virtual entity but his spirit has also planted roots in real *life*") and sometimes is situated squarely within world narratives but contrasted with one's own life ("Fearless always willing to go into battles for a cause … Fighting for the top with no restrictions. The avatar that almost ruined my *life*.")

Power (*n* = 44)

References to strength and force in terms of abilities ("abilities circle around channeling her rage into a *power* that effectively lets her withstand more *damage*"), narrative framings of those abilities ("wreaks havoc with a giant mace and the *power* of the Light") specific kinds of gear ("currently in *power* armor"), and personality ("faces life with unshakable faith and an unwavering power of will").

Appearance (*n* = 40)

Descriptions of the overall *look* of avatars ("I usually transmogrify his gear so he *looks* a bit like Indiana Jones."), similarity to self ("try to make my avatar *look* somewhat like myself but within the game parameters"), or appreciation for the appearance ("it just *looks* badass").

Gear (*n* = 19)

Avatar equipment (clothing and weapons) garnered as a matter of achievement ("my only focus for 8 + months in terms of gearing and raiding") or visual appeal ("I usually transmogrify his gear so he looks a bit like Indiana Jones").

Role (*n* = 17)

Functional or social purpose within a *guild*. This role is sometimes grounded in the avatar's persona or gameplay value (going from "a lowly nameless individual to one of the biggest guild's leader") or in that of the player ("I have been my *guild's* main tank for the previous 18 months").

Influence (*n* = 11)

Impacts on *people*. *People* here most often referred to in-game characters ("a Hero of the Wasteland restoring hope and civilization to ordinary people"), but sometimes ambiguously to other players or players and characters jointly ("a beam of sunshine until it's time to shoot people then she's silent and efficient.")

The Symbiote model featured relatively low density, with its clusters rather simple in structure (most with only a few keywords) and few connections among them. This is perhaps unsurprising given the inherent flexibility and variability with Symbiote relations, where the source corpus of avatar descriptions likely included of relations with varied player/avatar entanglements. That the persona cluster was as (a) the most prevalent and (b) the most central to the model reflects Symbiote relations' tendencies to characterize avatars as simultaneously "me" but "not-me." In particular, that persona-cluster tokens were connected with liminality is particularly reflective of this PAR's characteristic engagement of avatars to solve identity challenges (Banks, 1995) at the intersection of embodied identities (clusters toward the left of the graph, inclusive of power) and agentic identities (play-descriptive clusters toward the right).

Aggregate Model for Avatars in Object Relations

The Other model comprised eight clusters (**Figure 4**) interpreted to indicate the following mental-model components (with induced concept keywords in italics):

Features (*n* = 99)

Specific descriptions of avatar body characteristics, specifically constellated around *hair*, *colors*, *eyes*, *outfits worn*, *armor*, height, *build*, *face*, and *dark*ness of these features. Descriptions of *hair* (of various *colors*, lengths, and textures) were central to this cluster, with relatively detailed descriptions often attributed to avatars' own tendencies or preferences, as when an avatar "*wears* a *dark red* leather coat with a tail that extends half way down her thighs over a thin *red* and *gray* chainmail vest."

Backstory (n = 98)

Formal role play narratives or more latent headcanon that marry descriptors (*race* and appearance) with the character's situation in the game *world*. Often beginning with "[*name*] is …," these narratives position avatars in relation to a home *world*, as having a role in or disposition toward the *world*, and as having traveled the *world* in the course of its (often *long*) life. Sometimes these were sage-like dispositions, while others were more naïve (e.g., "Her thoughts and perception of the *world* is innocent and very childlike."). Backstories often combined *racial* lore from the game universe with player-created narratives, as with an avatar canonically described as "a *human* ranger who was born in Ascalon and had to escape the City of Ascalon after the Searing" along with its emergent gameplay history, "He is accompanied by his pet … They have both traveled the *world* and saved it multiple times from Gods, evil characters, or dragons."

Resources (n = 66)

Assets engaged in gameplay activities, on two levels: Diegetic assets *used* by avatars (force, armor, weapons, magic, mounts, and knowledge)—generally or in *time*-specific events—that, in turn, manifested the avatar as a resource *used* by players (name, caricature, spec, gestures, and *persona*), especially as a vehicle for specific kinds of play. Resources as engaged by the avatar exemplify the kind of *person* the avatar is seen to be—e.g., kind, free, terrible, knowledgeable, fictional, normal, quirky, and professional.

Authorship (n = 61)

Phenomenal composition of avatars within the *game* space, as a thing *created* at the intersection of *story* and *gear*. This *creation* is situated in relation to the *game* (as players go "back into," "within," or work "outside of" the *game*) or the *game* content is a resource for *creation*. The avatar's *gear* is something "gotten," "loved," or "achieved." *Creation* work relies in part on stories that are "crafted," "invested in," "allowed," or "acquired" over time. Authorship constellates gameplay, narrative, and item creation, as when an avatar was described as "wearing a white headdress shoulder pad and cloak created from the very first polar bear she slayed in the cold lands of Winter spring the gloves are created from the Moon stags and the white wooly boots crafted with the fur from the Mammoths in Northrend."

Gameplay (n = 53)

Activities and dynamics of *play*, inclusive of avatar *class* (and associated playstyle), *level* (and activities engaged into achieve that level), and the *decisions* made by players in the course of those activities. Notably, these descriptions leaned toward characterizing *levels* less as markers of progress or achievement and more as processual or experiential phenomena as in "the *leveling* process," and *classes* less as markers of function and more in terms of enjoyment as in "I quickly fell in love with the *class* and the spec."

Demographics (n = 35)

Membership in nondiegetic social groups—those that do not necessarily belong to the gameworld, most clearly *gender* constructions—often reflected in avatar *appearance*. These markers often appeared in relation to backstories, as with "slightly older *looking man* with long gray hair a well as gray facial hair he *appears* rough hardened through years of fighting" and "much more Mercenary in *appearance* and action as opposed to the mindful shopkeep he was, though he still sets up shop on occasion."

Power (n = 23)

References to strength and force in terms of *combat* abilities or weapons ("exceptional control and utility in *combat*" or "high *powered* silenced Recon Sniper"), narrative framings of those abilities ("sweetest girl in all the land with unmatched *power* of the tides of healing"), or specific kinds of gear ("Best BBQ and *power* armor in the game.").

Life (n = 12)

Life, as ascribed to either player (usually "real *life*"), to avatars ("has taken on a *life* of her own") or referred to in general ("the purpose of *life* is to have fun").

Somewhat similar to the Symbiote model, the Other model was diffuse—interpreted as reflecting the variability that comes in describing avatars as discrete social others. Interestingly, the most complex and prevalent cluster was features from rich descriptions of avatar appearances, indicating internalization of avatars as cohesively embodied characters. However, most *central* to the model as a whole is the cluster representing avatar backstories, again (as with the Symbiote model) linking a grouping of embodied-description clusters (features, demographics, and power) with more agency-indicative clusters. Notably, this core backstory cluster was tied directly to the cluster indicating authorship, indicating that although the sociality of avatars-as-Other relies on a perception of anthropomorphic autonomy (Banks et al., 2019), the avatar is still internalized as a thing made by the player and even allowed to exist authentically in the PAR through the player's suspension of disbelief (Banks and Bowman, 2016b).

DISCUSSION

When we play videogames, we often enter a digital world through an avatar—a representation of our agency in that space, where the relationship between player and avatar is phenomenologically complex. Although much attention has been given to the psychological merging of player and avatar (in which the former comes to identify as the latter), emerging perspective has suggested that players can relate to their avatars in variably social ways. Ranging from asocial Object and merged Me to blended Symbiotes and differentiated Others, these PAR categories have been found across several studies. Less explored, however, is how players understand and internalize avatars—i.e., the subjective interpretation of exactly what they are in a relation *with*. The nature and implications of internalization can be discerned by inferring the mental models that players have for avatars within each of these relational categories. To this end, we engaged a secondary analysis of $N = 1{,}201$ avatar descriptions, discovering how players in different PAR types internalize elements of avatars. For the balance of this paper, we compare the four PAR types' inferred MM components, providing critical inferences as to how player-avatar bonds are associated with fundamentally different understandings of what avatars are and why they matter. This discussion is anchored in **Table 1**, which presents a matrix of aggregate MM clusters across the four PAR types, with semantically similar clusters presented in shared rows and distinctions between these clusters represented in cluster labeling.

Common Mental Model Clusters Across all PAR Types

Two categories of clusters emerged from avatar descriptions across all PAR types—demographics and features. Notably, although these clusters appeared universally, they did so in different permutations across the four PARs such that knowledge tokens suggest variance in how the clusters formed.

Demographics

For all PAR types, players discussed the demographic properties of their avatars. However, there was a meaningful distinction among PAR types in how these demographics were incorporated into mental models as inherent or external to the game's diegetic frame (Wolf, 1997). Demographic clusters for Object and Me relations were primarily diegetic markers, detailing the races, classes, and levels that help to organize avatars within the gameworld—all as part of more rote descriptions or suggestive of how avatars are situated in the world. Notably, Object relations emphasized avatar sex and race labels while Me relations included the more tightly clustered race, class, and level labels and an entire separate cluster devoted to gender. Thus, although both more asocial PARs relied on diegetic avatar-group markers, demographic clustering differences suggest that for Object relations these markers are more functional identifiers while for Me relations they may be more complex assemblages of (perhaps shared) social-group membership. This aligns with these PARs' gameplay activities to be mostly focused on either challenge and competition (Object players: Banks, 1995) or immersion and presence (Me players: Banks, 1995; Schuman et al., 2016). In relation to gameplay, Object-PAR demographic labels function much in the same way that one might describe the different pieces on a chessboard—gamepiece materials, such as "ivory" and "ebony," classify team membership and class labels, such as "knight" or "pawn," encapsulate function—as allusions to particular ludic roles. In turn, Me relations appear to be marked by demographics as situated in the gameworld (another keyword in that cluster) that are engaged to limit, mark, and frame avatars' capabilities and role in that world. Acknowledging Me PARs' tendencies to emphasize identification with avatars (Banks, 1995), these demographics could function as identity assemblages by which players may see themselves in that world.

For Symbiote and Other relations, discussion of demographics trended toward more nondiegetic demographics (i.e., those that may apply to players themselves) and in each case, the demographic cluster was linked to another cluster through a link between gender and appearance keywords. This suggests that, for more social PARs, demographics are important to internalizations of avatars as more socially real (i.e., not merely ludic) personas. This aligns with Symbiote and Other relations' tendencies to emphasize avatars as partly or wholly independent beings that boast rich identities (Banks, 1995).

Features

Feature clusters appeared across all PAR types. They tended to have a greater number of constitutive keywords and to be more tightly networked, compared to other clusters, containing relatively similar contents, such as clothing, face, hair, eyes, height, build, and skin. That said, the relative complexity of

TABLE 1 | Matrix of mental model clusters across PAR types.

	Object	Me	Symbiote	Other
Demographics	Demographics	Demographics/Gender	Demographics	Demographics
Features	Features/Skin	Features/Face	Features	**Features**
Time	Tenure	**Trajectory**	Trajectory/Time	
Appearance	Aesthetic	Appearance	Aesthetic/Appearance	
Clothing	Armor	Attire	Gear	
Creative Agency	Agency/Crafting	Change		Authorship/Resources
Significance	**Centrality**	Value		
Character Narrative			**Persona**	Backstory
Power			Power	Power
Game Dynamics		Playstyle		Gameplay
Liminality			Liminality/Influence/Role	Life
Gratification	Gratification			

Labels in bold are the most central (i.e., semantically well connected) concept-clusters for that PAR type.

these clusters seemed to vary as a function of PAR type, suggesting that descriptions of avatar features were somewhat scaled depending on the degree to of relational sociality.

The more social PARs (Symbiote and Other) exhibited singular feature clusters, where each was a tight-knit collection of many attributes that (as with demographics) suggest consistently rich descriptions of avatars as complex personas, inclusive of their embodied features. This is especially so for Other relations for which the features cluster as the most robust in the model. Interestingly, the more asocial PARs (Object and Me) also exhibited formal feature clusters, but they consisted of fewer attributes and the respective models also exhibited linked secondary feature clusters: a skin cluster for Object and a face cluster for Me. That skin is literally a surface-level characteristic corresponds with Object relations' tendency to focus more on gameplay and less on the avatar as a persona (reflecting the self or otherwise), while the face as a key differentiator by which people come to know oneself and differentiate among others (Ahn, 2018) reflects Me relations' marked identification with avatars. Indeed, for those relations, height and eyes are somewhat residual features not captured by other more focused clusters.

Common Mental Model Clusters Across a Majority of PAR Types

Three mental model clusters were observed in three of the four PAR types: time, appearance, and clothing were present in all but the Other model, while creative agency was present for all but the Symbiote model. Notably, that these three clusters were *not* present for Other players may be reflective of player investment—how time and energy are spent to advance avatars as collections of items that reflect preferences, tastes, and skills.

Time

Time-related concept clusters comprised indications of avatars' tenure as persistent presence in gameplay activities (especially as a project or achievement, for Object relations) or of its trajectory over the course of (often years long) gameplay careers (for Me and Other relations). Notably, the tenure and trajectory clusters for Object and Me relations, respectively, both contain *friends* tokens, indicative of known tendencies for more asocial PARs to emphasize cooperative/competitive and social play (Banks, 1995)—the former using their avatar-as-Object as a play piece to game with others, and the latter using their avatar-as-Me to socially bond with others. While Object relations' tenure cluster emphasized longstanding use of avatars, Me and Symbiote relations' clusters included references to *time* or *playtime* that is indicative of players' felt investment in avatars—so much so that for the Symbiote model it parceled out as a separate cluster. This aligns with Symbiotes' more social orientation to avatars, such that notions of time being spent together appear to be more salient overall, compared to other PARs. For all, keywords pertaining to time, play, starting, and origins indicate that avatars' trajectories are semantically entangled with players' own trajectories within the gameworld. This appears to be especially important for Me relations, as the trajectory cluster was the most robust in the model.

Appearance

Clusters conveying internalization of avatars' holistic visual impression came in two forms: aesthetic and appearance. The former represents an overall *look* that tends to be inherent to a *race* and class (e.g., a dark aesthetic or one common to female blood elves) and the latter more shorthand references to overall look or appreciation thereof (e.g., looking awesome or like oneself). Importantly, these clusters engage avatar appearance heuristically, such that even in the face of complex clusters including myriad tokens for avatar appearance, players still draw on shorthand impressions or tropes to characterize design aims or impressions. These clusters are, however, notably absent in Other relations, where the model for that PAR type instead (as discussed above) included detailed clusters for appearance. So, while most relations engage appearance somewhat heuristically, Other relations (grounded in seeing avatars as authentic social agents) emphasize internalization of appearance details and coordinated features.

Clothing

Clusters depicting clothing differed in meaningful ways across these PARs, aligning clearly with core gameplay motivations differentiating the types (Banks, 1995). Object relations focused on *armor* as primarily functional clothing that is less relevant as character or socioemotional marker and more semantically framed as items with ludic value, earned sets, or achievement markers. Said another way, the Object model exhibits that players in this PAR type leverage avatar clothing as a device for creating and controlling a competitive and purpose-built in-game presence. In Me relations, clothing was discussed more as one might discuss a coordinated outfit or ensemble—perhaps just as one would be interested in coordinated representations of oneself (e.g., Goffman, 1959). A deeper read of these narratives and core keywords suggests knowledge tokens much in line with the "proximity of clothing to self" (Sontag and Schlater, 1982)—clothing seen as a component of and external validation of one's self-concept or self-worth, as well as a symbol of one's preferences, as there were varied references to liking the outfits, outfitting habits, or aligning outfits with gameplay activities. Finally, for Symbiote relations, discussions of clothing as *gear* (common videogame language describing a variety of "equippable" items, such as clothing, weapons, or accessories) generally leaned toward either functionality or aesthetics, but sometimes engaged both qualities. Such descriptions are not dissimilar from how uniforms or other types of clothing are understood in professional settings (e.g., in a hospital setting, auxiliary workers wearing hospital-issued uniform scrubs while medical students wearing decorated white coats over brand-named clothing), in which clothing can manifest as a normative symbol of professional and sociocultural stratification and distinction (Jenkins, 2014).

Creative Agency

The creative clusters for Object and Me players emphasize crafting and personal agency in enacting progress and change in avatars, while Other relations instead focus on drawing from relevant diegetic resources in the *authoring* of avatars. This Other-PAR authoring emphasizes original creation at the intersection of gear, game, and story such that those players' investments are less about time and activity and more about a commitment to crafting a cohesive persona that exists separately from the player.

Distinctive Mental Model Clusters Between PAR Types

To this point, we have discussed the resonance of clusters across PARs, with special attention to variance in the constituency of those shared clusters even when the clusters themselves persist across PAR types. However, for the remaining seven of our 12 categories (**Table 1**), PAR types generated more distinction that they did cohesion. On the surface, such distinction is further evidence that the heuristic PAR types represent qualitatively different approaches to avatars' role in gameplay—either as a ludic-functional body or the legitimate form of a social other. This distinction is discussed below, along with remarks on clusters that were idiosyncratic to some PAR types.

Object and Me MMs (i.e., those for the more asocial PARs) included clusters emphasizing the significance of avatars in gameplay, where Object relations focused on the functional significance (i.e., the centrality to play, usually as a "main" avatar) and Me relations focused on personal value (as a "favorite") or legitimacy. Importantly, the concept cluster representing centrality to gameplay was the most robust cluster for the Object model, signaling the importance of having a focal avatar-as-gamepiece to focus on for gameplay (Banks and Bowman, 2015). In contrast, Symbiote and Other models (i.e., those for more social PARs) included clusters emphasizing avatars' status as characters (personas grounded in backstories, versus gamepieces) and notions of power—both as a personality trait and as a ludic force. Indeed, the persona cluster was the most robust of all clusters in the Symbiote model, signaling the importance of a cohesive character as a bridge as the relation is characterized as being "part of each other." This stark parceling of clusters reflects the fundamental underpinnings of the PAR framework (Banks, 1995): Asocial relations emphasize the ego as it engages in ludic activities while social relations reflect deeper engagement of the avatar-as-character in narrative activities. Importantly, the game and gameplay are accounted for across the spectrum (as "game" concepts are embedded in other clusters). However, Me and Other models, respectively, illustrate a parceling out of playstyle (affinity and skill in the method of playing) and gameplay (the activities and processes inherent to playing). This supports the PAR-framework assertion that asocial PARs are associated with more egoistic and goal-oriented play and social PARs more with processual and affect-oriented play.

Finally, some clusters were idiosyncratic to PAR types. The Object model was the only to include a cluster clearly depicting gratifications, where the emphasis on enjoyment highlights the hedonic nature of those players' gaming activities. In contrast, Symbiote and Other models featured clusters representative of avatars' liminality—their situatedness between the "real" and unreal, having a kind of aliveness, and functioning as a mediator in relations with both game characters and other players.

Limitations and Future Research

Our findings above should be interpreted with proper consideration of the current work's limitations. There are, of course, the standard limitations of the method—survey-elicited data are subject to risks around reliability of self-reports and the broad elicitations could have garnered different interpretations of what it means for one to "describe" an avatar. Perhaps, the most pressing limitation is that as a secondary data analysis, we were unable to further probe participants to better understanding their unique gaming experiences. For example, at a descriptive level, we do not have data on participants prior gaming history (either with a focal avatar or with gaming broadly). Likewise, we did not sample purposefully from different videogame genres or videogame properties and thus, we could not control the homogeneity or heterogeneity of gaming experiences (for example, focusing on unique attributes of a given videogame that might influence how players take up and relate to an avatar). With respect to variance in PAR types between videogames, prior research has not found that their frequency varies significantly as a function of game genre (comparing MMORPGs to first-person shooters and other types of role-playing games; Bowman et al., 2016), although this early research did not focus on specific games. Importantly, because we engage data here according to aggregate semantic-network models such that the unit of analysis is the categorical PAR type, we cannot make claims about specific player-avatar relations or other variations within PAR types.

With these limitations in mind, the present findings provide a conceptual and empirical ground for more complex approaches to understanding PARs. Across PAR types, it is broadly clear that what constitutes an avatar is fundamentally different—the avatar-assemblage is internalized differently as a function of player-avatar sociality. Extant literature is rich with discussions of creation and customization as key to avatar engagement, but even those notions differ among PAR types (e.g., creation as crafting vs. authorship, detailed versus heuristic references to appearance). In some cases, notable clusters were either present or absent in PAR-aligned ways—those in Object relations internalized avatar-specific gratifications and Symbiote and Other relations held salient the relative positionality of avatars within narrative worlds. Perhaps even more revealing (and potentially more complicating) are those scenarios in which clusters appeared across all PAR types but reflected differently internalized assemblages. Both demographics and features were broadly relevant across the sample, but for very different reasons: At lower levels of sociality, these clusters indicate mostly descriptive internalizations (for quickly identifying one's Object or finding oneself among crowds of avatars); at higher levels of sociality, those clusters represent more detailed and specific mental models critical to how players see the avatar as a complex persona. In short, these patterns indicate there is not a consistently monolithic body with which players are connection, but a cadre of diverse avatar-assemblages varying in likely meaningful ways. Future work should explore how the content and structure of these sociotechnical assemblages—in part as well as whole—may reflect antecedents, processes, and effects of gameplay at the individual player level. Regarding players' abilities to engage in assembly, we could investigate the extent to which avatar customization and creation systems present options that enhance (or perhaps, even hinder) enjoyment and appreciation by making PAR-relevant features more or less available and manipulable.

CONCLUSION

From similarities in considering demographics to differences in how armor is discussed, the present data support the four-category typology of player-avatar relations along a continuum of self-differentiated sociality—the similarities and differences in aggregate models for those PARs vary in ways that align with that model. Most importantly, data illustrate that player-avatar relations are grounded in fundamentally different internalizations of what avatars are and why they matter, as varied assemblages of social/technical, material/semiotic, ludic/narrative, and digital/physical components. Because avatars are internalized by players as meaningfully different assemblages, it is critical that they be examined as such. That is, understanding relations with avatar-assemblages requires some bit of scholarly assembly itself, toward understanding the discrete and aggregated contributes of avatar components to play experiences.

DATA AVAILABILITY STATEMENT

The original contributions presented in this study are included in an online data repository: https://osf.io/8n9mp/. Further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

JB conducted the Leximancer analyses. JB and NB contributed equally to all other aspects of this manuscript and approved the submitted version.

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REFERENCES

Ahn, S. J. (2018). "Face & hair: looks that change behaviors," in *Avatar, Assembled: The Social and Technical Anatomy of Digital Bodies*. ed. J. Banks (New York, NY: Peter Lang), 53–60.

Ask, K. (2017). The value of calculations: the coproduction of theorycraft and player practices. *Bull. Sci. Technol. Soc.* 36, 190–200. doi: 10.1177/0270467617690058

Banks, J. (1995). Object, Me, Symbiote, Other: a social typology of player-avatar relationships. *First Monday.* 20. doi: 10.5210/fm.v20i2.5433

Banks, J. (2013). Human-technology relationality and self-network organization: players and avatars in world of warcraft. PhD Thesis. Ft. Collins, CO: Colorado State University.

Banks, J. (2017). Of beard physics and worldness: the (non-)effect of enhanced anthropomorphism on player-avatar relations. *Psychol. Pop. Media Cult.* 6, 381–393. doi: 10.1037/ppm0000104

Banks, J. (ed.) (2018). "Introduction: (dis)assembling the avatar," in *Avatar, Assembled: The Sociotechnical Anatomy of Digital Bodies* (New York, NY: Peter Lang), 1–10.

Banks, J. (2020). Optimus primed: media cultivation of robot mental models and social judgments. *Front. Robot. AI* 7:62. doi: 10.3389/frobt.2020.00062

Banks, J., and Bowman, N. D. (2015). From toy and tool to partner and person: phenomenal convergence/divergence among game avatar metaphors. *Selec. Paper. Int. Res.* 5.

Banks, J., and Bowman, N. D. (2016a). Avatars are (sometimes) people too: linguistic indicators of parasocial and social ties in player-avatar relationships. *New Media Soc.* 18, 1257–1276. doi: 10.1177/1461444814554898

Banks, J., and Bowman, N. D. (2016b). Emotion, anthropomorphism, realism, control: validation of a merged metric for player-avatar interaction (PAX). *Comput. Hum. Behav.* 54, 215–223. doi: 10.1016/j.chb.2015.07.030

Banks, J., Bowman, N. D., Lin, J.-H., Pietschmann, D., and Wasserman, J. (2019). The common player-avatar interaction scale (cPAX): expansion and cross-language validation. *Int. J. Hum. Comput. Stud.* 129, 64–73. doi: 10.1016/j.ijhcs.2019.03.003

Banks, J., Bowman, N. D., and Wasserman, J. A. (2018). A bard in the hand: the role of materiality in player–character relationships. *Imagin. Cogn. Pers.* 38, 61–81. doi: 10.1177/0276236617748130

Banks, J., and Cole, J. G. (2016). Diversion drives and superlative soldiers: game-based coping practices among military personnel and veterans. *Game Stud.* 16.

Banks, J., and de Graaf, M. M. A. (2020). Toward an agent-agnostic transmission model: integrating anthropocentric and technocentric paradigms in communication. *Hum. Mach. Commun.* 1, 19–36. doi: 10.30658/hmc.1.2

Boellstorff, T. (2008). *Coming of Age in Second Life: An Anthropologist Explores the Virtually Human*. Princeton, NJ: Princeton University Press.

Bowen, M. (1978). *Family Therapy in Clinical Practice*. Lanham, USA: Jason Aronson.

Bowman, N. D., and Banks, J. (2021). "Player-avatar identification, relationships, and interaction: entertainment through asocial, parasocial, and fully social processes," in *Oxford Handbook of Media Entertainment*. eds. C. Klimmt and P. Vorderer (Oxford, UK: Oxford University Press).

Bowman, N. D., Banks, J., and Downs, E. P. (2016). The duo is in the details: game genre differences in player-avatar relationships. *Selec. Paper. Int. Res.* 6 (in press).

Bowman, N. D., Banks, J., and Downs, E. P. (in press). Mechanisms of identification and social differentiation in player-avatar relations. *J. Gaming Virtual World.*

Bowman, N. D., Banks, J., and Rittenour, C. (2020). Country roads through 1s and 0s: sense of place for and recognition of West Virginia following long-term engagement with fallout 76. *Technol. Mind Behav.* 1. doi: 10.1037/tmb0000001

Burgess, J., and Jones, C. M. (2018). "Is it too much to ask that we're allowed to win the game?": character attachment and agency in the mass effect 3 ending controversy. *Bull. Sci. Technol. Soc.* 37, 146–158. doi: 10.1177/0270467618819685

Clark, O. J., Grogan, S., and Cole, J. (2018). "A sort of half-way house, a hero version of me": men and women's accounts of creating their ideal-self avatar and being portrayed as normative ideal in an exercise videogame [Preprint]. doi:10.31234/osf.io/6ensp

Consalvo, M. (2007). *Cheating: Gaining Advantage in Video Games*. Cambridge, MA: The MIT Press.

Craik, K. (1943). *The Nature of Exploration*. Cambridge, UK: Cambridge University Press.

de Peuter, G. (2015). "Online games and counterplay," in *The International Encyclopedia of Digital Communication and Society*. eds. R. Mansell and P. H. Ang (Hoboken, NJ: Wiley Blackwell), 1–7.

de Wildt, L., Apperley, T. H., Clemens, J., Fordyce, R., and Mukherjee, S. (2019). (re-)orienting the video game avatar. *Games Culture* 15, 962–981. doi: 10.1177/1555412019858890

Downs, E., Bowman, N. D., and Banks, J. (2019). A polythetic model of player-avatar identification: synthesizing multiple mechanisms. *Psychol. Pop. Media Cult.* 8, 269–279. doi: 10.1037/ppm0000170

Giddings, S. (2009). Events and collusions: a glossary for the microethnography of video game play. *Games Culture* 4, 144–157. doi: 10.1177/1555412008325485

Goffman, E. (1959). *The Presentation of Self in Everyday Life*. London: Penguin.

Hagström, C. (2008). "Playing with names: gaming and naming in *world of Warcraft*," in *Digital Culture, Play, and Identity: A World of Warcraft Reader*. eds. H. G. Corneliussen and J. W. Rettberg (Cambridge, MA: MIT Press), 265–286.

Jenkins, T. M. (2014). Clothing norms as markers of status in a hospital setting: a bourdieusian analysis. *Health* 18, 526–541. doi: 10.1177/1363459314524800

Johnson, M. R. (2018). "Glitches & lag: unanticipated variables," in *Avatar, Assembled: The Social and Technical Anatomy of Digital Bodies*. ed. J. Banks (New York, NY: Peter Lang), 217–224.

Johnson-Laird, P. N. (1989). "Mental models," in *Foundations of Cognitive Science*. ed. M. I. Posner (MIT Press), 469–499.

Johnson-Laird, P. N. (1995). "Inference and mental models," in *Perspectives on Thinking and Reasoning: Essays in Honour of Peter Wason*. eds. S. E. Newstead and J. S. B. T. Evans (Lawrence Erlbaum Associates), 115–146.

Johnson-Laird, P. N., and Byrne, R. (2002). Conditionals: a theory of meaning, inference, and pragmatics. *Psychol. Rev.* 109, 646–678. doi: 10.1037/0033-295X.109.4.646

Klimmt, C., Hefner, D., and Vorderer, P. (2009). The videogame experience as "true" identification: a theory of enjoyable alterations of players' self-perception. *Commun. Theor.* 19, 351–373. doi: 10.1111/j.1468-2885.2009.01347

Ko, D. W., and Park, J. (2020). I am you, you are me: game character congruence with the ideal self. *Internet Res.* 31, 613–634. doi: 10.1108/INTR-05-2020-0294

Koles, B., and Nagy, P. (2016). Avatars as transitional objects: the impact of avatars and digital objects on adolescent gamers. *J. Gaming Virtual World.* 8, 279–296. doi: 10.1386/jgvw.8.3.279_1

Koles, B., and Nagy, P. (2021). Digital object attachment. *Curr. Opin. Psychol.* 39, 60–65. doi: 10.1016/j.copsyc.2020.07.017

Korkeila, H., and Hamari, J. (2020). Avatar capital: the relationships between player orientation and their avatar's social, symbolic, economic and cultural capital. *Comput. Hum. Behav.* 102, 14–21. doi: 10.1016/j.chb.2019.07.036

Kudenov, P. (2018). "Code and logic: procedural desire," in *Avatar, Assembled: The Social and Technical Anatomy of Digital Bodies*. ed. J. Banks (New York, NY: Peter Lang), 207–216.

Latour, B. (2005). *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford, UK: Oxford University Press.

Lewis, M. L., Weber, R., and Bowman, N. D. (2008). "They may be pixels, but they're MY pixels:" developing a metric of character attachment in role-playing videogames. *Cyberpsychol. Behav.* 11, 515–518. doi: 10.1089/cpb.2007.0137

Leximancer (2021). Leximancer user guide. Available at: https://doc.leximancer.com/doc/LeximancerManual.pdf (Accessed April 28, 2021).

Markus, H., and Nurius, P. (1986). Possible selves. *Am. Psychol.* 41, 954–969. doi: 10.1037/0003-066X.41.9.954

Martey, R. M., and Consalvo, M. (2011). Performing the looking-glass self: avatar appearance and group identity in second life. *Pop. Commun.* 9, 165–180. doi: 10.1080/15405702.2011.583830

McKnight, J. (2018). "Headcanon & lore: owning the narrative," in *Avatar, Assembled: The Social and Technical Anatomy of Digital Bodies*. ed. J. Banks (Peter Lang), 137–146.

Melenson, J. (2011). "The axis of good and evil," in *Designing Games for Ethics: Models, Techniques and Frameworks*. eds. K. Schrier and D. Gibson (PA: IGI Global), 57–71.

Mukherjee, S. (2012). Vishnu and the videogame: the videogame avatar and hindu philosophy. *Game Philosophy Network*. Available at: https://www.scribd.com/document/86566895/Vishnu-and-the-Videogame-The-Videogame-Avatar-and-Hindu-Philosophy (Accessed April 28, 2021).

Nail, T. (2017). What is an assemblage? *SubStance* 46, 21–37. doi: 10.3368/ss.46.1.21

Nakamura, L. (1995). Race in/for cyberspace: identity tourism and racial passing on the internet. *Works Days* 13, 181–193.

Oliver, M. B., Bowman, N. D., Woolley, J. K., Rogers, R., Sherrick, B., and Chung, M.-Y. (2016). Videogames as meaningful entertainment experiences. *Psychol. Pop. Media Cult.* 5, 390–405. doi: 10.1037/ppm0000066

Rickheit, G., and Sichelschmidt, L. (1999). "Mental models: some answers, some questions, some suggestions," in *Mental Models in Discourse Processing and Reasoning*. eds. G. Rickheit and C. Habel (Amsterdam: Elsevier), 9–40.

Schuman, C., Bowman, N. D., and Schultheiss, D. (2016). The quality of video games: subjective quality assessments as predictors of self-reported presence in first-person shooter and role-playing games. *J. Broadcast. Electron. Media* 60, 547–566. doi: 10.1080/08838151.2016.1234473

Seel, N. M., and Strittmatter, P. (1989). Presentation of information by media and its effect on mental models. *Adv. Psychol.* 58, 37–57. doi: 10.1016/S0166-4115(08)62146-9

Sherry, J. L., Lucas, K., Greenberg, B., and Lachlan, K. (2006). "Videogame uses and gratifications as predicators of use and game preference," in *Playing Videogames: Motives, Responses, and Consequences*. eds. J. Bryant and P. Vorderer (Mahwah, NJ: LEA), 213–224.

Smith, A. E., and Humphreys, M. S. (2006). Evaluation of unsupervised semantic mapping of natural language with leximancer concept mapping. *Behav. Res. Methods* 38, 262–279. doi: 10.3758/BF03192778

Sontag, M. S., and Schlater, J. D. (1982). Proximity of clothing to self: evolution of a concept. *Cloth. Text. Res. J.* 1, 1–8. doi: 10.1177/0887302X8200100101

Sowa, J. F. (1992). Semantic networks. Available at: http://www.jfsowa.com/pubs/semnet.htm (Accessed April 28, 2021).

Steinkuehler, C. A. (2008). "Cognition and literacy in massively multiplayer online games," in *Handbook of Research on New Literacies*. eds. C. Lankshear, D. J. Leu, J. Coiro and M. Knobel (Oxfordshire: Taylor & Francis), 611–634.

Taylor, T. L. (2009). The assemblage of play. *Games Culture* 4, 331–339. doi: 10.1177/1555412009343576

Teng, C. I. (2017). Impact of avatar identification on online gamer loyalty: perspectives of social identity and social capital theories. *Int. J. Inf. Manag.* 37, 601–610. doi: 10.1016/j.ijinfomgt.2017.06.006

Teng, C. I. (2019). How avatars create identification and loyalty among online gamers: contextualization of self-affirmation theory. *Internet Res.* 29, 1443–1468. doi: 10.1108/INTR-05-2018-0222

Turkle, S. (1995). *Life on the Screen: Identity in the Age of the Internet*. New York, NY: Simon & Schuster.

Wolf, M. J. P. (1997). Inventing space: toward a taxonomy of on- and off-screen space in video games. *Film Q.* 51, 11–23. doi: 10.2307/1213527

Woods, W. A. (1975). What's in a link: foundations for semantic networks. *Advananced Research Projects Agency*. Available at: https://apps.dtic.mil/dtic/tr/fulltext/u2/a022584.pdf (Accessed April 28, 2021).

Yee, N. (2006). Motivations for play in online games. *Cyberpsychol. Behav.* 9, 772–775. doi: 10.1089/cpb.2006.9.772

Yee, N., Ellis, J., and Ducheneaut, N. (2008). The tyranny of embodiment. *Artifact* 2, 88–93. doi: 10.1080/17493460903020398

Zylinska, J. (2002). *The Cyborg Experiments: The Extensions of the Body in the Media Age*. London: Continuum.

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Testing Moral Disengagement and Proteus Effect Predictions on Feelings of Guilt and Self-Empowerment Attributed to Bearing Guns

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This study (179 participants, mean age 19. 98, 85% female) examined how violence justification via avatar role manipulations affected first-person shooter game players' subsequent feelings of guilt and self-empowerment attributed to bearing guns in the real-world. In support of the moral disengagement in violent video games model, an independent samples *t*-test suggested that participants assigned to play as gang members shooting at police officers felt guiltier than those assigned to play as police officers shooting at gang members. In support of Proteus effect predictions linked with self-perception and priming mechanisms, a one-way repeated measures analysis of variance suggested that self-empowerment attributed to carrying guns for both avatar roles increased from baseline to after gameplay, but avatar roles did not influence the increase. The lack of influence could be because participants did not adopt avatar behaviors with undesirable connotations. The results highlight avatar-user bonds through which the associations raised by virtual personas affected players' emotions and self-perception when engaging in simulated violence.

Keywords: moral disengagement, Proteus effect, guilt, gun perceptions, shooter video game, gang avatar, police avatar

INTRODUCTION

Gun violence is commonplace in video games. For example, three out of five best-selling games in 2019 prominently feature gun violence: *Call of Duty: Black Ops 4*, *Red Dead Redemption 2*, and *Grand Theft Auto 5* (Entertainment Software Association, 2019). Technological advancements have made first-person shooter (FPS) video games, which directly pair players with gun violence, more realistic, and immersive (Lachlan and Maloney, 2008; McGloin et al., 2015). Current research is still divided as to the consequences of video game gun violence. While some researchers contend that video game gun violence contributes to real-life violence (Anderson and Bushman, 2002; Bushman et al., 2015), others dispute this link and find weak evidence for video game violence as a risk factor to real-life violence (Ferguson and Rueda, 2010; Ferguson, 2015).

Though the focus on whether video game violence contributes to real-life violence continues (Grizzard et al., 2016; Allen and Anderson, 2021), there is also interest in how violent video games influence moral disengagement or how players may display less aversive feelings after committing violent or immoral acts in a video game (Bandura, 1999; Hartmann and Vorderer, 2010). Moral disengagement is consequential because it leads players to become desensitized to violence (Grizzard et al., 2016) and to objectify human characters (Krcmar et al., 2014; Allen and Anderson, 2021). In particular, guilt—feelings about the consequences of a negative act, such as feeling that oneself has done something wrong—is a key emotional response that may be triggered and attenuated by violent video game play (Hartmann and Vorderer, 2010; Hartmann et al., 2010; Grizzard et al., 2016; Hartmann, 2017). This study aims to examine moral disengagement by investigating how playing a violent game in morally unjustified or justified character roles influence feelings of guilt.

More specifically, this study examined how playing as a game character with or without moral justification to use violence (i.e., police officer vs. gang member) influences feelings of guilt among video game players. Police officers and gang members are archetypal heroes and villains of many forms of media, and are often portrayed as "good guys" and "bad guys" (Eden et al., 2015; Bushman, 2018). In the U.S., these archetypes originated from the Western genre, in which police officers originated from Caucasian cowboys who act as law enforcers and gang members originating from people of color (especially Native Americans) who, disparagingly, represented the uncivilized (Ames, 1992). In addition, the image of police officers somewhat overlaps with military forces. Both police officers and military forces are uniformed and bear firearms (Bushman, 2018). SWAT forces particularly blur the line between the police and the military, due to the SWAT using equipment and weapons similar to those of soldiers (Kraska, 2006). Some modern examples of police and gang representation in the media include the *Lethal Weapon* TV series, the *Grand Theft Auto* (*GTA*) game series, and the international streaming service series *Narcos* (Ames, 1992; DeVane and Squire, 2008; Egner, 2015; Miller, 2016). The development of the *GTA* series reveals an interesting self-contained and influential role of media archetypes about police officers and gang members. Although *GTA* ostensibly takes place in a fictionalized Los Angeles, California, the developers from Dundee, Scotland, were mainly inspired by earlier media portrayals, rather than real-life personal experiences or research about crime and law enforcement in L.A. (DeVane and Squire, 2008).

The present study also attempts to increase the depth of the literature on psychological avatar-user bonds by examining how playing a violent game as a gang member vs. police officer avatar may influence players' self-empowerment attributed to carrying guns or beliefs about how carrying a gun makes players feel stronger, safer, and more powerful (Shapiro et al., 1997). On this regard, the Proteus effect predicts that avatar appearance and role may then steer players' self-perception (Yee and Bailenson, 2007), exert priming effects (Peña et al., 2009), or both (Ratan et al., 2019), which increase the salience of known stereotypes and concepts. However, individuals may be less likely to assimilate to avatars with negative social connotations (McCain et al., 2018). Considering the above, this study examines the yet untested prediction that playing a violent game from the perspective of a gang member or police officer will influence players' subsequent beliefs regarding how carrying a gun makes them feel strong and powerful.

MORAL DISENGAGEMENT

In order to understand the how avatar-user bonds can influence players' feelings of guilt, we turn to moral disengagement processes associated with mediated experiences. This mechanism attempts to explain how mediated behaviors that usually would violate morality in real life may become permissible or even desirable when playing video games. Hartmann (2011, 2017) postulated that the processes are dual in nature, with an experiential (or automatic) and a rational (or reflective) component. The experiential component is faster and utilizes less cognitive energy, while the rational component is slower and expends more energy (Hartmann, 2011). Bandura (1999) explicated eight specific ways moral disengagement can occur, which later scholars summarized it as being related to reframing morally suspect actions as more positive, reducing individual responsibility over and negative consequences of the immoral actions, and reframing nature and role of the victims to make them more blameworthy (Allen and Anderson, 2021). Moral disengagement may occur when one or more of the processes above occurs (Allen and Anderson, 2021). One form of moral disengagement involving some of these processes is justification of violence, which refers to the extent to which individuals find it necessary and valid to physically harm another person (Hartmann et al., 2010). Violent virtual behavior then is not necessarily limited to "bad" game characters, even "good" game characters may behave violently (Eden et al., 2015; Hartmann, 2017). Individuals may understand violence as being justified if it is for a greater good, such as when game narratives involve saving the world or restoring justice (Hartmann et al., 2010).

Moral disengagement processes associated with mediated experiences assume that interactions with media are similar to social interactions in real life (Reeves and Nass, 1996; Hartmann, 2017). In particular, moral disengagement decreases perceived guilt, which refers to an aversive emotion stemming from violating societal or self-imposed morals (Hartmann, 2011, 2017). Guilt may result from reactions to the consequences of violating morals (e.g., causing harm; breaking norms, traditions, or laws; fear of punishment, etc., Caprara et al., 1992; Grizzard et al., 2016). Note that guilt relies on higher levels of rational or reflective involvement, because it is more intricate. Unlike basic emotions such as fear and anger, guilt relies on reflective recognition that one has transgressed a prohibition and on cognitive awareness of the consequences of the transgression (Grizzard et al., 2016).

In video games, guilt can be increased by manipulating game opponents, game avatars, avatar actions, and game environments. For example, older game visual and auditory characteristics, such as those less naturalistic classic arcade games like *Space Invaders*, may be less alike real life and utilize more player cognitive effort (Hartmann, 2011). As another example, just providing more personal background information of game opponents results in higher player guilt outcomes, likely due to players perceiving their opponents as more individualized and unique (Hartmann et al., 2010, study 2). Even game environments involving participant avatars acting violently toward non-player characters can increase guilt if the participants consider the environment more similar to real life (Weaver and Lewis, 2012). Other factors that may decrease guilt include distancing oneself from a game avatar's actions (Allen and Anderson, 2021), portraying game opponents as blameworthy (Hartmann and Vorderer, 2010), and when enemy characters are perceived as non-human (Krcmar et al., 2014).

Additionally, experimentally manipulating violence justification using game roles may affect players' feelings of guilt (Hartmann and Vorderer, 2010; Hartmann et al., 2010). In an experiment using a modified version of the FPS *Operation Flashpoint*, players randomly assigned to the role of a United Nations soldier who used violence to save innocents from torture and imprisonment reported less guilt than those assigned to a paramilitary soldier role who used violence to defend imprisonment and the torture camp (Hartmann and Vorderer, 2010). In a follow-up study, participants were randomly assigned to repeatedly play the modified *Operation Flashpoint* for 4 days after assignment in justified or unjustified violence roles (Grizzard et al., 2016). On the fifth and last day of the study, researchers assigned all participants to play as terrorists in *Call of Duty*. Participants assigned to unjustified violent roles reported increased guilt relative to their justified violence role counterparts in the first 4 days and, additionally, repeated play in an unjustified violent game role led players to feel less guilty when playing as terrorists in the new game (Grizzard et al., 2016). In addition, playing as a character that performed moral actions (i.e., helping and protecting game characters in *Fallout 3*) compared with playing as a character that committed immoral actions (i.e., hurting and killing game characters) resulted in increased feelings of guilt and shame, especially among players who were more transported by the game narrative (Mahood and Hanus, 2017). Finally, playing as a protagonist who exterminates evil creatures (i.e., poisonous, insect-like creatures in a modified version of *The Elder Scrolls V: Skyrim*) compared with a protagonist who exterminates innocents (i.e., townspeople, children, and dogs) resulted in higher feelings of guilt (Allen and Anderson, 2021).

Given this literature as background, this study contributes to the moral disengagement literature by examining how the archetypical image of gang member avatar may lead to higher perceived guilt due to lower moral disengagement relative to using police officer avatars. Specifically, the archetypal image of police officer avatars may lead to lower perceived guilt due to increased perceived justification to use violence relative to the image of gang member avatars. Specifically, players assigned to police avatars may have automatic images that their virtual violent action is justified by a greater good and that the gang members are to blame.

H1: Participants who play a violent game in the role of a gang member character will feel guiltier than those who play a violent game as a police officer.

THE PROTEUS EFFECT

The Proteus effect refers to a specific avatar-user bond in which the appearance and role of a user's digital body directly influences their cognition and behavior. It predicts that individuals may conform to the stereotypical connotations inferred from their avatar. The Proteus effect has been linked to self-perception, priming mechanism, and both. From a self-perception perspective, individuals may draw inferences about the self-based on spontaneous past behavior (Yee and Bailenson, 2007). In support of these assumptions, participants randomly assigned to operate physically attractive avatars stood closer and disclosed more information in a conversation relative to those assigned to unattractive avatars (Yee and Bailenson, 2007). From a priming perspective, avatar appearance and roles can activate known concepts and stereotypes stored in memory and as such individuals displayed stereotype-consistent thoughts and behavioral scripts (Peña et al., 2009). For instance, participants assigned to thin instead of obese avatars showed more physical activity while playing a motion-controlled tennis game (Peña et al., 2016). Relative to participants assigned to young avatar or a control group, participants who had earlier embodied older avatars took longer to walk a set distance (Reinhard et al., 2020).

Though the Proteus effect has been tested in several contexts and displays a reliable small to medium statistical effect size (Ratan et al., 2019), studies have not yet examined whether the associations raised by avatars can influence individual perceptions about guns in the real world. In particular, self-empowerment attributed to bearing guns refers to the perception that firearms strengthen armed individuals (Shapiro et al., 1997; Matson et al., 2019). Self-empowerment attributed to bearing guns may stem from the belief that firearms are useful for controlling threats (Shapiro et al., 1997; Matson et al., 2019). Of key importance to this study, media consumption can influence attitudes toward guns. For example, heavy viewership of crime television dramas was associated with the belief that carrying guns can best prepare individuals for self-defense (Dowler, 2002). Moreover, greater experience with video game gun controller use was associated with increased support for the instrumental utility of guns, though FPS playing frequency was not correlated with the greater support for guns' instrumental utility (Lapierre and Farrar, 2016). Participants who played *Time Crisis 4* with gun replica game controllers showed increased perceptions of realism, controller naturalness, immersion, and cognitive aggression compared with those who played with traditional button and joystick controllers (McGloin et al., 2015). In addition, aggressive thoughts were more accessible for participants who were exposed to photos of people shooting at other people relative to those exposed to photos of people shooting at inanimate objects and photos of people without guns (Bushman, 2018, experiment 2). Moreover, participants assigned to play with Black avatars that targeted White enemies in a third-person shooter game selected more difficult geometrical figures to a White individual in the real-world relative to participants assigned to play with Black avatars targeting Black enemies (Hawkins et al., 2021). This implies increased post-game aggressive behavior in intergroup instead of ingroup conditions. Relative to those who played as a Black avatar against Black enemies, participants who played with White avatars also showed increased motivation to harm a White partner when game enemies were Black (Hawkins et al., 2021).

Considering that mediated experiences may affect perceptions about guns, it is possible that playing a shooter game as police and gang member avatars may increase self-empowerment attributed to bearing guns relative to baseline scores. Such prediction is congruent with the self-perception mechanism in the Proteus effect (Yee and Bailenson, 2007), which anticipates that unprompted overt behavior, such as shooting guns as police officers or gang members in a game may influence individuals' attitudes. This prediction also agrees with the priming mechanism in the Proteus effect (Peña et al., 2009), which expects that the associations about gun empowerment raised in a shooter game when playing in the role of police officers or gang members may transfer to subsequent situations. Thus:

H2: Relative to baseline scores, participants will show increased self-empowerment attributed to bearing guns after playing a violent game in the role of police officers and gang members.

Though moral disengagement mechanisms have not been directly linked to the Proteus effect, there is evidence that individuals are less likely to adopt the behaviors of avatars with undesirable connotations. For example, participants did not take on the luxury purchase behaviors after embodying an avatar representing a narcissistic celebrity relative to those who embodied a generic avatar (McCain et al., 2018). This hypothesis needs to be further tested as there is conflicting evidence implying that individuals may also exhibit the behaviors of avatars with negative connotations. For instance, participants show increased violent intentions after controlling avatars in dark instead of light uniforms (Peña et al., 2009, experiment 1). In addition, participants assigned to Ku Klux Klan-like avatars generated more aggressive spontaneous stories in reaction to ambiguous drawings relative to those assigned to doctor and transparent avatars (Peña et al., 2009, experiment 2). Moreover, participants show increased aggressive behavior after playing a game using villainous instead of heroic and control avatars (Yoon and Vargas, 2014). Based on moral disengagement and Proteus effect assumptions, we predict that:

H3: Relative to baseline scores, participants assigned to play a violent video game in the role of police officers will show increased self-empowerment attributed to bearing guns relative to those assigned to play as gang members.

METHOD

Participants

One hundred and eighty-nine undergraduate students at a large U.S. West Coast university participated in the study for extra credit. The data were collected in 2019. Thus, the findings were not influenced by the 2020 movement for police restructuring and defunding. Ten participants were disqualified from the study because they showed high suspicion of the study's purpose, reported feeling unwell, or experienced technical difficulties. Out of the remaining 179 participants (gang members = 90; police officers = 89), 85% were female, their ages ranged from 18 to 54 ($M = 19.98$, $SD = 3.51$), were from all class standing levels (44% Freshmen, 21% Sophomore, 25% Junior, and 10% Senior), and liberal leaning (1 = *extremely liberal*, 7 = *extremely conservative*; median = slightly liberal). **Table 1** lists more detailed descriptive statistics and statistical comparisons of the demographic information, offering support for the study's internal consistency.

Assuming a small to medium effect size of Cohen's $d = 0.30$ on the relationship between violence justification and guilt similar to Hartmann and Vorderer (2010) and Ratan et al. (2019), we conducted a sensitivity power analysis (with $\alpha = 0.05$) on G*Power 3.1.9.4 (Faul et al., 2007). The power analysis indicated that the participant sample size was sufficient to detect the small to medium effect with 0.80 power in a t-test, as at least 75 participants were necessary per condition to detect a significant effect.

Stimulus

A video game was custom-made to test for the hypotheses above. The game was conceptualized and overseen by the authors, and it was programmed by four undergraduate students using the Unity platform and its assets. The video game featured a short cutscene with the game's story. It introduced a large luxury department store in a dangerous city, with the gang member game version presenting a story that the player was a criminal caught stealing and then fighting off armed police officers (unjustified violence). In the police officer game version, the player was on duty investigating a theft and then fighting against armed gang members (justified violence). The introductory cutscene and the game itself were identical across conditions except for the experimental manipulations. The face, body, and skin color of the game character operated by participants was not shown. **Figure 1** shows the main avatar manipulation in the cutscene. In both versions, gang member game enemies were Caucasian. This was done to avoid biases linked to an increased likelihood of shooting dark-skinned enemy characters (Correll et al., 2007). In both versions, the enemies wore black tactical clothes. In the gang member avatar condition, enemies had the word "POLICE" affixed on their clothes. Enemies did not have "POLICE" affixed to their clothes in the police member avatar condition.

The game tasked players to shoot and kill their enemies while avoiding getting shot. Players had to kill their enemies in order to collect ammunition and advance in the game. The game discouraged players to be reckless with their ammunition and health. If the players' health deteriorated, the screen showed larger blood spots that impeded vision and the game played faster heartbeat sounds. In order to increase tension, onscreen blood spots made it more difficult for players to see and aim. However, the game did not allow players to die, and the onscreen blood spots slowly disappeared if they avoided being hit by enemy fire. This allowed participants to experience high-paced action and a degree of risk when playing the game, while also allowing for participants with less shooter game experience—who often partake in lab studies (Hartmann and Vorderer, 2010; Krcmar et al., 2014)—to participate in the study with less frustration. The game ended when the player killed all of the enemies and passed through the department store exit. **Figure 2** shows the two versions of the game environment. Both versions of the game are

TABLE 1 | Descriptive statistics and statistical comparisons of the avatar groups.

	Both avatars (n = 179)	Gang member avatar (n = 90)	Police officer avatar (n = 89)	Comparisons of the gang members vs. police officers
Gender	Males = 26 Females = 152 Non-binary = 1	Males = 13 Females = 77 Non-binary = 0	Males = 13 Females = 75 Non-binary = 1	$\chi^2_{(2)} = 1.02, p = 0.600$
Age	M = 19.98, SD = 3.51	M = 19.63, SD = 1.45	M = 20.24, SD = 4.74	$t_{(104.13)} = -1.34, p = 0.183$
Class standing	Freshmen = 78 Sophomore = 38 Junior = 45 Senior = 18	Freshmen = 39 Sophomore = 21 Junior = 24 Senior = 6	Freshmen = 39 Sophomore = 17 Junior = 21 Senior = 12	$\chi^2_{(3)} = 2.62, p = 0.455$
Political ideology	M = 2.93, SD = 1.26	M = 2.94, SD = 1.35	M = 2.92, SD = 1.17	$t_{(173.94)} = 0.12, p = 0.903$

Political ideology (1 = extremely liberal, 7 = extremely conservative). M, mean; SD, standard deviation; n, sample size. Statistical comparisons in independent samples t-tests for continuous variables and chi-square tests for categorical variables.

FIGURE 1 | A comparison of a zoomed-in cutscene screenshot showing what participants saw of themselves, that is, assigned gang members and their equipment (**Top** image) and assigned police officers and their equipment (**Bottom** image).

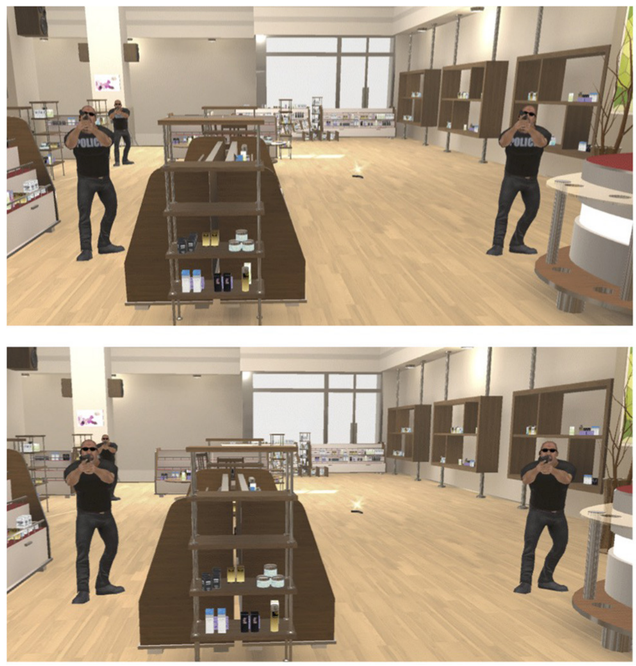

FIGURE 2 | A comparison of a zoomed-in game screenshot showing what participants saw of their enemies, that is, assigned gang members (whose enemies are police officers, **Top** image) and assigned police officers (whose enemies are gang members, **Bottom** image).

available at https://osf.io/p8cnq/?view_only=246dc4e4fa5848e1acfefef12292593a.

Procedure

Ethical approval was granted by the Institutional Review Board Administration office of the participants' university. The participants were recruited through the university's online social science research administration system. Participants consented to partaking in this study and then completed an online questionnaire with demographics measures and a self-empowerment attributed to bearing guns baseline items. The questionnaire also contained gun policy and demographic measures that were reported in a separate study (Huang-Isherwood, 2020). After the questionnaire but still in the same school term (M = 19.82 days, SD = 15.20 days), participants scheduled an in-person lab appointment. To avoid self-selection based on pre-existing video game preference, the study's online recruitment and scheduling page in the administration system did not specify the topic or procedure of the study; it only mentioned its time and location. The baseline questionnaire and the experiment took place in different days because the questionnaire contained sensitive questions about bearing guns and gun policy that may have increased participant suspicion and raised their awareness about the study's hypotheses. This procedure has been applied in other studies on sensitive topics (e.g., Bailenson et al., 2008).

At the in-person lab appointment, a lab research assistant welcomed each individual participant and, to mask the purpose of the study, the assistant told the participant that the session was to test materials for future research. Lab assistants followed a previously prepared random assignment master list spreadsheet, which included an ordered number list (1, 2, 3,… 200) and the corresponding random avatar assignment (police, gang, gang,… police). Participants were assigned to the avatar according to their order of arrival to the lab appointment. Prior to the participants' arrival, lab assistants opened the corresponding version of the game. The assistants timed participants as they played. Consistent with other studies, participants played for up to 15 min (e.g., Grizzard et al., 2016; Mahood and Hanus, 2017). If a participant finished before 15 min, assistants recorded the time and allowed participants to proceed. This was to ensure that more skilled participants were not bored or frustrated for having to replay the game. Still, participants played for almost 15 min ($M =$ 14:17 min, $SD =$ 1:44 min). After playing the game, participants answered a questionnaire with their recollection of their assigned role, feelings of guilt, again the self-empowerment attributed to bearing guns, and shooter game experience. Assistants debriefed the participants and awarded them with an extra credit. The complete study took about 90 min.

Measures

Feelings of Guilt

We employed a three-item guilt as a state measure that was used in studies examining guilty feelings after playing video games (e.g., Hartmann and Vorderer, 2010). The measure asked if the participant, while playing the game, felt "regret," "sorry about something you've done," and "like you've done something wrong" (Hartmann et al., 2010) on a 5-point Likert-type scale (1 = *Rarely or never*, 5 = *Very often*). The items were reliable (Cronbach's $\alpha = 0.92$) and hence were averaged into a single score.

Self-Empowerment Attributed to Bearing Guns

We adapted items from the attitudes toward guns and violence questionnaire (Shapiro et al., 1997) to measure participants' self-empowerment attributed to carrying guns before and after the playing the experimental game. The items measured participant's level of agreement/disagreement that "carrying a gun makes me feel strong," "bearing a firearm can increase my sense of power," "carrying a gun makes me feel safe," and "bearing a firearm can increase my sense of safety" on a 17-point Likert-type scale (1 = *Strongly disagree*, 17 = *Strongly agree*). The decision to employ a 17-point scale recognizes the need to be sensitive to the participant sample attitudes (Blanton and Jaccard, 2006). The participant sample involved students from a left-leaning West Coast university and most of the sample had anti-gun attitudes, more concretely, negative attitudes about the action of carrying/bearing guns (Miller et al., 2002). In addition, more than half of the participants self-identified as being liberal. In this context, using a 17-point bipolar rating, instead of the more common 5- or 7-point bipolar rating allowed for more variability at the ends of the scale (i.e., 1–8 range or 10–17 range). For example, Burrows and Blanton (2016) conducted three studies to examine the effect of anti-drunk driving ads embedded in a game on participants' willingness to drive under the influence (DUI) of alcohol, a socially undesirable behavior. This study employed 17-point scales to be able to capture subtle variability in DUI attitudes. Indeed, for both the baseline and the post-gameplay measurements of self-empowerment attributed to bearing guns, the averages leaned toward "disagree" end of the scale (see **Table 2**). The pre and post-scales were reliable (Cronbach's $\alpha_{\text{Time1}} = 0.90$; Cronbach's $\alpha_{\text{Time2}} = 0.93$) and were thus averaged into corresponding baseline and post-gameplay self-empowerment attributed to bearing gun scores.

Shooter Game Experience

We employed a two-item shooter game experience measure to capture the participants' background on playing such games (Matthews, 2011), due to the possible cumulative effects of repeated play of shooter games (Grizzard et al., 2016). The measure offered contemporary popular examples of shooter games (*Call of Duty*, *Battlefield*, *Halo 5: Guardians*) and asked the participant their play "frequency" and "on higher difficulty than default" (Matthews, 2011) on a 5 Likert-type scale (1 = *Never*, 5 = *Frequently*). The items were reliable (Pearson's $r = 0.75$, $p < 0.001$) and hence were averaged into a single score.

Statistical Analysis

We first planned to conduct a manipulation check by testing actual avatar role assignment with participant recollection of their assigned role. To examine H1, we planned to carry out an independent samples t-test of the participant assigned role on feelings of guilt. To examine the remaining hypotheses, we planned to carry out a one-way repeated measures analysis of variance (ANOVA) to test for the differences between the baseline and post-gameplay self-empowerment attributed to bearing guns (H2) and the interaction between increase over time and role assignment (H3). All analyses were conducted in SPSS 27.

RESULTS

Table 2 presents the descriptive statistics of the main variables of interest, specifically means and standard deviations.

To ensure that the violence justification manipulation was successful, we evaluated whether participants correctly recalled their assigned gang member or police officer avatar role. A comparison of actual role assignment against participant self-reported assignment found that most participants correctly recalled that they were assigned to play as a gang member ($n = 87$, 97%) or as a police officer ($n = 78$, 88%). A chi-square test revealed that comparing the actual avatar role assignment against recollection of the role assignment did not vary by experimental condition, $\chi^2_{(1)} = 0.21$, $p = 0.650$, thus suggesting no differences in avatar role assignment recall between the conditions. Because a small proportion of participants did not correctly recall their role assignment, the data analyses included

TABLE 2 | Descriptive statistics of the main variables of interest.

	Both avatars		Gang member		Police officer	
	M	*SD*	*M*	*SD*	*M*	*SD*
Feelings of guilt	2.26	1.19	1.90	1.07	2.51	1.22
Self-empowerment attributed to bearing guns						
Time 1	5.45	3.98	5.05	4.03	5.66	3.94
Time 2	6.79	4.43	6.16	4.43	7.43	4.35
Shooter game experience	1.65	1.04	1.65	1.02	1.66	1.06

M, mean; SD, standard deviation.

all participants who completed the study, as participants could have unconsciously perceived their avatar's role even if they did not explicitly report it (O'Keefe, 2003; Hartmann and Vorderer, 2010). Furthermore, (https://osf.io/p8cnq/?view_only=246dc4e4fa5848e1acfefef12292593a) report data on whether correct or incorrect recollection of assignment condition was a relevant covariate and found no significant differences.

To test for whether players randomly assigned to play as gang members would feel guiltier than the players assigned to play as police officers (H1), we carried out an independent samples t-test of the participant assigned condition on feelings of guilt. Indeed, participants assigned to the gang member avatar role ($M = 2.51$, $SD = 1.22$) show increased feelings of guilt relative to those assigned to the police officer version ($M = 1.90$, $SD = 1.07$), $t_{(174.46)} = 3.55$, $p < 0.001$, Cohen's $d = 0.53$. Thus, H1 was supported. Furthermore, to check if shooter game experience altered the finding, we conducted an analysis of covariance (ANCOVA) of assigned role on feelings of guilt with shooter game experience as the covariate. We found similar results with only assigned role as being statistically significant on guilt, $F_{(1,176)} = 12.73$, $p < 0.001$.

To test for baseline and post-gameplay self-empowerment attributed to bearing guns (H2) and the interaction between increase over time and avatar assignment (H3), we carried out a one-way repeated measures ANOVA. As expected, there were no statistically significant differences in baseline scores between participants assigned to gang member and police officer avatars, $t_{(173.92)} = -0.68$, $p = 0.500$. The results of the one-way repeated measures ANOVA show that self-empowerment attributed to bearing guns significantly increased from baseline scores ($M_{\text{Time1}} = 5.45$, $SD_{\text{Time1}} = 3.98$) to post-game play ($M_{\text{Time2}} = 6.79$, $SD_{\text{Time2}} = 4.43$), $F_{(1,167.06)} = 25.72$, $p < 0.001$, Cohen's $f = 0.38$. Since Mauchley's test of sphericity was violated, the Greenhouse-Geisser correction was employed. Thus, H2 was supported.

However, there was no significant interaction between time (baseline, post-gameplay) and avatar assignment, $F_{(1,13.72)} = 2.11$. This analysis also employed the Greenhouse-Geisser correction. Thus, H3 was not supported. Furthermore, to check if shooter game experience altered the findings, we conducted a repeated measures ANCOVA with the same variables as the ANOVA above and shooter game experience as a covariate. We found similar results, with only a statistically significant increase from baseline scores to post-game play, $F_{(1,63.26)} = 9.70$, $p = 0.002$, and no other factors.

DISCUSSION

This study investigated how violence justification through video game avatar manipulations influenced players' feelings of guilt and self-empowerment attributed to bearing guns. The findings from hypothesis 1 supported the predicted moral disengagement processes in video games. Perceived guilt was higher for participants randomly assigned to play a custom-made shooter game as gang members robbing a store and shooting at police officers relative to those assigned to play as police officers shooting at gang members robbing the store. By focusing on these archetypal avatar roles in this scenario, this study extended previous studies that focused on the how player's game role and actions, such as committing virtual physical harm and homicide influenced perceived guilt (Hartmann and Vorderer, 2010; Hartmann et al., 2010; Weaver and Lewis, 2012; Grizzard et al., 2016; Mahood and Hanus, 2017; Allen and Anderson, 2021), to also apply to virtual property crimes (i.e., robbing luxury goods). In particular, it extended previous studies which focused on military and combat environments with avatars more frequently being soldiers in order to examine moral disengagement (Hartmann and Vorderer, 2010; Grizzard et al., 2016; Hartmann, 2017) to more civilian contexts. This initial contribution may serve as a starting point for future studies that employ police and gang avatar roles to examine desensitization—i.e., habituation to violence through repeated exposure—and real-life violent behavior outcomes. For example, longitudinal analyses may show whether individuals display increased desensitization in earlier game stages when embodying morally justified instead of justified roles. It is also possible that, at later stages, players assigned to both morally justified and unjustified game avatars experience low guilt. Based on Grizzard et al. (2016) findings, future studies should also test whether switching after repeated play from police officer avatar roles to a morally unjustified role, such as playing as a gang member, leads to decreased guilt relative to switching from gang members to police officers.

In addition, future studies should investigate the internal mechanisms in moral disengagement processes. In this study, it is unclear whether the justification for violence occurred due to moral reframing of the avatar self or of the actions of the game opponents. This could be tested by breaking apart the two conditions of this study into four: police officers shooting at opponents who are also officers, police officers shooting at opponents who are gang members, gang members shooting at opponents who are also gang members, and gang members shooting at opponents who are police officers. Examining guilt across these four conditions would allow a deeper understanding of whether the deciding factor is the nature of the avatar self or of the opponent.

Considering that cognitive awareness of the consequences of a moral transgression is needed to experience guilt (Grizzard et al., 2016), manipulating the amount of cognitive resources available to participants may be employed to test whether lack of cognitive resources influences how game-related moral justification affects perceived guilt. Manipulating the availability of cognitive resources could be done by asking participants to remember short or long digits (Peña et al., 2018; Read et al., 2018). One possibility is that the lack of cognitive resources could make players in unjustified avatar roles to be less likely to feel guilty because they may be temporarily unable to reflect on their actions. Alternatively, moral disengagement processes can occur with little cognitive effort, thus implying that mental overload may not influence player guilt (e.g., Krcmar et al., 2014; Eden et al., 2015).

This initial contribution has practical implications for both violent and non-violent serious games. Particularly, serious games with robbery scenarios that can help law enforcement and rehabilitation officials—police officers, judges, prosecutors, prison guards, wardens, probation officers, and parole officers—take on the perspectives of criminals and perceive guilt. These effects could help these officials better understand the point of view of criminals, avoid dehumanizing them, and reintegrate them to the wider society. Moreover, the benefit of such serious games is that the scenarios would be virtual and there would not be the same degree of risk and harm involved.

In regard to hypothesis 2, the study uncovered that relative to baseline scores, self-empowerment attributed to bearing guns was increased after playing an FPS game regardless of avatar role. From a Proteus effect standpoint, this was rooted in how both avatar conditions asked participants to use guns along with how avatar appearance primed aggressive constructs stored in the memory. This finding is also congruent with the General Aggression Model (GAM), which proposes that exposure to video game violence increases the accessibility of aggression-related knowledge structures (Anderson and Bushman, 2002). According to GAM, the increased accessibility of aggressive thoughts and emotions may lead to an augmented likelihood of resorting to violence as a viable response. This finding is also congruent with the Game Transfer Phenomena (GTP), which proposes that players, with different levels of susceptibility, can unconsciously replicate their in-game virtual world experiences to the real world, particularly through altered perceptions, sensations, cognitive processes, and behaviors (Ortiz de Gortari and Griffiths, 2016; Ortiz de Gortari, 2019). Of particular interest here are cognitive distortions from in-game shooting cues and repeated shooting tasks that carry over to perceptions about guns in the real world (Ortiz de Gortari and Griffiths, 2014, 2016).

The findings from hypothesis 3 did not suggest that controlling morally unjustified or justified avatars engaged in gun violence had different effects on self-empowerment attributed to bearing guns. Future studies could test whether controlling for other archetypes, such as soldier and vigilante avatars may specifically influence self-empowerment attributed to bearing guns. In order to further explore this effect and to separate Proteus effect from GAM predictions, future studies should assign participants to either control or watching police and gang member avatars enacting gun violence. Controlling avatars may have stronger effects than simply watching (Yee and Bailenson, 2009), and thus self-empowerment attributed to bearing guns may be more strongly influenced by controlling instead of watching avatars carrying on gun violence. This could also be achieved by implementing control conditions with no visible avatars in order to detangle the effect of playing as an avatar archetype from simply playing a given shooter game.

LIMITATIONS

Despite this study's insights, there were limitations. Our sample was mostly college freshmen women, who are often not the target population of FPS games (Entertainment Software Association, 2020). Our measurement of shooter game experience further confirmed that the majority of the sample participants had little shooter gameplay experience. Additionally, our sample was mostly of students who had negative attitudes about carrying guns. Future studies could replicate this study, including samples with both anti- and pro-gun attitudes, to test whether the perceived guilt and gun empowerment findings remain the same. Future studies should also more directly address racialized violence by displaying police officer and gang member game characters as being racial majorities or minorities. In a study examining shooting decisions in a simulated environment, community members were more likely than police officers to mistakenly shoot at Black than Caucasian targets (Correll et al., 2007). In another study manipulating participants' avatar as being Caucasian or Black, relative to those with Caucasian avatars, those with Black avatars decreased their implicit bias against Black people, an effect that was maintained for at least 1 week (Banakou et al., 2016). Thus, future research could investigate whether the manipulation of enemy characters' skin color affects guilt and attitudes about gun self-empowerment.

CONCLUSION

In conclusion, the moral justification of game avatars to use violence can influence players' feelings of guilt. This indicates how avatar-user relationships reliably influence emotions that require self-reflection and evaluation. In addition, the mere act of playing a shooter game increased self-empowerment attributed to bearing guns from baseline scores. Future research is needed to establish whether controlling different avatar archetypes that use guns can affect self-empowerment attributed to bearing guns.

DATA AVAILABILITY STATEMENT

Anonymized data supporting the conclusions of this article will be made available by the corresponding author, without undue reservation. Additional analyses and the game stimulus materials are available at https://osf.io/p8cnq/?view_only=246dc4e4fa5848e1acfefef12292593a an Open Science Framework page.

ETHICS STATEMENT

The study was reviewed and approved by the UC Davis IRB Administration under IRBNet no. 1358880. The participants provided their written informed consent to participate in the study.

AUTHOR CONTRIBUTIONS

KH-I designed, collected data, analyzed data, and wrote up the study. JP advised and supported in all the aforementioned tasks. All authors contributed to the article and approved the submitted version.

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REFERENCES

Allen, J. J., and Anderson, C. A. (2021). Does avatar identification make unjustified video game violence more morally consequential? *Med. Psychol.* 24, 236–258. doi: 10.1080/15213269.2019.1683030

Ames, C. (1992). Restoring the Black man's lethal weapon: race and sexuality in contemporary cop films. *J. Popular Film Television* 20, 52–60. doi: 10.1080/01956051.1992.9944228

Anderson, C. A., and Bushman, B. J. (2002). Human aggression. *Ann. Rev. Psychol.* 53, 27–51. doi: 10.1146/annurev.psych.53.100901.135231

Bailenson, J. N., Iyengar, S., Yee, N., and Collins, N. A. (2008). Facial similarity between voters and candidates causes influence. *Public Opin. Q.* 72, 935–961. doi: 10.1093/poq/nfn064

Banakou, D., Hanumanthu, P. D., and Slater, M. (2016). Virtual embodiment of White people in a Black virtual body leads to a sustained reduction in their implicit racial bias. *Front. Hum. Neurosci.* 10:601. doi: 10.3389/fnhum.2016.00601

Bandura, A. (1999). Moral disengagement in the perpetration of inhumanities. *Pers. Soc. Psychol. Rev.* 3, 193–209. doi: 10.1207/s15327957pspr0303_3

Blanton, H., and Jaccard, J. (2006). Arbitrary metrics in psychology. *Am. Psychol.* 61, 27–41. doi: 10.1037/0003-066X.61.1.27

Burrows, C. N., and Blanton, H. (2016). Real-world persuasion from virtual-world campaigns: how transportation into virtual worlds moderates in-game influence. *Commun. Res.* 43, 542–570. doi: 10.1177/0093650215619215

Bushman, B. J. (2018). Guns automatically prime aggressive thoughts, regardless of whether a "good guy" or "bad guy" holds the gun. *Soc. Psychol. Pers. Sci.* 9, 727–733. doi: 10.1177/1948550617722202

Bushman, B. J., Gollwitzer, M., and Cruz, C. (2015). There is broad consensus: media researchers agree that violent media increase aggression in children, and pediatricians and parents concur. *Psychol. Popular Med. Cult.* 4, 200–214. doi: 10.1037/ppm0000046

Caprara, G. V., Barbaranelli, C., and Comrey, A. L. (1992). A personological approach to the study of aggression. *Pers. Individ. Diff.* 13, 77–84. doi: 10.1016/0191-8869(92)90222-B

Correll, J., Park, B., Judd, C. M., Wittenbrink, B., Sadler, M. S., and Keesee, T. (2007). Across the thin blue line: police officers and racial bias in the decision to shoot. *J. Pers. Soc. Psychol.* 92, 1006–1023. doi: 10.1037/0022-3514.92.6.1006

DeVane, B., and Squire, K. D. (2008). The meaning of race and violence in Grand Theft Auto: San Andreas. *Games Cult.* 3, 264–285. doi: 10.1177/1555412008317308

Dowler, K. (2002). Media influence on attitudes toward guns and gun control. *Am. J. Crim. Just.* 26, 235–247. doi: 10.1007/BF02887829

Eden, A., Oliver, M. B., and Tamborini, R. (2015). Perceptions of moral violations and personality traits among heroes and villains. *Mass Commun. Soc.* 18, 186–208. doi: 10.1080/15205436.2014.923462

Egner, J. (2015, August 26). Netflix looks to 'Narcos' for a new audience. *The New York Times*. Available online at: https://www.nytimes.com/2015/08/30/arts/television/netflix-looks-to-narcos-for-a-new-audience.html (accessed April 11, 2021).

Entertainment Software Association (2019). *2019 Essential Facts: About the Computer and Video Game Industry*. Retrieved from: https://www.theesa.com/wp-content/uploads/2019/05/2019-Essential-Facts-About-the-Computer-and-Video-Game-Industry.pdf (accessed June 20, 2021).

Entertainment Software Association (2020). *2020 Essential Facts: About the Video Game Industry.* Retrieved from: https://www.theesa.com/wp-content/uploads/2020/07/Final-Edited-2020-ESA_Essential_facts.pdf (accessed June 20, 2021).

Faul, F., Erdfelder, E., Lang, A.-G., and Buchner, A. (2007). G*power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav. Res. Methods* 39, 175–191. doi: 10.3758/bf03193146

Ferguson, C. J. (2015). Do angry birds make for angry children? A meta-analysis of video game influences on children's and adolescents' aggression, mental health, prosocial behavior, and academic performance. *Perspect. Psychol. Sci.* 10, 646–666. doi: 10.1177/1745691615592234

Ferguson, C. J., and Rueda, S. M. (2010). The hitman study: violent video game exposure effects on aggressive behavior, hostile feelings, and depression. *Eur. Psychol.* 15, 99–108. doi: 10.1027/1016-9040/a000010

Grizzard, M., Tamborini, R., Sherry, J. L., and Weber, R. (2016). Repeated play reduces video games' ability to elicit guilt: evidence from a longitudinal experiment. *Med. Psychol.* 20, 267–290. doi: 10.1080/15213269.2016.1142382

Hartmann, T. (2011). "Players' experiential and rational processing of virtual violence," in *Vice City Virtue: Moral Issues in Digital Game Play,* eds S. Malliet and K. Poels (Leuven: Acco), 135–150.

Hartmann, T. (2017). The "moral disengagement in violent videogames" model. *Game Stud.* 17. Available online at: http://gamestudies.org/1702/articles/hartmann (accessed April 2, 2021).

Hartmann, T., Toz, E., and Brandon, M. (2010). Just a game? Unjustified virtual violence produces guilt in empathetic players. *Med. Psychol.* 13, 339–363. doi: 10.1080/15213269.2010.524912

Hartmann, T., and Vorderer, P. (2010). It's okay to shoot a character: moral disengagement in violent video games. *J. Commun.* 60, 94–119.

Hawkins, I., Saleem, M., Gibson, B., and Bushman, B. J. (2021). Extensions of the proteus effect on intergroup aggression in the real world. *Psychol. Popular Med. Adv Online Public*. doi: 10.1037/ppm0000307. [Epub ahead of print].

Huang-Isherwood, K. M. (2020). Sociodemographic and gun possession factors contributing to gun policy attitudes among undergraduate students. *J. Am. Coll. Health*. doi: 10.1080/07448481.2020.1762607. [Epub ahead of print].

Kraska, P. (2006). "The blurring of war and law enforcement," in *Violence, Conflict, and World Order: Critical Conversations on State Sanctioned Justice,* ed G. Barak (Lanham, MD: Rowman and Littlefield), 161–188.

Krcmar, M., Hartmann, T., and Eden, A. (2014). Rational vs. intuitive processing: the impact of cognitive load on moral responses in video game play. *Paper Presented at the 100th Annual Conference of the National Communication Association* (Chicago, IL).

Lachlan, K. A., and Maloney, E. K. (2008). Game player characteristics and interactive content: exploring the role of personality and telepresence in video game violence. *Commun. Q.* 56, 284–302. doi: 10.1080/01463370802240866

Lapierre, M. A., and Farrar, K. M. (2016). Learning to love guns? Gun-based gameplay's links to game attitudes. *Psychol. Popular Med. Cult.* 7, 216–230. doi: 10.1037/ppm0000132

Mahood, C., and Hanus, M. (2017). Role-playing video games and emotion: how transportation into the narrative mediates the relationship between immoral actions and feelings of guilt. *Psychol. Popular Med. Cult.* 6, 61–73. doi: 10.1037/ppm0000084

Matson, K., Russell, T. D., and King, A. R. (2019). Gun enthusiasm, hypermasculinity, manhood honor, and lifetime aggression. *J. Aggress. Maltreat. Trauma* 28, 369–383. doi: 10.1080/10926771.2017.1420722

Matthews, N. L. (2011). *Skill gap: Quantifying violent content in video game play between variably skilled users* (Master's thesis), Indiana University. Available online at: http://bit.ly/2smC7q1 (accessed May 17, 2021).

McCain, J., Ahn, S. J. G., and Campbell, W. K. (2018). Is desirability of the trait a boundary condition of the Proteus effect? A pilot study. *Commun. Res. Rep.* 35, 445–455. doi: 10.1080/08824096.2018.1531212

McGloin, R., Farrar, K. M., and Fishlock, J. (2015). Triple whammy! Violent games and violent controllers: investigating the use of realistic gun controllers on perceptions of realism, immersion, and outcome aggression. *J. Commun.* 65, 280–299. doi: 10.1111/jcom.12148

Miller, M. (2016). *Legal Weapon.* Burbank: Warner Bros.

Miller, M., Hemenway, D., and Wechsler, H. (2002). Guns and gun threats at college. *J. Am. Coll. Health.* 51, 57–65. doi: 10.1080/07448480209596331

O'Keefe, D. J. (2003). Message properties, mediating states, and manipulation checks: claims, evidence, and data analysis in experimental persuasive message effects research. *Commun. Theor.* 13, 251–274. doi: 10.1111/j.1468-2885.2003.tb00292.x

Ortiz de Gortari, A. B. (2019). "Game transfer phenomena: origin, development, and contributions to the video game research field," in *The Oxford Handbook of Cyberpsychology,* eds A. Attrill-Smith, C. Fullwood, M. Keep, and D. J. Kuss (Oxford: Oxford University Press), 531–556. doi: 10.1093/oxfordhb/9780198812746.013.29

Ortiz de Gortari, A. B., and Griffiths, M. D. (2014). Automatic mental processes, automatic actions and behaviours in game transfer phenomena: an empirical self-report study using online forum data. *Int. J. Mental Health Addict.* 12, 432–452. doi: 10.1007/s11469-014-9476-3

Ortiz de Gortari, A. B., and Griffiths, M. D. (2016). Prevalence and characteristics of game transfer phenomena: a descriptive survey study. *Int. J. Hum. Comput. Interact.* 32, 470–480. doi: 10.1080/10447318.2016.1164430

Peña, J., Hancock, J. T., and Merola, N. A. (2009). The priming effects of avatars in virtual settings. *Commun. Res.* 36, 838–856. doi: 10.1177/0093650209346802

Peña, J., Khan, S., and Alexopoulos, C. (2016). I am what I see: how avatar and opponent agent body size affects physical activity among men playing exergames. *J. Comput. Med. Commun.* 21, 195–209. doi: 10.1111/jcc4.12151

Peña, J., Khan, S., Burrows, C. N., and Blanton, H. (2018). How persuasive are health advertisements in first-person shooter games? Exploring knowledge-activation and thought-disruption mechanisms. *Commun. Res. Rep.* 35, 293–302. doi: 10.1080/08824096.2018.1469484

Ratan, R., Beyea, D., Li, B. J., and Graciano, L. (2019). Avatar characteristics induce users' behavioral conformity with small-to-medium effect sizes: a meta-analysis of the proteus effect. *Med. Psychol.* 23, 651–675. doi: 10.1080/15213269.2019.1623698

Read, G. L., Lynch, T., and Matthews, N. L. (2018). Increased cognitive load during video game play reduces rape myth acceptance and hostile sexism after exposure to sexualized female avatars. *Sex Roles* 79, 683–698. doi: 10.1007/s11199-018-0905-9

Reeves, B., and Nass, C. (1996). *The Media Equation: How People Treat Computers, Television, and New Media Like Real People and Places*. Cambridge: Cambridge University.

Reinhard, R., Shah, K. G., Faust-Christmann, C., and Lachmann, T. (2020). Acting your avatar's age: effects of virtual reality avatar embodiment on real life walking speed. *Med. Psychol.* 23, 293–315. doi: 10.1080/15213269.2019.1598435

Shapiro, J. P., Dorman, R. L., Burkes, W. M., Welker, C. J., and Clough, J. B. (1997). Development and factor analysis of a measure of youth attitudes toward guns and violence. *J. Clin. Child Psychol.* 26, 311–320. doi: 10.1207/s15374424jccp2603_10

Weaver, A. J., and Lewis, N. (2012). Mirrored morality: An exploration of moral choice in video games. *Cyberpsychol. Behav. Soc. Netw.* 15, 610–614. doi: 10.1089/cyber.2012.0235

Yee, N., and Bailenson, J. (2007). The proteus effect: the effect of transformed self-representation on behavior. *Hum. Commun. Res.* 33, 271–290. doi: 10.1111/j.1468-2958.2007.00299.x

Yee, N., and Bailenson, J. N. (2009). The difference between being and seeing: the relative contribution of self-perception and priming to behavioral changes via digital self-representation. *Med. Psychol.* 12, 195–209. doi: 10.1080/15213260902849943

Yoon, G., and Vargas, P. T. (2014). Know thy avatar: the unintended effect of virtual-self representation on behavior. *Psychol. Sci.* 25, 1043–1045. doi: 10.1177/ 0956797613518350

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Protean Kinematics: A Blended Model of VR Physics

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Avatar research largely focuses on the effects of the appearance and external characteristics of avatars, but may also warrant further consideration of the effects of avatar movement characteristics. With *Protean kinematics*, we offer an expansion the avatar-user appearances-based effects of the Proteus Effect to a systematic exploration into the role of movement in affecting social perceptions (about others) and idealized perceptions (about self). This work presents both a theoretical (typology) and methodological (physics-based measurement) approach to understanding the complex blend of physical inputs and virtual outputs that occur in the perceptual experience of VR, particularly in consideration of the collection of hippocampal (e.g., place cells, grid cells) and entorhinal neurons (e.g., speed cells) that fire topologically relative to physical movement in physical space. Offered is a novel method that distills the blend of physical and virtual kinematics to contribute to modern understandings of human-agent interaction and cognitive psychology.

Keywords: VR/XR, locomotion, motion tracking and capture, neuroscience, game studies, kinematics

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1. INTRODUCTION

Social psychologists have long argued that human behavior is a function of both "persons" and "environment", represented by the formula, $B = F(P, E)$ (Lewin, 1936, 1943). Gibson's (1979) perceptual theory of affordances added that perceptual objects are understood in terms of the possible actions that the objects can engage perceivers, thus binding the existence of organisms to their environment. Following the above, the current work explores the intersection of the persons and the affordances of their environments across physical and virtual domains. We investigate this intersection particularly in the context of Virtual Reality (VR), examining the transfer from human users in physical environments to avatars in virtual environments [see Grabarczyk and Pokropski (2016) for a discussion of Gibsonian affordances and VR].

We anchor this work upon the conceptual framework of the Proteus Effect, which argues that physical cues of avatars direct behavioral and attitudinal changes among human users in accordance with the perceptions tied to the avatar appearances (Yee and Bailenson, 2007; Yee et al., 2009). The current work proposes to expand the logic of the Proteus Effect (Yee and Bailenson, 2007) from avatar-user appearances-based effects to a theory of movement-based effects[1] vis–vis user and avatars in VR. We propose a systematic exploration into the role of movement in VR and virtual environments, both in terms of social perceptions (about others) and idealized perceptions (about self).

In the current work, we argue that VR represents a potential methodological tipping point for the social sciences. Whereas, computer-mediated communication focuses on a distinction between in-person and mediated communication, VR represents a blend of both. For instance, in-person communication examines physical cues, such as proxemics (Hall et al., 1968), while computer-mediated communication focuses on perceptions of such physical closeness, such as presence (Lee, 2004) and narrative transportation (Green and Brock, 2000). Recent research have applied such concepts in VR settings, such as in perceived realism (Shin et al., 2019), narrative immersion (Cummings et al., 2021) and conversational immersion (Oh et al., 2019).

VR, and more specifically the networked connectivity of social VR (e.g., VRChat, AltSpaceVR), represents a novel blend of the in-person (i.e., physical) and the computer-mediated (i.e., virtual) (Kruzan and Won, 2019; Oh et al., 2019). This is because social VR represents real-time virtual interactions between avatar representations of remote users, where in-person cues re-emerge as critical real-time factors. Further, the development and adoption of wireless 6 degrees of freedom (DOF) VR headsets affords greater flexibility in movements than what was possible with early VR headsets (e.g., tethered to PC, 3 DOF), thus enhancing the affordances of in-person communication.

Integration with social media functionality, online game communities, and wireless connectivity have all contributed to making VR an increasingly remote device[2]. Indeed, Kruzan and Won (2019) discuss the emerging blend between VR and social media on social VR platforms (e.g., Altspace VR, VRChat, Rec Room, Big Screen). It should be noted that the social media function of some of these platforms also blend with online game communities, or more specifically, online VR game communities. Whether approaching from a social media perspective or a game community perspective, it is important for media researchers to consider the increasingly socially networked nature of VR that embraces the interaction of remote VR users in virtual spaces. Critically, social VR platforms demonstrate that VR is more than a modality of representation (e.g., 360 VR), but a unique social experience with unique scripts (Schank and Abelson, 1975) and norms navigated between users. Altogether, it is increasingly important to consider the role of "cues" that occur at the intersection of physical inputs and corresponding virtual outputs.

The current work expands on the Proteus Effect by offering the following contributions: First, we introduce the concept of Social Kinematics, which provides the physics-based foundation to analyze and measure virtual movement, specifically in VR. Second, we explicate a typology of Protean Kinematics, which refers to movement-based effects at the intersection of physical affordances/actions and virtual affordances/actions. Finally, we present a computational model to compute physical to virtual movement, which researchers may ultimately use to more accurately and reliably measure the VR user actions and movements. In doing so, we aim to advance the replicability and transparency of measurement in the psychological and communication sciences, as noted by the open science movement in psychology (Ioannidis, 2012; Brandt et al., 2014; Nosek et al., 2015; Open Science Collaboration, 2015; Klein et al., 2018) and in communication (Benoit and Holbert, 2008; Bowman and Keene, 2018; McEwan et al., 2018; Keating and Totzkay, 2019; van Atteveldt et al., 2019; Dienlin et al., 2020; Lewis, 2020).

2. RELATED WORK

We position this work at the intersection of traditional psychology and human-computer interaction. As such, we structure our related work to begin with relevant literature in traditional psychology. Next, we discuss work in media psychology, namely anchoring upon the Proteus Effect. Finally, we discuss connections to relevant work in human-computer interaction, which sets the stage for the introduction of our conceptual typology of Protean Kinematics.

2.1. Proteus Effect

The Proteus Effect (Yee and Bailenson, 2007) is arguably the leading media psychology theory on avatars as representations of self [see Praetorius and Görlich (2020) for a review]. According to the Proteus Effect, identity cues among user avatars may direct behavioral and attitudinal changes (Yee and Bailenson, 2007; Yee et al., 2009). Since its inception, the Proteus Effect has been explored in a wide range of contexts, such as dating (Yee et al., 2009), pedagogy (Ratan and Dawson, 2016), consumer choices (Ahn and Bailenson, 2011), public speaking anxiety (Aymerich-Franch et al., 2014), embodiment of elderly bodies (Beaudoin et al., 2020). One of the notable areas of application of the Proteus Effect has been in cross-gendered embodiment of avatars (Slater, 2009), such as in the context of gendered avatar customization and pedagogical stereotype threat (Lee et al., 2014; Ratan and Sah, 2015), stereotypically gendered behaviors (Sherrick et al., 2014), and sexualized self-objectification (Vandenbosch et al., 2017). A recent meta-analysis of 46 research studies on the Proteus Effect found a small-but-approaching-medium effect size (0.22 0.26), which is notably large relative to comparable meta-analyses on digital media effects (Ratan et al., 2020).

2.2. Real-Virtual Consistency

The question of avatars—not unlike digital media effects at large—starts and ends with a question of real to virtual consistency (Williams, 2010). That is, does the virtual avatar accurately represent the actual real-world self? Bente et al. (2001) demonstrate the overlap between real-world experiences and virtual representations of those experiences by finding only marginal differences in socio-emotional impressions between dyadic interactions and virtual animations of the

[1] For example, dunking in a basketball video game, traversing a wall in Fortnight, and teleporting in VRChat each represent unique movement affordances that are not feasible for average users.

[2] Not to mention COVID-19 constraints on in-person lab spaces.

same interactions. Beyond impressions, virtual environments afford opportunities to test for correlations between real-world decisions and virtual versions of those decisions, otherwise known as *virtual validity* (Godoy et al., 2008; Smith et al., 2018; Miller et al., 2019a,b,c). In addition to behavioral decisions, avatars may further influence behavioral change, such as those sought by health interventions. For instance, interventions may utilize avatars that represent a virtual future self that is older and wiser in order to influence (healthier) behavior and decisions (Christensen et al., 2013), akin to a self-fulfilling Bandura-esque process (Bandura, 2001).

Returning to our discussion of the Proteus Effect, it is thought that individuals infer their own attitudes and beliefs by taking on a third person perspective of oneself (Bem, 1972). Accordingly, it would seem to follow that the Proteus Effect would be best optimized for third person avatars. That said, the original Proteus Effect study (Yee and Bailenson, 2007) utilized first-person avatars based on the idea that first-person avatars elicited a stronger Proteus Effect than third-person avatars (Yee et al., 2009). Others have explored a hybrid first-person/third-person perspective, affording a combined benefit of first-person embodiment and third-person avatar appearance cues (Ratan and Sah, 2015).

2.3. Psychology of VR

The effectiveness of first-person perspectives may be attributed to embodiment (Barsalou, 2009), particularly in game avatars (Fox and Ahn, 2013; Ratan, 2013; Nowak and Fox, 2018). The merits of first person avatars in traditional games (e.g., Proteus Effect, embodiment, self-presence) translate conveniently in VR. Both take place in a first-person perspective where users' avatars are not readily viewable by the user. Certainly, a hypothetical user may meticulously craft a particular appearance of an avatar, but avatars in VR are generally used as cues for other users that interact with the given user.

Many have identified embodiment, such as embodied simulations (Riva et al., 2007, 2019; Riva and Gaudio, 2018), as one of the key conceptual phenomena underlying social presence (Lee, 2004) of avatar representations of users in virtual environments (Ratan and Sah, 2015; Ratan and Dawson, 2016; Ratan et al., 2020). VR extends this line of inquiry both literally and conceptually, as "cyborg prosthetics" (Biocca, 1997) present a paradoxical combination of the a) sensory and b) mental experience of agents, objects, and environments (Benthall and Polhemus, 1975).

That said, VR differs from traditional game environments in two prominent ways, both of which operate under the assumption of a first-person perspective. First, VR relies on "body illusions" that have roots in phenomena such as the "rubber hand illusion" (Botvinick and Cohen, 1998; Slater, 2009). Such body illusions have a powerful impact on a variety of psychological outcomes (Gonzalez-Franco and Lanier, 2017), such as effects on human perception (Cummings and Bailenson, 2016). This effect can be seen with "switched" hand controls from real to virtual hands (Bailey et al., 2016). Won et al. (2015) "playfully" pushed the envelope of such "homuncular flexibility" of somatic mappings by having a physical leg control a virtual arm, and vice versa (Won et al., 2015). More recently, Kocur et al. (2020a) leveraged new developments in hand tracking capacity across VR by exploring the impact of missing fingers in VR. Notably, representation of hands and limbs was observed to have no significant impact on various outcomes (e.g., body ownership, immersion, and emotional involvement) relative to VR representations excluding visual representations of limbs (Lugrin et al., 2018).

Second, unlike in traditional game environments, VR involves the added dimension of body kinematics, where users' actual body movements have a direct and corresponding virtual output on avatars' movements. That said, virtual avatar movements are certainly not constrained purely to the movement affordances of human bodies. For instance, a common movement in VR is the teleport movement, which allows individuals to point to and automatically move to a new location in a given space without having to physically "walk" to that location (Bozgeyikli et al., 2016).

3. PSYCHOLOGY OF MOVEMENT

Consideration of movement in VR warrants a re-tracing of steps to the psychology of human movement. Indeed, we emphasize that the current work is an exploration of sensory perception (e.g., visual processing) and social perception (e.g., inference making). To address the sensory perception, we first discuss the role of hippocampal place cells (O'Keefe and Dostrovsky, 1971). Next, we turn our focus to the social perception of movement (Heider and Simmel, 1944).

3.1. Neuroscience and Movement

Human movement, and specifically locomotive movement, involves concurrent coordination of multiple brain systems. First, the sheer physical act of moving one's body requires activation of one's motor cortex. As one navigates from one point to another, visual inputs may vary. For instance, one may encounter a wall or a tree that prevents further navigation. Physical movement and visual perception however, are not the sole contributors to successful spatial navigation.

Place cells, discovered by O'Keefe and Dostrovsky (1971), are a specific type of neuron located in the hippocampus that aid in the perception of one's environment within spatial navigation. In a landmark study that later contributed to a Nobel Prize[3], Moser and colleagues (Fyhn et al., 2004; Moser et al., 2017) discovered that place cells in the dorsal hippocampus had firing fields with precise spatial positioning and changes in positioning that formed a 2-dimensional "grid" representation of a subject's spatial environment. In other words, brain scans during spatial navigation (3D physical environments) revealed neural activations (2D images) that correspond precisely to the physical environment. This means that the brain may have specific neurons responsible for encoding each of the relevant objects and features (including perimeter) within one's physical

[3]Moser and O'Keefe were jointly awarded the 2014 Nobel Prize in Medicine/Physiology for their landmark discoveries of grid and place cells.

environment, altogether contributing to the construction of a spatial map of one's surroundings.

A methodological constraint faced by neuroscientists studying movement is that brain imaging at the cellular level requires immobilization of subjects. How does one measure how the brain processes information during movement when the subject is unable to move during measurement? In order to offset restrictions in physical movement during brain imaging, neuroscientists rely on virtual reality (Carandini and Churchland, 2013; Stowers et al., 2017; Pinto et al., 2018).

Critically however, hippocampal place cell activation may not necessarily be consistent across navigation of real and virtual worlds, as evidenced by recent work that finds that place cell neurons fire more actively in the real world than in virtual worlds (Ravassard et al., 2013; Aghajan et al., 2015; Acharya et al., 2016).

This difference may be attributed to the reduction of navigation in VR to visual inputs and locomotion that does not account for the integration of olfactory stimuli and vestibular information that is needed in real-world navigation (Minderer et al., 2016). Given the lack of such proximal cues (olfactory, vestibular stimuli) in virtual environments, place cells may have difficulty accurately perceiving one's positionality. In VR simulations of immobilized subjects, place cells seem to keep track of a subject's relative distance along a virtual track, as opposed to encoding a position in absolute space.

While neuroscientific research about hippocampal place cells deals strictly with neural processing of spatial navigation, the revelation that place cell activations are attenuated in virtual settings relative to physical settings is an unwitting contribution to research in media psychology and human-computer interaction. Neuroscience may contribute to addressing the questions central to VR research. For instance, are VR simulations representative of our physical experience? Why do VR users experience motion sickness? In fact, the mismatch between visual perceptual information and lack of olfactory/vestibular stimuli during VR spatial navigation may be a factor contributing to VR-induced motion sickness (e.g., when one is physically sitting down while exploring a VR environment) (Langbehn et al., 2020). We will circle back to this discussion in latter sections of this work.

This all being said, these findings may be limited to the mechanisms of rodent navigation and may not generalize to humans. Due to measurement constraints most hippocampal place cell research is conducted on rodents and primates (Rolls and Wirth, 2018). Distinguishing between primates and rodents, however, Rolls and Wirth (2018) found that primate hippocampal spatial neurons activate to where a primate is looking (allocentric visual perception) (Rolls and O'Mara, 1995; Georges-François et al., 1999) in both virtual and physical environments (Wirth et al., 2017), whereas rodent hippocampal neurons activate corresponding to their positionality (ideothetic visual perception) (McNaughton et al., 1991; Jeffery et al., 1997) in a process known as "dead reckoning"[4] (McNaughton et al., 1991). In other words, rodents navigate their environment based on a calibration of their current position relative to previous positionality. Thus, rodents seem to rely less on visual perception and more on a mental map of a spatial environment, lending literal support to the idiom, "even a blind squirrel finds a nut in awhile." Taken together, the literature on hippocampal place cells seem promising yet with many questions unanswered. Prominently, in line with Ravassard et al. (2013), do human place cells differ in activations in VR than in the real world? This question is contingent on the integration of (a) precise hippocampal measurement, (b) free-moving navigation, and (c) human subjects in VR. While more mobile forms of brain-imaging (e.g., EEG and MEG) have been used to study hippocampal activity (Pizzo et al., 2019), it is currently not feasible to investigate hippocampal activity at the cellular level (e.g., place/grid cells).

While not specifically measuring neural activity, the following further unpacks the social perception of movements, namely the correspondence between socially meaningful human and avatar movements.

3.2. Social Perception of Movement

Research on the social perception of human movement cues can be traced to the Heider-Simmel simulation (Heider and Simmel, 1944), where individuals tend to attribute human-like qualities (i.e., anthropomorphize, theory of mind) to moving inanimate objects (e.g., geometric shapes).

Modern avatars in virtual environments and VR may then be understood as extensions of the Heider-Simmel geometric shapes. Like the geometric shapes of the original Heider-Simmel simulation, avatars are themselves geometric shapes, namely collections of polygons, that are not necessarily any more "human" than simple geometric shapes. Of course, the visual closeness of modern avatars to human likeness, or greater anthropomorphism, may contribute to a greater sense of "a psychological state in which the virtuality of experience is unnoticed" (Lee, 2004, p. 32). Anthropomorphism notwithstanding, the *virtuality* (Lee, 2004) of avatars and geometric shapes are one and the same.

The impact of the Heider-Simmel simulation on virtual avatar simulations today is the understanding that the attribution of human-like qualities to geometric shapes is largely credited to the *movement* generated by these shapes. To that end, social perception of movements aims to delineate how humans draw social meaning from particular types of movements.

To address the social perception of movements, we first focus on the motivation systems underlying movement, before shifting to a mechanistic typology of understanding human movement.

3.3. Approach-Avoidance Motivations

Approach and avoidance have long been understood as the fundamental building blocks of human behavior (Miller and Dollard, 1941; Miller, 1944). For instance, the approach-avoidance conflict is one of the most fundamental concepts in social psychology (Lewin, 1935; Miller, 1959) and is colloquially understood as the "pros and cons" of every decision. This work was followed with an idea that approach and avoidance were managed by distinct nervous system structures and distinct neural substrates (Miller, 1944; Schneirla, 1959), with arguably

[4]In robotics, the concept of dead reckoning describes the calculation of positionality of a moving object based on previously determined positions (Borenstein and Feng, 1994).

the most prominent theory being the interaction between a behavioral approach system (BAS) and a behavioral inhibition system (BIS) introduced by Gray and Smith (1969). The BAS governs sensitivity to rewarding cues and stimuli, whereas the BIS governs sensitivity (i.e., avoidance) to punishment and threat cues (Gray, 1981).

Approach-avoidance systems may even be observed among single-celled organisms (Schneirla, 1959), suggesting that approach and avoidance responses may be observed across all biological species. In microscopic videos, single celled organisms (e.g., protozoa) are observed to physically approach weak light (e.g., reward) and physically avoid strong light (e.g., threat). Unlike the physical manifestations approach-avoidance observed in these rudimentary organisms, human approach-avoidance is traditionally measured as a psychological construct (Carver and White, 1994) rather than as physical movement.

In line with such physical manifestations of approach and avoidance among rudimentary organisms, can human movement represent psychological approach and avoidance systems? For instance, could approach systems (e.g., BAS) be responsible for forward movement as opposed to a reversing movement?

3.4. Social Kinematics

The lack of accounting for physical movement in traditional psychological research on human approach-avoidance systems may have been attributed to measurement constraints. In VR, however, such physical movements are a natural and fundamental feature, warranting consideration in approach-avoidance research. In games and VR, avatar representations can be understood as visual outputs of computational data. In the context of movement and physics of avatars, every position and movement of an avatar represents a visual output based on kinematic data (e.g., position, trajectory, speed). In classic mechanics, kinematics refers to mass and acceleration explaining the geometric nature of movement, whereas dynamics refers to force explaining the cause of the movement. Expanding kinematics into a social context, we introduce the concept of *social kinematics*, which we define as socially meaningful outcomes associated with the geometric nature of human movement according to distance, trajectory, and speed (Jeong et al., 2018). More specifically, social kinematics refers to psychological inferences humans draw from precise measurable units of the combined planes and axes of movements of users' (virtual) bodies (e.g., legs, arms, heads, hands), the changes in these units of measurements (representing directional movement), and the rate of those changes (representing speed of movement). In VR, users experience a virtual world 3-dimensionally, with 6 measurable degrees of freedom (DOF) in spatial representation. In addition to the 3 DOF (x, y, and z axes; pitch yaw, and roll) of rotational movement specific to head movements, modern VR adds 3 additional DOF of translational movement along the x, y, and z axes. As VR systems are equipped with sensors and accelerometers on headsets as well as controllers, VR systems combine kinematic fidelity of hand (e.g., waving) and head (e.g., nodding) with a sense of shared physical (virtual) space.

While legs, arms, head, and hands have unique mechanics that impact their respective kinematic ranges, the current work focuses on the most basic of movements relying solely on the x and y axes, namely locomotion, or user navigation of space. In simplest terms, locomotion may be understood as 2-dimensional movement across a 2-dimensional plane, as seen in the Heider-Simmel simulation. Much like the microscopic 2D representations of single celled organisms representing approach-avoidance, the literal approach (forward) and avoid (backward) movement in human locomotion may be examined in terms of approach-avoidance systems[5]. Indeed, recent work has applied approach-avoidance systems to user navigation of virtual spaces in VR with outcomes, such as interest, attention, and curiosity, which may in turn impact social presence (Lee et al., 2019). This landmark work introduces player movement as a measurable phenomenon, and VR and virtual environments as an innovative methodology for social science outcomes. Generally, as VR takes place within finite virtual environments, VR experiences represent a negotiation of spatial politics (Pierce et al., 2011; Jones et al., 2014), departing from other modalities where space is not a finite resource. As such, the use of locomotion and co-navigation of a virtual environment among users vis-à-vis one another represents a uniquely critical aspect of social presence.

4. PROTEUS EFFECT, EXPANDED

Having established our focus on kinematics within VR, we now circle back to the central purpose of this work: an expansion of the Proteus Effect. To reiterate, the Proteus Effect is an effect that is reliant on avatar appearance as movement-based representations of identity. That said, relatively less work has focused on the action affordances of avatars as additional idealized representations of identity. For instance, participants embodying more "muscular" avatars exhibit higher grip strength (Kocur et al., 2020b).

At the core of the current proposal to expand the Proteus Effect are two questions: First, in line with Kocur et al. (2020b) how does the appearance of an avatar correspond with the action affordances of the avatar? Here, we refer primarily to movement affordances, but we do recognize that virtual affordances are not limited to purely human movements. For instance, a mixture of game-based fantasy (e.g., flying, casting spells) may blend with real-world human affordances (e.g., walking, running). Second, to what degree do the physical actions of the user correspond with the virtual actions of the avatar?

We propose a systematic exploration into the role of movement affordances in VR and virtual environments, both in terms of (a) social perceptions (by others) and (b) idealized perceptions (of oneself). Movements in VR may range from high fidelity direct representations (e.g., motion tracking) to an interaction with game-based fantasy. For instance, boxing games on VR represent the former, as physical and virtual movements

[5]In fact, microscopic videos of moving single cell organisms may also be attributed with human intentions and goals in line with the original Heider-Simmel simulation.

(e.g., a punch) have a direct correspondence. Not only is this movement high in fidelity (an actual punch is a virtual punch), but the physical punch is an actual human affordance. On the other hand, social VR platforms (e.g., VRChat) have a teleport function that is not necessarily a high fidelity translation of actual movement to virtual movement. In other words, instead of a punch being represented as a punch, teleporting in VR is achieved with a controller button press. Along this vein, movements may be categorized according to representativeness to one's actual kinematics relative to one's affordances.

In line with the above, we propose expanding the Proteus Effect to account for movement affordances vis-à-vis user and avatars, which we refer to as *Protean kinematics* (**Figure 1**).

4.1. Typology of Protean Kinematics

Drawing from Lewin's argument that human behavior is a function of both "persons" and "environments" (Lewin, 1936, 1943), our typology of Protean kinematics (see **Figure 2**) begins with a distinction between what is possible given one's environment (*affordances*), and what is acted upon by the person (*actions*). Along this vein, we may interpret human behavior in virtual reality as a continuum of movements along the two axes of affordances and actions in the real-world (physical) and in the virtual world. In other words, affordances and actions may be distinguished between human movement in physical environments and avatar movement in virtual environments.

In the current typology, affordances refer to the movement constraints of one's ability (person-based) and one's surroundings (environment-based). *Person-based affordances* refer to both the physical capacity of the particular user (e.g., the capacity to walk among able-bodied individuals), or the virtual capacity of an avatar (e.g., such as the capacity to leap 40 feet in the air). Person-based affordances are central to traditional applications of the Proteus Effect, such the degree to which the appearance of an avatar may or may not correspond with the actions of the human user Kocur et al. (2020b), or studies that examine plasticity of virtual and physical body ownership (Piryankova et al., 2014). *Environment-based affordances*, on the other hand, refer to the constraints in one's physical environment (e.g., a limited play space), or the constraints in one's virtual environment (e.g., the perimeter of a virtual map). Altogether, different degrees and levels of person-based and environment-based affordances in VR modify and bend common assumptions of 1-to-1 correspondence between physical and virtual actions, as seen in natural mapping technologies (Birk and Mandryk, 2013; Vanden Abeele et al., 2013), such as Microsoft Kinect.

4.2. Person-Based Actions

VR presents a unique psycho-physiological quandary of physical inputs and virtual outputs. On one hand, the degree of overlap and correspondence between physical inputs and virtual outputs may be understood as a measure of *validity* (Godoy et al., 2008). That is, does the device (e.g., headset, hand controller) reliably measure human kinematics as assumed within natural mapping technologies (Birk and Mandryk, 2013; Vanden Abeele et al., 2013)? On the other hand, it is worth understanding the conditions for demanding high reliability, namely considering a potential mismatch between goal-driven intent (e.g., a greeting "hello" wave) and perception (e.g., a dismissive wave). We first proceed with an *assumption* of correspondence between physical behavior (inputs) and virtual behavior (outputs), which we refer to in our typology of Protean kinematics as *person-based actions*. That said, certainly a 1-to-1 correspondence would not be particularly protean! Our subsequent section on affordances will address this issue, but we begin by addressing correspondence.

The transfer of physical human movement to virtual avatars is certainly not a novel concept. Broadly speaking, human movement behavior has long been of interest to scholars examining natural mapping (Birk and Mandryk, 2013; Vanden Abeele et al., 2013), intelligent virtual agents (Gratch et al., 2002; Thiebaux et al., 2008; Marsella et al., 2013; Kucherenko et al., 2021), VR-based gesture tracking (Won et al., 2012; Christou and Michael, 2014), and pose estimation of anatomical keypoints (Andriluka et al., 2010; Pishchulin et al., 2012; Cao et al., 2017). Natural mapping motion capture systems, which generate virtual avatar representations based on physical human behavior, vary from 3D pose estimation [See (Wang et al., 2021) for a review] to facial expression sensors (Lugrin et al., 2016). A commercial example of such systems is the Microsoft Kinect, which has been utilized for detecting gender (Won et al., 2012) as well as differences in avatar types (Christou and Michael, 2014). That said, given computational constraints of such systems, there are efforts to more reliably map human movement to 3D graphical representations using full-body motion tracking suits (Roetenberg et al., 2009). These motion capture systems may be integrated with wearable micro-electromechanical systems (MEMS) to promote health outcomes (Brigante et al., 2011). The cost and accessibility constraints of such systems however, have motivated the development of lower-cost alternatives using fewer sensors (Caserman et al., 2019b). A potential compromise between the accessibility (e.g., less costly) of fewer sensors and greater reliability of motion capture systems (Jeong et al., 2020) may be achieved by integrating virtual reality sensors with a combination of inverse kinematic techniques (Roth et al., 2016; Caserman et al., 2019a), pose estimation (Cao et al., 2017), and temporal convolutional networks (Lea et al., 2017). Motion tracking in VR has already been used to test homuncular flexibility (Won et al., 2015; Bailey et al., 2016; Herrera et al., 2020; Kocur et al., 2020a), as well as health-based physical activity (Hahn et al., 2020; Navarro et al., 2020).

In prior work (Jeong et al., 2020), we have proposed utilizing existing sensors native to VR headsets and controllers among users as an alternative to costlier motion tracking procedures. This involves utilizing a technique known as inverse kinematics to represent these first-person movements of users as third-person movements avatars (Roth et al., 2016). At the final step, third-person avatars "re-create" a third-person virtual representation of the first-person human movements. This step requires the use of multiple virtual cameras to attain multiple perspectives of the third-person avatar movement in order to achieve an accurate representation of depth and to avoid object occlusion. The resulting simulated avatar/character animations may then be analyzed computationally using computer vision (e.g., pose estimation), which in turn may be used to analyze

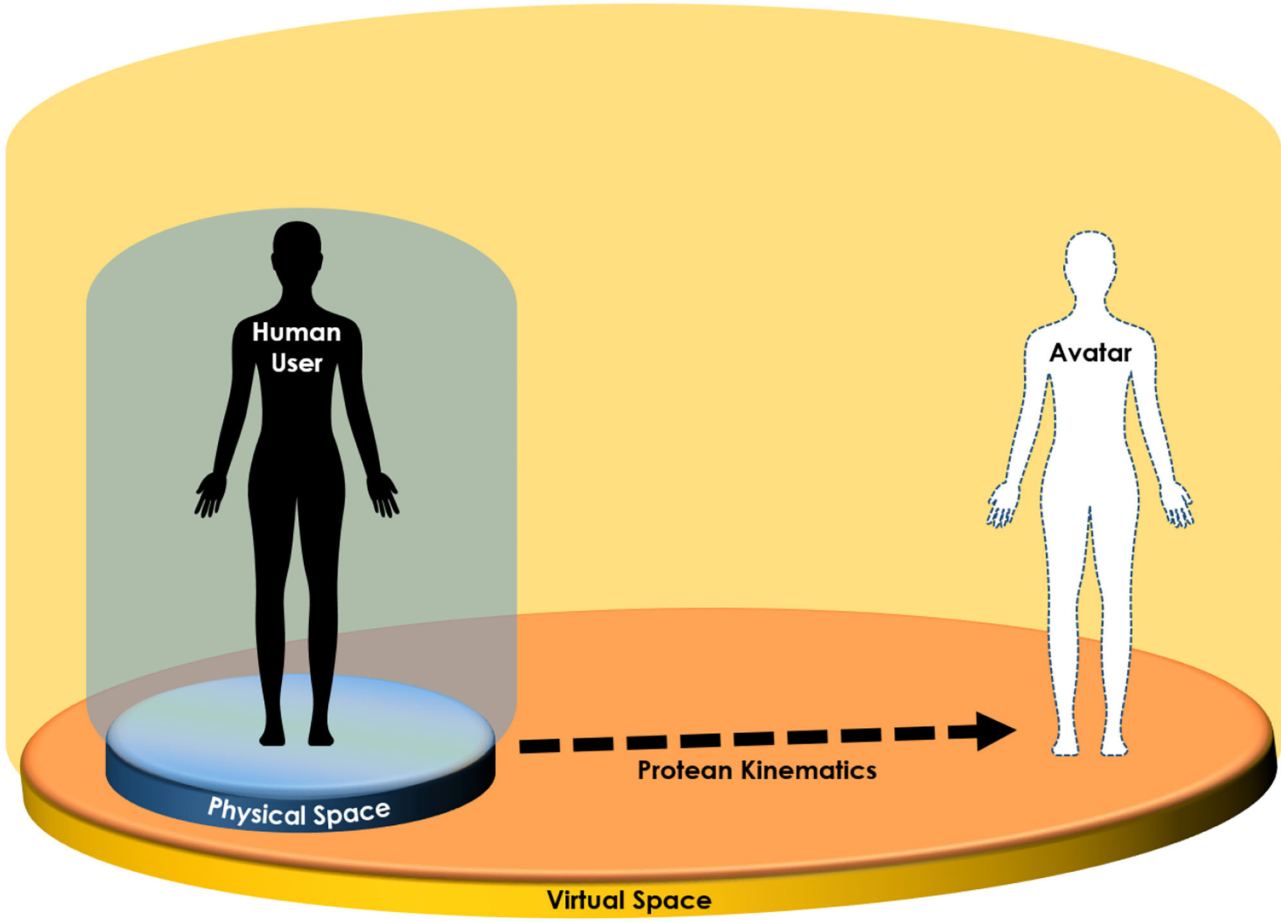

FIGURE 1 | Protean kinematic refers to the idealized virtual movements that can take human users beyond the constraints of their physical affordances (e.g., space).

		Physical	Virtual
Environment-based	*Affordances*	Space available in physical environment	Space available in virtual environment
Person-based	*Actions*	A physical movement to map onto a virtual movement	A virtual movement contingent on a physical movement
	Ability	Capacity (or lack thereof) to perform a physical action	Capacity (or lack thereof) to perform a virtual action

FIGURE 2 | Typology of Protean kinematics, which refers to the intersection of physical affordances/actions and virtual affordances/actions. Here, we depict affordances as space, physical actions as human actions, and virtual actions as avatar actions.

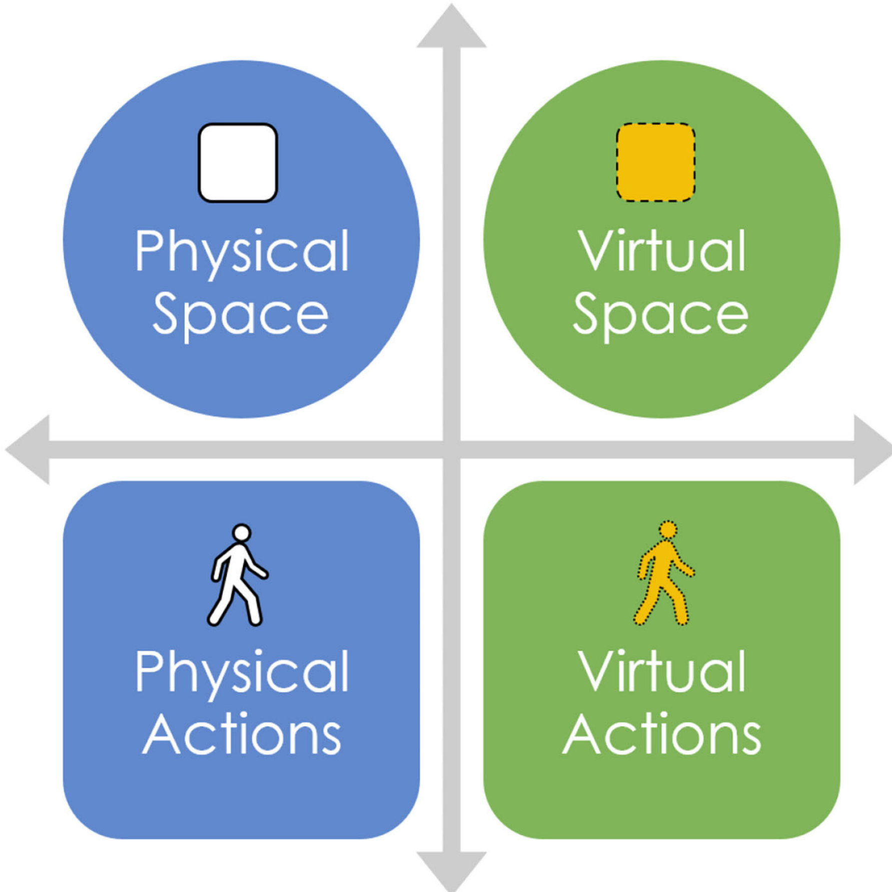

FIGURE 3 | Protean kinematics occurs at the intersection of physical affordances/actions and virtual affordances/actions. Here, we depict affordances as space.

human behavior in various "virtual" contexts (e.g., doctor's office, job interview, romantic date, interracial dialogue). Such virtual animations may potentially approach hybrid avatar-agent systems of human-human interactions mediated by avatars and artificial social intelligence (e.g., to moderate intercultural conversations) (Roth et al., 2015).

We pause to reiterate the emphasis of the current work on the kinematic representations in VR. Within Protean kinematics, person-based actions assume or aim for a correspondence between physical and virtual actions. That said, the degree of correspondence between physical and virtual actions is constrained by both person-based and environment-based affordances. Virtual person-based affordances (avatar movements) are so-defined by the game developers, while physical person-based affordances (human movements) represent the physical capacity of an individual. For instance, differences in body size of an avatar will place a natural constrain on range of movements, which may be associated with different perceptions of meaning and intent. While we intend to expand our investigation of such person-based affordances in forthcoming work, our subsequent references to affordances in the current work refer to environment-based affordances, or the spatial constraints of one's physical and virtual environments (see **Figure 2**), which we elaborate in the following.

4.3. Environment-Based Affordances

Replicability and methodological reliability are certainly paramount to the development of science. What is the role of virtual reality and virtual environments in such scientific development? Virtual environments may afford an emergence of a uniquely virtual form of validity that measures the correlation between virtual and real-world behavior (Godoy et al., 2008). Ultimately, virtual environments may warrant a shift in the use of traditional experimental designs in the social sciences into more systematic designs that are representative of the real-world social situations (e.g., interpersonal conflict) and outcomes (e.g., promote vaccination) they reference (Miller et al., 2019a,b). That said, virtual environments are not a one-size-fits-all panacea for all science. Indeed, recent a meta-analysis rejected a longstanding misconception of VR as a "device of empathy" (Martingano et al., 2021). Another misconception of VR research is that all types of VR affords a complete perceptual embodiment, such as a window to another world and another person's perspective and experience. The former may be possible in a "television" model of VR in 3DOF experience (e.g., 360 VR), while the latter would require the full 6DOF range of human head rotation.

While virtual human behavior may correlate to real-world behavior (and vice-versa), a central aim in VR research should be to establish the kinematic fidelity, or reliability between physical and virtual behavior. The correspondence between physical and virtual behavior warrants the consideration of environment-based affordances in addition to the person-based affordances taken into account in natural mapping and motion tracking. On the contrary, a blanket argument that physical behavior corresponds to virtual behavior would assume that the physical inputs may be occurring in a vacuum or in infinite space.

Indeed, a requisite consideration to the real-world correlates of virtual avatar/agent outputs in VR is—quite literally—*space* (**Figure 3**). VR movement is constrained by the availability of free physical space the user has to navigate, regardless of infinite virtual space. While physical space is typically not a major concern for research lab environments dedicated to providing obstacle-free "play areas[6]," casual users rarely have the opportunity to navigate (e.g., walk around) a truly physical environment that is "true to scale" with the given size of a virtual environment. When constrained by space, VR users rely on a *stationary* play area that assumes a seated and immobile position that relies more heavily on a teleport function for locomotive navigation throughout a virtual space[7]. As such, VR does not necessarily assume high fidelity of kinematics from physical inputs (by humans) to virtual outputs (by avatars). Indeed, users consistently underestimate depth perception in VR (Renner et al., 2013; Maruhn et al., 2019). This lack of correspondence between the physical inputs and virtual outputs warrants investigating the intersection of affordances-actions across physical and virtual environments.

Here, we circle back to our earlier discussion of place cells/neurons in the brain's hippocampus. VR devices are designed as (head-mounted) displays (i.e., screens, monitors) that provide visual representations of virtual spaces (environment) larger than what is physically available. This visual information from the display, however, may not necessarily correspond with the combination of olfactory and vestibular sensory information (or lack thereof) required in traditional spatial navigation. In fact, the absence of these additional sensory inputs may be responsible for the notorious cybersickness users experience in VR [See Weech et al. (2019) for review of the relationship between cybersickness and presence]. Although a systematic analysis of cybersickness is beyond the scope of the current work, the conditions that are associated with VR cybersickness are relevant to the intersection of physical and virtual spatial navigation. For instance, cybersickness has been examined among subjects that are sitting (Palmisano et al., 2017) and standing still (Palmisano et al., 2018). Sitting and standing are both physical orientations that are stationary (e.g., no locomotion involved), and would warrant the utilization of virtual locomotive techniques to navigate in a virtual space, namely *steering* and *teleporting*. Clifton and Palmisano (2020) recently examined potential interactions between physical body positioning (sit/stand) and virtual locomotive techniques (steer/teleport), reporting greater cybersickness for stand-steer conditions than others, least cybersickness for sit-steer conditions than the teleport conditions. The authors also report that cybersickness progressively increase over time in teleport conditions, but level off after an initial spike during sickness (Clifton and Palmisano, 2020). This may be attributed to the smoother contiguity of previous scenes and subsequent scenes during steering-based locomotion relative to teleport-based locomotion. Among the above conditions, the standing conditions is of most relevance to the current work. In a growing body of work, Palmisano and colleagues have attributed cybersickness to lack of postural stability, measured by fluctuations in center-of-foot pressure (Palmisano et al., 2014, 2018). Indeed, merely standing-still requires engaging multiple physiological and neurological systems to achieve and maintain balance.

Recently, VR has been utilized to rehabilitate the gait and balance challenges experienced by Parkinson's patients (Canning et al., 2020). That said, is the design of VR devices able to accurately simulate the requisite conditions for physical walking, or locomotion? The somewhat disparate domains of rehabilitation, cybersickness, and redirected walking are all united by the lack of correspondence between physical and virtual spatial navigation. Taken together, VR locomotion must account for the incongruity between simulated locomotion in the absence of (corresponding) physical locomotion and the manner in which the brain processes physical locomotion.

The above however, is assuming a model of physical inputs and virtual outputs fully dependent on corresponding physical inputs. An alternative approach is to consider goal-directed (e.g., approach-avoidance systems) virtual outputs with the use of physical inputs as tools for achieving a virtual goal. In line with the Proteus Effect, different avatar identities may elicit different types of movements both physically in-person, as well as virtually in-game. For instance, Kocur et al. (2020b) demonstrate that identification with a "strong appearing" virtual avatar may elicit greater physical strength (e.g., grip strength). Of course, this physical-to-virtual correspondence may be constrained at the game development level. For instance, if the maximum virtual output is generated by gripping a controller with 10 pounds of force, then gripping a controller with 100 pounds of force will have no net difference in the virtual output. Alternatively, in keeping with our focus on locomotion, greater identification with an aggressive avatar may elicit a more direct (as opposed to circuitous) locomotive trajectory and velocity toward a virtual target/goal (e.g., another avatar).

Regardless of the nature of movement, VR movement tends to operate in this goal-directed manner. For instance, the teleport movement is the clearest example of goal-directed behavior in VR that relies minimally on corresponding physical inputs. This represents a developmental paradox of VR: on one hand, the lack

[6]HTC refers to this area as the "play area", whereas Oculus refers to this area as the "guardian boundary".

[7]In addition to the teleport function, there are other methods of seamless locomotion, such as redirected walking (Razzaque et al., 2005), which locks the rotation of the virtual world by holding down the button so that users may maximize their limited physical space to be used as an infinite play space.

of available physical space as well as the onset of cybersickness compels users to use virtual locomotive techniques that require minimal physical movement such as teleporting and steering; on the other hand, kinematic fidelity between physical and virtual locomotion may be required. Ultimately, hippocampal place cells, vestibular inputs, olfactory inputs, visual-spatial inputs, as well as postural stability may all require physical locomotion (actual walking) to afford the virtual representation of VR locomotion.

Having established space as central to environment-based affordances, we continue our proposal to expand the Proteus Effect by discussing the challenges of translating locomotive kinematics from physical to virtual environments.

5. MEASURING LOCOMOTIVE KINEMATICS

In the following, we continue to discuss the challenges of translating physical kinematics to virtual kinematics in VR. Kinematic fidelity would assume a seamless correspondence between physical movements as inputs and virtual movements as equivalent outputs (e.g., a physical "thumbs-up" and a virtual "thumbs-up"). Kinematic fidelity in VR is particularly operative in the case of head rotations and arm movements, but less so for locomotion, where users may utilize a number of virtual locomotion techniques (e.g., teleporting, steering) in lieu of the physical locomotion (which take up considerable physical space/affordances). Two main constraints to kinematic fidelity in VR locomotion may be (a) the absence of leg sensors, and (b) calibrating physical units of measurement (e.g., meters) to virtual units of measurement (e.g., pixels). For instance, computer mouse cursors are calibrated with a specific sensitivity for each computer user. Certainly, one inch of physical mouse movements does not necessarily output one inch of mouse cursor movements. In an attempt to explain the mechanistic process of transforming physical movements into virtual movements, we focus specifically on the locomotive navigation of users and avatars in a virtual space, and exclude other forms of movement, such as head rotations and arm movements. Although head rotations and arm movements rely on VR sensors that are unavailable to measure leg movements on most commercial VR systems, it is worth noting that meter-pixel calibration issues remain for all types of VR movement. As we elaborate below, the calibration of physical-to-virtual units of measurement warrants a perspective grounded in image processing (i.e., computer vision), where sequences of movements are measured as sequences of images, otherwise known as frames.

5.1. 3D to 2D Transformation

In examining the transformation (i.e., natural mapping) of physical movements onto virtual movements, we first consider the dimensionality of physical space. Naturally, our experience of the physical world is 3-dimensional and game engines (e.g., Unity) may provide corresponding options to view active layers of 3D planes to provide a visual reference point relative to the objects on a layer (i.e., scene). This *active layer plane* (i.e., ground plane) may be understood as the floor in the physical world. Working in 3D games and modeling however, requires the cursor to snap to a 3D location. When no other 3D snap is active (the cursor is not snapping to 3D geometry), the cursor still needs to snap to a 3D location in order to provide a reference point to the 3D object (e.g., an avatar). This 3-dimensional plane is known as the *working plane*. The working plane is what allows an avatar to move across 3-dimensional space in VR environments.

However, 3-dimensionality is not necessarily a requirement when focusing strictly on locomotion. Locomotion may be understood purely as a human or agent navigating throughout a given 2-dimensional space. Here, we are disregarding characteristics of movement that invoke 3-dimensionality, such as gait style. As referenced earlier, this 2-dimensional conceptualization of locomotion aligns with the original Heider-Simmel simulation, where geometric shapes move throughout 2-dimensional space. As such, projecting a 3D space into a 2D space affords a strict focus on locomotive kinematics within the virtual space.

The first step to transforming physical world movements to virtual movements requires projecting 3-dimensional (3D) space into a 2-dimensional (2D) "image space." Critically, this projection of 3D space into a 2D space involves rotating the active working plane to become parallel to the working plane (e.g., ground), thus degrading the projection into a planar projection (**Figure 4**).

5.2. Physical to Virtual Units of Measurement

Working in 2D, the next step is to convert 2D representations of physical movements onto 2D representations of virtual movements, which is achieved by observing physical movements across x and y axes in physical space, such as with a downward-facing overhead camera. Physical movement, however, is not readily converted into virtual movement because of the differences in units of measurements in physical (e.g., meters) and virtual (e.g., pixels) environments. Further, we cannot assume a consistent "conversion" of physical to virtual units of measurement because this is point of personal preference and calibration. For instance, computer mouse cursors are calibrated with a specific sensitivity for each computer user. Certainly, one inch of physical mouse movements does not necessarily output one inch of mouse cursor movements. We represent the variable scale of the conversion between the physical space and virtual space using the scalar variable, γ. The complete relationship between virtual and physical movements may be represented using the equation $\vec{m}_v = \gamma\vec{m}$, where γ is a ratio between the size of the physical space, $\vec{m}$, and the size of the virtual space, $\vec{m}_v$.

5.2.1. Meter-Pixel Calibration

Beyond the personal preference of γ, the conversion of physical movements to virtual movements, the transformation of physical space to virtual spaces warrants meter (physical) to pixel (virtual) *calibration*. This calibration is represented by the formula $\frac{D}{d} = k$ where k is a scalar value that can be used to model the projection on the 2D space. k must be calibrated using the physical distance between two physical landmarks (e.g., tape

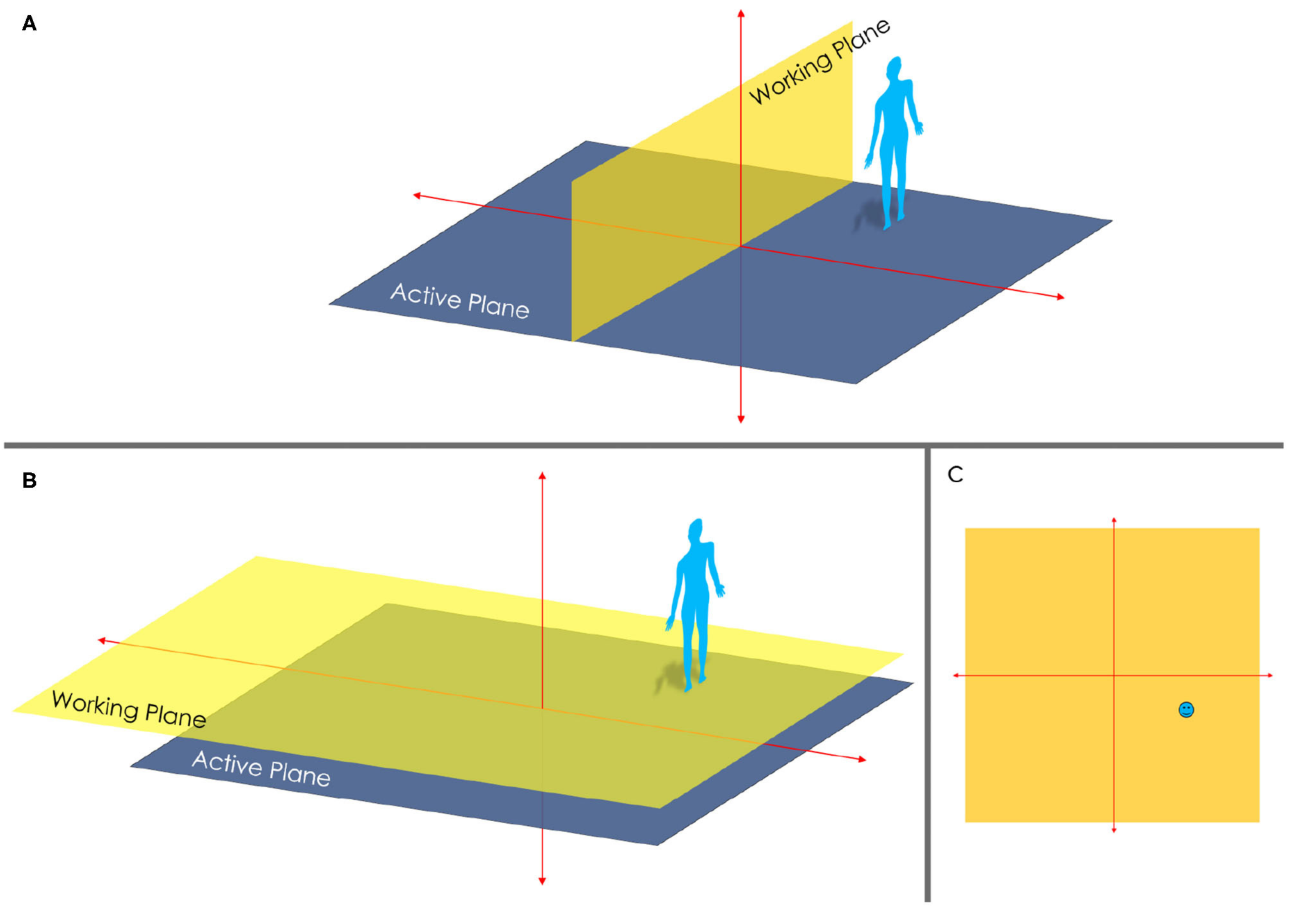

FIGURE 4 | **(A)** depicts the distinction from a working plane and an active plane in 3D. **(B)** depicts the transposing of the working plane so that it is parallel to the active plane. This is what happens when transforming a 3D image into 2D. **(C)** depicts the outcome of transforming a 3D image into 2D.

on ground), denoted D in meters, which are in turn used to determine the image-based distance between the two landmarks, denoted d in pixels. The complete transformation of the physical space to the virtual space is represented as follows: $\vec{m} = k\vec{a}$ where $\vec{m}$ represents the physical space and $k\vec{a}$ represents the calibrated (k) image of the image space ($\vec{a}$) (taken from a downward facing overhead perspective).

5.2.2. Virtual Locomotion

Now that the physical space is transformed into an image space (2D), we can represent locomotion of individuals (or avatar/agent representations of individuals) within this space (**Figure 5**). As alluded earlier, the process of converting physical to virtual kinematics borrows from traditions in image processing, where motion is represented as sequential coordinates from point to point (e.g., frame by frame): $P_i = (u_i, v_i)$ where u and v represent coordinates in the image space at a specific prior time point (e.g., before movement), and that i is the frame index in the image flow. While x-axis and y-axis are physical world coordinates, u and v are image-based coordinate representations of vector spaces, represented by $\Delta u - axis$ and $\Delta v - axis$. Each successive point is represented by $P_{i+1} = (u_{i+1}, v_{i+1})$. P assumes frame by frame processing, which should suffice for a wide range of human movements[8].

5.2.3. Virtual Kinematics

To reiterate, kinematics is a branch of physics derived from classical mechanics that describes the geometry of motion. Having explained the preparation of movement data as image-based coordinate representations of sequential frames and subsequent frames, the following addresses how to compute some of the notable kinematic quantities, namely trajectory, velocity, and distance.

5.2.3.1. Trajectory

Assuming that there are only 2 time points (or frames) of movement, we would represent the *trajectory* of movement between these 2 points as $\vec{a} = (u_2 - u_1, v_2 - v_1)$, where $\vec{a}$ represents the trajectory of movements in coordinates across 2 points along the first time point, (u_1, v_1) and the second time point, (u_2, v_2) (**Figure 5**).

[8]If however, movements are slow and incremental, movements and images may be processed every 10 frames as opposed to for each frame.

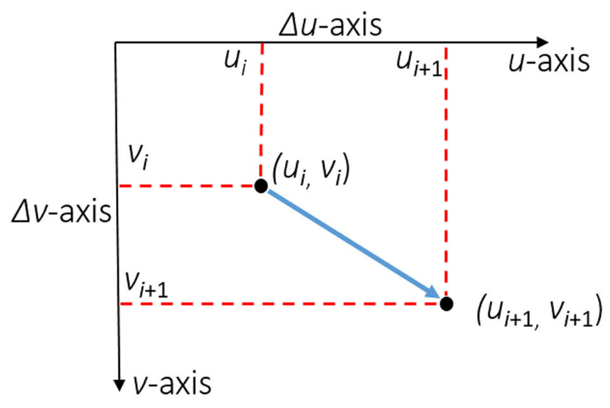

FIGURE 5 | Here we depict where movements in 2D image space. *u* and *v* represent coordinates in the image space at a specific prior time point (e.g., before movement), and *i* is the frame index in the image flow. *u* and *v* are image-based coordinate representations of vector spaces, represented by $\Delta u - axis$ and $\Delta v - axis$. Each successive point is represented by $P_{i+1} = (u_{i+1}, v_{i+1})$.

5.2.3.2. Velocity

Velocity of movement would simply be calculated by dividing the trajectory of movements by Time, $\text{Vel} = \vec{a}/\text{T}$.

5.2.3.3. Distance

Finally, in order to compute the distance between the two points, we use the ℓ^2-norm, otherwise known as the Euclidean norm, which is used to compute vector lengths in Euclidean space using the square root of the sum of the squares of the values in each dimension (Weisstein, 2000; Li and Jain, 2015):

$$\|a\| = \sqrt{(u_2 - u_1) \times (u_2 - u_1) + (v_2 - v_1) \times (v_2 - v_1)} \quad (1)$$

6. DISCUSSION

At its core, the current work focused on a conceptualization of human-agent interaction, namely the relationship between human interlocutors and the agents that represent them. Broadly defined, avatars may be understood as virtual (i.e., visual) representations of agent simulations of human interlocutors. In the narrower context of virtual reality, virtual representations rely on physical kinematic inputs with varying degrees of fidelity. For instance, VR head rotations represent movements that involve a high degree of correspondence between physical inputs and virtual outputs. Alternatively, VR locomotion may occur fully in the absence of corresponding physical locomotion, producing a perceptual experience of walking (e.g., teleporting, steering) without the physical act of walking. The current work investigated the complex relationship between physical and virtual movement in two ways. First, we explicated a typology of Protean Kinematics, focusing particularly on the physical-virtual intersection of person-based actions and environment-based affordances. Second, we outlined the steps required to transform physical locomotion into virtual representations, namely by undergoing a 3D to 2D transformation, as well as by calibrating the conversion of physical to virtual units of measurement (meters to pixels).

Ultimately, Protean kinematics assumes a mismatch between the physical and virtual actions, a mismatch predicated on affordances in physical and virtual spaces, preferential sensitivity (e.g., mouse sensitivity), and calibration of physical to virtual units of measurement (e.g., meters to pixels). Such a lack of kinematic fidelity across physical and virtual experiences, as well as biological advances that underscore the significance of "actually walking" to the brain's perception of one's spatial environment introduce constraints and limitations to VR development. Insofar as VR is conceptualized as a "window" into an alternate reality (e.g., environment) for users that lack adequate physical space to navigate such virtual spaces, user experience may be considerably constrained (e.g., cybersickness). Addressing such a constraint may warrant re-conceptualizing VR development beyond purely the visual perception of image projections on screens (e.g., monitors), and incorporating additional systems, such as vestibular and olfactory inputs, as well as postural stability. Scholarly work on hippocampal place cells and grid cells indicate that beyond the visual perception of navigating an environment, our brains may require the act of walking to encode both objects within and perimeters of a given environment/space. Further, recent evidence suggests that speed of movement (e.g., running) is reflected in the firing rate of a distinct class of entorhinal neurons, knwon as "speed cells" (Kropff et al., 2015). Perhaps the simplest solution may be to utilize expansive physical environments that afford corresponding fidelity between physical and virtual locomotion. Another option may be to equip VR headsets with multi-directional thrusters (i.e., fans) that would blow physical air in the direction and strength corresponding with a virtual locomotive trajectory. Both of the above suggestions however, are quite costly in both physical space and hardware development. An alternative solution may be to abandon virtual reality altogether and to turn to mixed/augmented reality, thus affording virtual objects and actions to appear within a fully perceivable physical environment.

By introducing Protean kinematics, we present a conceptual model that blends and blurs the distinction between physical and virtual experience. The future of avatar research in VR should consider the increasingly blended nature of mediated experience. Mixed reality or augmented reality (Silva and Teixeira, 2020; Papakostas et al., 2021a,b) quite literally address the "blend" between physical and virtual experiences (e.g., objects, people/avatars, environments) (Miller et al., 2019d). In mixed reality, the hippocampus may retain normative processing of spatial navigation in one's physical environment while users flexibly engage in a variety of virtual actions. Given the potential harmony between physical environments and virtual actions, mixed reality may afford tremendous potential to improve our biological understanding of spatial navigation. That being said, mixed reality excludes the virtual environment, one of the fundamental components of multiplayer gaming and the sharing of virtual spaces (e.g., social VR).

Social perception of movement is important in considering avatars in present day and into the future given expanding use and applications of avatars beyond gaming contexts, such as by major social media platforms (Snapchat Bitmoji, Apple Memoji) and web conferencing platforms (Mozilla Hubs, Gather.Town) which are cost-efficient and have low barriers for entry. Internet users are also increasingly using avatar generating platforms such as FaceRig, and VRoid Studio, which are "face-rigging" software that generates real-time responsive avatars[9]. Meanwhile, developers continue to improve the accessibility of avatars, virtual humans, and character animations for researchers, as seen in the Microsoft Rocketbox virtual human library (Gonzalez-Franco et al., 2020) and the Adobe Mixamo character animation system[10], both of which are readily integrated with Unity and capable of being imported into Blender.

6.1. Future Research

Continued innovation and rising demand for avatars warrants widespread scholarly attention from social science researchers. Avatars may be understood as virtual/visual representations of human goal-directed actions. While substantial avatar research is paid to avatar appearance (e.g., Proteus Effect), the current work focused on avatar movements, namely the complex relationship between physical and virtual kinematics. We propose future research to consider the role of kinematics in the social perception of avatar, with particular attention on the contingent physical actions driving virtual actions in VR. As noted in the current work, VR kinematics (particularly locomotion) must be understood in light of the oft-mismatched or lack of correspondence between physical and virtual environment-based affordances (e.g., space).

Within the social sciences, virtual representations of real-world situations may afford greater generalizability (Miller et al., 2019a,b), which may contribute to scientific replicability. By combining virtual flexibility and realism with culturally-nuanced representations of real-world situations and circumstances (Kim et al., 2021), VR affords investigating the dynamics of human behavior for real-world outcomes (e.g., decision-making). Further, the approach introduced in the current work may be supplemented using computer vision and machine learning techniques that afford analysis of real-time sequential behavior, such as gestures (Jeong et al., 2020). Although the current work focused on 2-dimensional locomotion, we will address the application of Protean kinematics on 3-dimensional arm gestures and head movements in forthcoming work.

The mismatch between physical inputs and virtual outputs experienced in Protean kinematics may not necessarily negatively impact VR user experience. Rather than kinematic fidelity between physical and virtual movements, VR movements may be better understood as goal-directed behavior (e.g., approach-avoidance motivation systems). VR behavior can be understood as a mouse cursor that does not necessarily correspond precisely with a physical computer mouse or trackpad. As demonstrated by Won et al. (2015), imperfections in correspondence between physical inputs and virtual outputs demonstrate the homuncular flexibility of the human mind. Ultimately, Protean kinematics may be conceptualized as a form of *presence*, a psychological state in which the virtuality of movement is unnoticed (Lee, 2004).

All this being said, we would be remiss to not discuss the ethical implications of motion tracking in VR (Miller et al., 2020; Carter and Egliston, 2021). Indeed, the platformization of VR (e.g., Oculus) is of grave concern to many VR users and researchers (Egliston and Carter, 2020). At this point, we reiterate the critical significance of open science among researchers of technology and platforms. With the possibility for ethical abuse and scientific malpractice, researchers' steadfast commitment to maintaining scientific transparency and openness is critical (Open Science Collaboration, 2015; Bowman and Keene, 2018; Lewis, 2020).

6.2. Conclusion

In the current work, we discuss the potential fallacy in emphasizing kinematic fidelity in VR as the perceptual experience of VR environments and users does not (yet) correspond with the perceptual experience of the physical world and people. We have also presented connections of VR kinematics to neurological understanding of spatial perception and motion perception, as well as outlining.

Our explication of Protean kinematics introduced its grounding in physics (i.e., kinematics), a typology of physical/virtual actions and affordances, and a computational model describing the physics and geometry underlying the intersection of physical and virtual experience. This process requires understanding calibration based on physical to virtual units of measurement (meters to pixels) as well as calibration based on personal preference (e.g., mouse sensitivity).

This work contributes to avatar embodiment with both a theoretical (typology) and methodological (physics-based measurement) approach to understanding the complex blend of physical inputs and virtual outputs that occur in VR (Won et al., 2015). Offered is a novel method of utilizing the unique blend of physical and virtual kinematics in VR for potentially reliable measures of goals and motivation (Lee et al., 2019).

Taken together, the current work introduces a framework for re-conceptualizing behavioral measurement. Physical behavior is understood as distinct from virtual representations of such behavior. While there has been evidence of behavioral consistencies (i.e., validity) across virtual and real contexts, the current work proposes a blended approach to virtuality by exploring the intersection of physical and virtual movement in VR. Moving forward, media researchers may consider moving beyond conceptualizing physical experience as non-virtual and virtual experience as non-physical.

AUTHOR CONTRIBUTIONS

DJ, SK, and LM developed theory and literature review. JX developed literature review. DJ developed locomotive

[9]Face-rigged avatars are primarily used by Virtual YouTubers (Zhao et al., 2019; Lu et al., 2021), such as Kizuna AI, although newer social media platforms such as ItsMe (https://www.itsme.video/) connect face-rigging avatars with social media functionality.

[10]www.mixamo.com

kinematic measurements and produced figures. All authors contributed to the article and approved the submitted version.

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REFERENCES

Acharya, L., Aghajan, Z., Vuong, C., Moore, J., and Mehta, M. (2016). Causal Influence of visual cues on hippocampal directional selectivity. *Cell* 164, 197–207. doi: 10.1016/j.cell.2015.12.015

Aghajan, Z. M., Acharya, L., Moore, J. J., Cushman, J. D., Vuong, C., and Mehta, M. R. (2015). Impaired spatial selectivity and intact phase precession in two-dimensional virtual reality. *Nat. Neurosci.* 18, 121–128. doi: 10.1038/nn.3884

Ahn, S. J., and Bailenson, J. N. (2011). Self-endorsing versus other-endorsing in virtual environments. *J. Advert.* 40, 93–106. doi: 10.2753/JOA0091-3367400207

Andriluka, M., Roth, S., and Schiele, B. (2010). "Monocular 3D pose estimation and tracking by detection," in *2010 IEEE Computer Society Conference on Computer Vision and Pattern Recognition* (San Francisco, CA,: IEEE), 623–630.

Aymerich-Franch, L., Kizilcec, R. F., and Bailenson, J. N. (2014). The relationship between virtual self similarity and social anxiety. *Front. Hum. Neurosci.* 8:944. doi: 10.3389/fnhum.2014.00944

Bailey, J. O., Bailenson, J. N., and Casasanto, D. (2016). When does virtual embodiment change our minds? *Presence* 25, 222–233. doi: 10.1162/PRES_a_00263

Bandura, A. (2001). Social cognitive theory of mass communication. *Media Psychol.* 3, 265–299. doi: 10.1207/S1532785XMEP0303_03

Barsalou, L. W. (2009). Simulation, situated conceptualization, and prediction. *Philos. Trans. R. Soc. B Biol. Sci.* 364, 1281–1289. doi: 10.1098/rstb.2008.0319

Beaudoin, M., Barra, J., Dupraz, L., Mollier-Sabet, P., and Guerraz, M. (2020). The impact of embodying an "elderly" body avatar on motor imagery. *Exp. Brain Res.* 238, 1467–1478. doi: 10.1007/s00221-020-05828-5

Bem, D. J. (1972). "Self-perception theory," in *Advances in Experimental Social Psychology*, Vol. 6, (Academic Press), 1–62.

Benoit, W. L., and Holbert, R. L. (2008). Empirical intersections in communication research: replication, multiple quantitative methods, and bridging the quantitative-qualitative divide. *J. Commun.* 58, 615–628. doi: 10.1111/j.1460-2466.2008.00404.x

Bente, G., Krämer, N. C., Petersen, A., and de Ruiter, J. P. (2001). Computer animated movement and person perception: methodological advances in nonverbal behavior research. *J. Nonverbal. Behav.* 25, 151–166. doi: 10.1023/A:1010690525717

Benthall, J., and Polhemus, T. (1975). *The Body as a Medium of Expression: Essays Based on a Course of Lectures Given at the Institute of Contemporary Arts*. London. Allen Lane.

Biocca, F. (1997). The cyborg's dilemma: progressive embodiment in virtual environments. *J. Comput. Med. Commun.* 3, JCMC324. doi: 10.1111/j.1083-6101.1997.tb00070.x

Birk, M., and Mandryk, R. L. (2013). "Control your game-self: effects of controller type on enjoyment, motivation, and personality in game," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Paris), 685–694.

Borenstein, J., and Feng, L. (1994). *UMBmark–A Method for Measuring, Comparing, and Correcting Dead-reckoning Errors in Mobile Robots*.

Botvinick, M., and Cohen, J. (1998). Rubber hands 'feel'touch that eyes see. *Nature* 391, 756–756. doi: 10.1038/35784

Bowman, N. D., and Keene, J. R. (2018). A layered framework for considering open science practices. *Commun. Res. Rep.* 35, 363–372. doi: 10.1080/08824096.2018.1513273

Bozgeyikli, E., Raij, A., Katkoori, S., and Dubey, R. (2016). "Point teleport locomotion technique for virtual reality," in *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play* (Austin, TX), 205–216.

Brandt, M. J., IJzerman, H., Dijksterhuis, A., Farach, F. J., Geller, J., Giner-Sorolla, R., et al. (2014). The replication recipe: what makes for a convincing replication? *J. Exp. Soc. Psychol.* 50, 217–224. doi: 10.1016/j.jesp.2013.10.005

Brigante, C. M., Abbate, N., Basile, A., Faulisi, A. C., and Sessa, S. (2011). Towards miniaturization of a mems-based wearable motion capture system. *IEEE Trans. Ind. Electron.* 58, 3234–3241. doi: 10.1109/TIE.2011.2148671

Canning, C. G., Allen, N. E., Nackaerts, E., Paul, S. S., Nieuwboer, A., and Gilat, M. (2020). Virtual reality in research and rehabilitation of gait and balance in parkinson disease. *Nat. Rev. Neurol.* 16, 409–425. doi: 10.1038/s41582-020-0370-2

Cao, Z., Simon, T., Wei, S.-E., and Sheikh, Y. (2017). "Realtime multi-person 2d pose estimation using part affinity fields," in *Proceedings of the IEEE Conference on CVPR* (Honolulu, HI), 7291–7299.

Carandini, M., and Churchland, A. K. (2013). Probing perceptual decisions in rodents. *Nat. Neurosci.* 16, 824–831. doi: 10.1038/nn.3410

Carter, M., and Egliston, B. (2021). What are the risks of virtual reality data? learning analytics, algorithmic bias and a fantasy of perfect data. *New Media Soc.* 14614448211012794. doi: 10.1177/14614448211012794. [Epub ahead of print].

Carver, C. S., and White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: the bis/bas scales. *J. Pers. Soc. Psychol.* 67:319. doi: 10.1037/0022-3514.67.2.319

Caserman, P., Achenbach, P., and Göbel, S. (2019a). "Analysis of inverse kinematics solutions for full-body reconstruction in virtual reality," in *2019 IEEE 7th International Conference on Serious Games and Applications for Health (SeGAH)* (Kyoto: IEEE), 1–8.

Caserman, P., Garcia-Agundez, A., Konrad, R., Göbel, S., and Steinmetz, R. (2019b). Real-time body tracking in virtual reality using a vive tracker. *Virtual Real.* 23, 155–168. doi: 10.1007/s10055-018-0374-z

Christensen, J. L., Miller, L. C., Appleby, P. R., Corsbie-Massay, C., Godoy, C. G., Marsella, S. C., et al. (2013). Reducing shame in a game that predicts hiv risk reduction for young adult men who have sex with men: a randomized trial delivered nationally over the web. *J. Int. AIDS Soc.* 16:18716. doi: 10.7448/IAS.16.3.18716

Christou, C., and Michael, D. (2014). "Aliens versus humans: do avatars make a difference in how we play the game?" in *2014 6th International Conference on Games and Virtual Worlds for Serious Applications (VS-GAMES)* (Valletta: IEEE), 1–7.

Clifton, J., and Palmisano, S. (2020). Effects of steering locomotion and teleporting on cybersickness and presence in hmd-based virtual reality. *Virtual Real.* 24, 453–468. doi: 10.1007/s10055-019-00407-8

Cummings, J. J., and Bailenson, J. N. (2016). How immersive is enough? a meta-analysis of the effect of immersive technology on user presence. *Media Psychol.* 19, 272–309. doi: 10.1080/15213269.2015.1015740

Cummings, J. J., Tsay-Vogel, M., Cahill, T. J., and Zhang, L. (2021). Effects of immersive storytelling on affective, cognitive, and associative empathy: the mediating role of presence. *New Media Soc.* 1461444820986816. doi: 10.1177/1461444820986816. [Epub ahead of print].

Dienlin, T., Johannes, N., Bowman, N. D., Masur, P. K., Engesser, S., Kümpel, A. S., et al. (2020). An agenda for open science in communication. *J. Commun.* 71, 1–26. doi: 10.1093/joc/jqz052

Egliston, B., and Carter, M. (2020). Oculus imaginaries: the promises and perils of facebook's virtual reality. *New Media Soc.* 1461444820960411. doi: 10.1177/1461444820960411. [Epub ahead of print].

Fox, J., and Ahn, S. J. (2013). "Avatars: portraying, exploring, and changing online and offline identities," in *Handbook of Research on Technoself: Identity in a Technological Society* (IGI Global), 255–271.

Fyhn, M., Molden, S., Witter, M. P., Moser, E. I., and Moser, M.-B. (2004). Spatial representation in the entorhinal cortex. *Science* 305, 1258–1264. doi: 10.1126/science.1099901

Georges-François, P., Rolls, E. T., and Robertson, R. G. (1999). Spatial view cells in the primate hippocampus: allocentric view not head direction or eye position or place. *Cereb. Cortex* 9, 197–212. doi: 10.1093/cercor/9.3.197

Gibson, J. J. (1979). *The Ecological Approach to Visual Perception*. Houghton, MI: Mifflin and Company.

Godoy, C. G., Appleby, P. R. R., Miller, L. C., Christensen, J. L., Read, S. J., and Corsbie-Massay, C. (2008). "Been there, done that: Virtual risk taking and the theory of planned behavior," in *Annals of Behavioral Medicine*, Vol. 35 (New York, NY: Springer), S63–S63.

Gonzalez-Franco, M., and Lanier, J. (2017). Model of illusions and virtual reality. *Front. Psychol.* 8:1125. doi: 10.3389/fpsyg.2017.01125

Gonzalez-Franco, M., Ofek, E., Pan, Y., Antley, A., Steed, A., Spanlang, B., et al. (2020). The rocketbox library and the utility of freely available rigged avatars. *Front. Virtual Real.* 1:561558. doi: 10.3389/frvir.2020.561558

Grabarczyk, P., and Pokropski, M. (2016). Perception of affordances and experience of presence in virtual reality. *Avant* 7, 25–44. doi: 10.26913/70202016.0112.0002

Gratch, J., Rickel, J., André, E., Cassell, J., Petajan, E., and Badler, N. (2002). Creating interactive virtual humans: some assembly required. *IEEE Intell. Sys.* 17, 54–63. doi: 10.1109/MIS.2002.1024753

Gray, J. A. (1981). "A critique of eysenck's theory of personality," in *A Model for Personality* (Heidelberg: Springer), 246–276.

Gray, J. A., and Smith, P. T. (1969). "An arousal-decision model for partial reinforcement and discrimination learning," in *Animal Discrimination Learning*, eds R. Gilbert and N. S. Sutherland (London: Academic Press), 243–272.

Green, M. C., and Brock, T. C. (2000). The role of transportation in the persuasiveness of public narratives. *J. Pers. Soc. Psychol.* 79, 701. doi: 10.1037/0022-3514.79.5.701

Hahn, L., Rathbun, S. L., Schmidt, M. D., Johnsen, K., Annesi, J. J., and Ahn, S. J. (2020). Using virtual agents and activity monitors to autonomously track and assess self-determined physical activity among young children: a 6-week feasibility field study. *Cyberpsychol. Behav. Soc. Netw.* 23, 471–478. doi: 10.1089/cyber.2019.0491

Hall, E. T., Birdwhistell, R. L., Bock, B., Bohannan, P., Diebold Jr, A. R., Durbin, M., et al. (1968). Proxemics [and comments and replies]. *Curr. Anthropol.* 9, 83–108. doi: 10.1086/200975

Heider, F., and Simmel, M. (1944). An experimental study of apparent behavior. *Am. J. Psychol.* 57, 243–259. doi: 10.2307/1416950

Herrera, F., Oh, S. Y., and Bailenson, J. N. (2020). Effect of behavioral realism on social interactions inside collaborative virtual environments. *Presence* 27, 163–182. doi: 10.1162/pres_a_00324

Ioannidis, J. P. (2012). Why science is not necessarily self-correcting. *Perspect. Psychol. Sci.* 7, 645–654. doi: 10.1177/1745691612464056

Jeffery, K. J., Donnett, J. G., Burgess, N., and O'Keefe, J. M. (1997). Directional control of hippocampal place fields. *Exp. Brain Res.* 117, 131–142. doi: 10.1007/s002210050206

Jeong, D. C., Feng, D., and Marsella, S. (2018). "Understanding human social kinematics using virtualAgents," in *Proceedings of the 40th Annual Meeting of the Cognitive Science Society, CogSci 2018*, eds C. Kalish, M. A. Rau, X. J. Zhu, and T. T. Rogers (Madison, WI: Cognitivesciencesociety.org).

Jeong, D. C., Xu, J. J., and Miller, L. C. (2020). "Inverse kinematics and temporal convolutional networks for sequential pose analysis in vr," in *2020 IEEE International Conference on Artificial Intelligence and Virtual Reality (AIVR)* (Utrecht: IEEE), 274–281.

Jones, M., Jones, R., Woods, M., Whitehead, M., Dixon, D., and Hannah, M. (2014). *An Introduction to Political Geography: Space, Place and Politics*. London: Routledge.

Keating, D. M., and Totzkay, D. (2019). We do publish (conceptual) replications (sometimes): publication trends in communication science, 2007–2016. *Ann. Int. Commun. Assoc.* 43, 225–239. doi: 10.1080/23808985.2019.1632218

Kim, S. S. Y., Liu, M., Qiao, A., and Miller, L. C. (2021). "I want to be alone, but I don't want to be lonely:" uncertainty management regarding social situations among college students with social anxiety disorder. *Health Commun.* 1–12. doi: 10.1080/10410236.2021.1912890. [Epub ahead of print].

Klein, O., Hardwicke, T. E., Aust, F., Breuer, J., Danielsson, H., Mohr, A. H., et al. (2018). A practical guide for transparency in psychological science. *Collabra Psychol.* 4, 20. doi: 10.1525/collabra.158

Kocur, M., Graf, S., and Schwind, V. (2020a). "The impact of missing fingers in virtual reality," in *26th ACM Symposium on Virtual Reality Software and Technology* (Ottawa, ON), 1–5.

Kocur, M., Kloss, M., Schwind, V., Wolff, C., and Henze, N. (2020b). "Flexing muscles in virtual reality: effects of avatars' muscular appearance on physical performance," in *Proceedings of the Annual Symposium on Computer-Human Interaction in Play* (Ottawa, ON), 193–205.

Kropff, E., Carmichael, J. E., Moser, M.-B., and Moser, E. I. (2015). Speed cells in the medial entorhinal cortex. *Nature* 523, 419–424. doi: 10.1038/nature14622

Kruzan, K. P., and Won, A. S. (2019). Embodied well-being through two media technologies: virtual reality and social media. *New Media Soc.* 21, 1734–1749. doi: 10.1177/1461444819829873

Kucherenko, T., Hasegawa, D., Kaneko, N., Henter, G. E., and Kjellström, H. (2021). Moving fast and slow: analysis of representations and post-processing in speech-driven automatic gesture generation. *Int. J. Hum. Comput. Interact.* 37, 1300–1316. doi: 10.1080/10447318.2021.1883883

Langbehn, E., Paulmann, H., Briddigkeit, D., Barnes, M., Husung, M., Kirsch, K., et al. (2020). "Frozen factory: a playful virtual experience for multiple co-located redirected walking users," in *SIGGRAPH Asia 2020 XR*, 1–2.

Lea, C., Flynn, M. D., Vidal, R., Reiter, A., and Hager, G. D. (2017). "Temporal convolutional networks for action segmentation and detection," in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition* (Honolulu, HI: IEEE), 156–165.

Lee, J., Eden, A., Ewoldsen, D. R., Beyea, D., and Lee, S. (2019). Seeing possibilities for action: orienting and exploratory behaviors in vr. *Comput. Hum. Behav.* 98, 158–165. doi: 10.1016/j.chb.2019.03.040

Lee, J.-E. R., Nass, C. I., and Bailenson, J. N. (2014). Does the mask govern the mind?: Effects of arbitrary gender representation on quantitative task performance in avatar-represented virtual groups. *Cyberpsychol. Behav. Soc. Netw.* 17, 248–254. doi: 10.1089/cyber.2013.0358

Lee, K. M. (2004). Presence, explicated. *Commun. Theory* 14, 27–50. doi: 10.1111/j.1468-2885.2004.tb00302.x

Lewin, K. (1935). *A Dynamic Theory of Personality: Selected Papers*. McGraw-Hill Book Company, Incorporated. Google-Books-ID: JxlHAAAAMAAJ.

Lewin, K. (1936). Some social-psychological differences between the united states and germany. *Charact. Pers. Q. Psychodiagnostic Allied Stud.* 4, 265–293. doi: 10.1111/j.1467-6494.1936.tb02034.x

Lewin, K. (1943). Defining the'field at a given time'. *Psychol. Rev.* 50, 292. doi: 10.1037/h0062738

Lewis Jr, N. A. (2020). Open communication science: a primer on why and some recommendations for how. *Commun. Methods Meas.* 14, 71–82. doi: 10.1080/19312458.2019.1685660

Li, S. Z., and Jain, A. (2015). *Encyclopedia of Biometrics*. Springer Publishing Company, Incorporated.

Lu, Z., Shen, C., Li, J., Shen, H., and Wigdor, D. (2021). "More Kawaii than a real-person live streamer: understanding how the otaku community engages with and perceives virtual YouTubers," in *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems. Association for Computing Machinery* (New York, NY), 1–14. doi: 10.1145/3411764.3445660

Lugrin, J.-L., Ertl, M., Krop, P., Klüpfel, R., Stierstorfer, S., Weisz, B., et al. (2018). "Any "body" there? avatar visibility effects in a virtual reality game," in *2018*

IEEE Conference on Virtual Reality and 3D User Interfaces (VR) (Reutlingen: IEEE), 17–24.

Lugrin, J.-L., Zilch, D., Roth, D., Bente, G., and Latoschik, M. E. (2016). "Facebo: real-time face and body tracking for faithful avatar synthesis," in *2016 IEEE Virtual Reality (VR)* (Greenville, SC: IEEE), 225–226.

Marsella, S., Xu, Y., Lhommet, M., Feng, A., Scherer, S., and Shapiro, A. (2013). "Virtual character performance from speech," in *Proceedings of the 12th ACM SIGGRAPH/Eurographics Symposium on Computer Animation* (Anaheim, CA), 25–35.

Martingano, A. J., Hererra, F., and Konrath, S. (2021). Virtual reality improves emotional but not cognitive empathy: a meta-analysis. *Technol. Mind Behav*. 2. doi: 10.1037/tmb0000034. [Epub ahead of print].

Maruhn, P., Schneider, S., and Bengler, K. (2019). Measuring egocentric distance perception in virtual reality: influence of methodologies, locomotion and translation gains. *PLoS ONE* 14:e0224651. doi: 10.1371/journal.pone.0224651

McEwan, B., Carpenter, C. J., and Westerman, D. (2018). On replication in communication science. *Commun. Stud*. 69, 235–241. doi: 10.1080/10510974.2018.1464938

McNaughton, B. L., Chen, L. L., and Markus, E. J. (1991). "Dead reckoning," landmark learning, and the sense of direction: a neurophysiological and computational hypothesis. *J. Cogn. Neurosci*. 3, 190–202. doi: 10.1162/jocn.1991.3.2.190

Miller, L. C., Jeong, D. C., Wang, L., Shaikh, S. J., Gillig, T. K., Godoy, C. G., et al. (2019a). Systematic representative design: a reply to commentaries. *Psychol Inq*. 30, 250–263. doi: 10.1080/1047840X.2019.1698908

Miller, L. C., Shaikh, S. J., Jeong, D. C., Wang, L., Gillig, T. K., Godoy, C. G., et al. (2019b). Causal inference in generalizable environments: systematic representative design. *Psychol Inq*. 30, 173–202. doi: 10.1080/1047840X.2019.1693866

Miller, L. C., Wang, L., Jeong, D. C., and Gillig, T. K. (2019c). "Bringing the real world into the experimental lab: technology-enabling transformative designs," *Social-Behavioral Modeling for Complex Systems*, eds P. K. Davis, A. O'Mahony, and J. Pfautz (John Wiley & Sons Inc.), 359–386. doi: 10.1002/9781119485001.ch16

Miller, M. R., Herrera, F., Jun, H., Landay, J. A., and Bailenson, J. N. (2020). Personal identifiability of user tracking data during observation of 360-degree vr video. *Sci. Rep*. 10, 1–10. doi: 10.1038/s41598-020-74486-y

Miller, M. R., Jun, H., Herrera, F., Yu Villa, J., Welch, G., and Bailenson, J. N. (2019d). Social interaction in augmented reality. *PLoS ONE* 14:e0216290. doi: 10.1371/journal.pone.0216290

Miller, N. E. (1944). "Experimental studies of conflict," in *Personality and the Behavior Disorders, Vol. 1*, ed J. M. Hunt (New York, NY: Ronald Press), 431–465.

Miller, N. E. (1959). Liberalization of basic sr concepts: extensions to conflict behavior, motivation and social learning. *Psychology* 2, 196–292.

Miller, N. E., and Dollard, J. (1941). *Social Learning and Imitation*. Yale University Press.

Minderer, M., Harvey, C. D., Donato, F., and Moser, E. I. (2016). Virtual reality explored. *Nature* 533, 324–325. doi: 10.1038/nature17899

Moser, E. I., Moser, M.-B., and McNaughton, B. L. (2017). Spatial representation in the hippocampal formation: a history. *Nat. Neurosci*. 20, 1448–1464. doi: 10.1038/nn.4653

Navarro, J., Pe na, J., Cebolla, A., and Ba nos, R. (2020). Can avatar appearance influence physical activity? user-avatar similarity and proteus effects on cardiac frequency and step counts. *Health Commun*. 1–8. doi: 10.1080/10410236.2020.1834194. [Epub ahead of print].

Nosek, B. A., Alter, G., Banks, G. C., Borsboom, D., Bowman, S. D., Breckler, S. J., et al. (2015). Promoting an open research culture. *Science* 348, 1422–1425. doi: 10.1126/science.aab2374

Nowak, K. L., and Fox, J. (2018). Avatars and computer-mediated communication: a review of the definitions, uses, and effects of digital representations. *Rev. Commun. Res*. 6, 30–53. doi: 10.12840/issn.2255-4165.2018.06.01.015

Oh, C., Herrera, F., and Bailenson, J. (2019). The effects of immersion and real-world distractions on virtual social interactions. *Cyberpsychol. Behav. Soc. Netw*. 22, 365–372. doi: 10.1089/cyber.2018.0404

O'Keefe, J., and Dostrovsky, J. (1971). The hippocampus as a spatial map: Preliminary evidence from unit activity in the freely-moving rat. *Brain Res*. 34, 171–175. doi: 10.1016/0006-8993(71)90358-1

Open Science Collaboration (2015). Estimating the reproducibility of psychological science. *Science* 349:aac4716. doi: 10.1126/science.aac4716

Palmisano, S., Apthorp, D., Seno, T., and Stapley, P. J. (2014). Spontaneous postural sway predicts the strength of smooth vection. *Exp. Brain Res*. 232, 1185–1191. doi: 10.1007/s00221-014-3835-y

Palmisano, S., Arcioni, B., and Stapley, P. J. (2018). Predicting vection and visually induced motion sickness based on spontaneous postural activity. *Exp. Brain Res*. 236, 315–329. doi: 10.1007/s00221-017-5130-1

Palmisano, S., Mursic, R., and Kim, J. (2017). Vection and cybersickness generated by head-and-display motion in the oculus rift. *Displays* 46, 1–8. doi: 10.1016/j.displa.2016.11.001

Papakostas, C., Troussas, C., Krouska, A., and Sgouropoulou, C. (2021a). Exploration of augmented reality in spatial abilities training: a systematic literature review for the last decade. *Inform. Educ*. 20, 107–130. doi: 10.15388/infedu.2021.06

Papakostas, C., Troussas, C., Krouska, A., and Sgouropoulou, C. (2021b). User acceptance of augmented reality welding simulator in engineering training. *Educ. Inform. Technol*. 1–27. doi: 10.1007/s10639-020-10418-7. [Epub ahead of print].

Pierce, J., Martin, D. G., and Murphy, J. T. (2011). Relational place-making: the networked politics of place. *Transactions of the Institute of British Geographers* 36, 54–70. doi: 10.1111/j.1475-5661.2010.00411.x

Pinto, L., Koay, S. A., Engelhard, B., Yoon, A. M., Deverett, B., Thiberge, S. Y., et al. (2018). An accumulation-of-evidence task using visual pulses for mice navigating in virtual reality. *Front. Behav. Neurosci*. 12:36. doi: 10.3389/fnbeh.2018.00036

Piryankova, I. V., Wong, H. Y., Linkenauger, S. A., Stinson, C., Longo, M. R., Bülthoff, H. H., et al. (2014). Owning an overweight or underweight body: distinguishing the physical, experienced and virtual body. *PLoS ONE* 9:e103428. doi: 10.1371/journal.pone.0103428

Pishchulin, L., Jain, A., Andriluka, M., Thormählen, T., and Schiele, B. (2012). "Articulated people detection and pose estimation: reshaping the future," in *2012 IEEE Conference on Computer Vision and Pattern Recognition* (Providence, RI: IEEE), 3178–3185.

Pizzo, F., Roehri, N., Medina Villalon, S., Trébuchon, A., Chen, S., Lagarde, S., et al. (2019). Deep brain activities can be detected with magnetoencephalography. *Nat. Commun*. 10, 971. doi: 10.1038/s41467-019-08665-5

Praetorius, A. S., and Görlich, D. (2020). "How avatars influence user behavior: a review on the proteus effect in virtual environments and video games," in *International Conference on the Foundations of Digital Games* (Bugibba Malta), 1–9.

Ratan, R. (2013). "Self-presence, explicated: Body, emotion, and identity extension into the virtual self," in *Handbook of Research on Technoself: IDENTITY in a Technological Society* (IGI Global), 322–336.

Ratan, R., Beyea, D., Li, B. J., and Graciano, L. (2020). Avatar characteristics induce users' behavioral conformity with small-to-medium effect sizes: a meta-analysis of the proteus effect. *Media Psychol*. 23, 651–675. doi: 10.1080/15213269.2019.1623698

Ratan, R., and Sah, Y. J. (2015). Leveling up on stereotype threat: The role of avatar customization and avatar embodiment. *Comput. Hum. Behav*. 50, 367–374. doi: 10.1016/j.chb.2015.04.010

Ratan, R. A., and Dawson, M. (2016). When mii is me: a psychophysiological examination of avatar self-relevance. *Commun. Res*. 43, 1065–1093. doi: 10.1177/0093650215570652

Ravassard, P., Kees, A., Willers, B., Ho, D., Aharoni, D., Cushman, J., et al. (2013). Multisensory control of hippocampal spatiotemporal selectivity. *Science* 340, 1342–1346. doi: 10.1126/science.1232655

Razzaque, S. (2005). *Redirected Walking (Order No. 3190299). Available from ProQuest Dissertations & Theses Global; ProQuest One Academic. (305393643)*. Available online at: http://libproxy.usc.edu/login?url=https://www.proquest.com/dissertations-theses/redirected-walking/docview/305393643/se-2?accountid=14749

Renner, R. S., Velichkovsky, B. M., and Helmert, J. R. (2013). The perception of egocentric distances in virtual environments-a review. *ACM Comput. Surveys* 46, 1–40. doi: 10.1145/2543581.2543590

Riva, G., and Gaudio, S. (2018). Locked to a wrong body: eating disorders as the outcome of a primary disturbance in multisensory body integration. *Conscious Cogn*. 59:57–59. doi: 10.1016/j.concog.2017.08.006

Riva, G., Mantovani, F., Capideville, C. S., Preziosa, A., Morganti, F., Villani, D., et al. (2007). Affective interactions using virtual reality: the link between presence and emotions. *Cyber Psychol. Behav*. 10, 45–56. doi: 10.1089/cpb.2006.9993

Riva, G., Wiederhold, B. K., and Mantovani, F. (2019). Neuroscience of virtual reality: from virtual exposure to embodied medicine. *Cyberpsychol. Behav. Soc. Netw*. 22, 82–96. doi: 10.1089/cyber.2017.29099.gri

Roetenberg, D., Luinge, H., and Slycke, P. (2009). *Xsens Mvn: Full 6dof Human Motion Tracking Using Miniature Inertial Sensors*. Technical Report 1. Xsens Motion Technologies BV.

Rolls, E. T., and O'Mara, S. M. (1995). View-responsive neurons in the primate hippocampal complex. *Hippocampus* 5, 409–424. doi: 10.1002/hipo.450050504

Rolls, E. T., and Wirth, S. (2018). Spatial representations in the primate hippocampus, and their functions in memory and navigation. *Progr. Neurobiol*. 171, 90–113. doi: 10.1016/j.pneurobio.2018.09.004

Roth, D., Latoschik, M. E., Vogeley, K., and Bente, G. (2015). Hybrid avatar-agent technology-a conceptual step towards mediated "social" virtual reality and its respective challenges. *i-com* 14, 107–114. doi: 10.1515/icom-2015-0030

Roth, D., Lugrin, J.-L., Büser, J., Bente, G., Fuhrmann, A., and Latoschik, M. E. (2016). "A simplified inverse kinematic approach for embodied vr applications," in *2016 IEEE Virtual Reality (VR)* (Greenville, SC: IEEE), 275–276.

Schank, R. C., and Abelson, R. P. (1975). Scripts, plans, and knowledge. *IJCAI* 75, 151–157.

Schneirla, T. C. (1959). "An evolutionary and developmental theory of biphasic processes underlying approach and withdrawal," in *Nebraska Symposium on Motivation*, Vol. 7, ed M. R. Jones (Lincoln: University Nebraska Press), 1–42.

Sherrick, B., Hoewe, J., and Waddell, T. F. (2014). The role of stereotypical beliefs in gender-based activation of the proteus effect. *Comput. Hum. Behav*. 38, 17–24. doi: 10.1016/j.chb.2014.05.010

Shin, M., Song, S. W., and Chock, T. M. (2019). Uncanny valley effects on friendship decisions in virtual social networking service. *Cyberpsychol. Behav. Soc. Netw*. 22, 700–705. doi: 10.1089/cyber.2019.0122

Silva, M., and Teixeira, L. (2020). "Developing an extended reality platform for immersive and interactive experiences for cultural heritage: Serralves museum and coa archeologic park," in *2020 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct)* (Recife: IEEE), 300–302.

Slater, M. (2009). Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. *Philos. Trans. R. Soc. B Biol. Sci*. 364, 3549–3557. doi: 10.1098/rstb.2009.0138

Smith, B. J., Xue, F., Droutman, V., Barkley-Levenson, E., Melrose, A. J., Miller, L. C., et al. (2018). Virtually 'in the heat of the moment': insula activation in safe sex negotiation among risky men. *Soc. Cogn. Affect. Neurosci*. 13, 80–91. doi: 10.1093/scan/nsx137

Stowers, J. R., Hofbauer, M., Bastien, R., Griessner, J., Higgins, P., Farooqui, S., et al. (2017). Virtual reality for freely moving animals. *Nat. Methods* 14, 995–1002. doi: 10.1038/nmeth.4399

Thiebaux, M., Marsella, S., Marshall, A. N., and Kallmann, M. (2008). "Smartbody: behavior realization for embodied conversational agents," in *Proceedings of the 7th International Joint Conference on Autonomous Agents and Multiagent Systems, Vol. 1* (Estoril), 151–158.

van Atteveldt, W., Strycharz, J., Trilling, D., and Welbers, K. (2019). Computational communication science| toward open computational communication science: a practical road map for reusable data and code. *Int. J. Commun*. 13:20. doi: 10.31235/osf.io/4dhfk

Vanden Abeele, V., De Schutter, B., Gajadhar, B., Johnson, D., and Geurts, L. (2013). "More naturalness, less control: The effect of natural mapping on the co-located player experience," in *Proceedings of the 8th International Conference on the Foundations of Digital Games, Vol. 2013* (Chania: Society for the Advancement of the Science of Digital Games), 174–182.

Vandenbosch, L., Driesmans, K., Trekels, J., and Eggermont, S. (2017). Sexualized video game avatars and self-objectification in adolescents: the role of gender congruency and activation frequency. *Media Psychol*. 20, 221–239. doi: 10.1080/15213269.2016.1142380

Wang, J., Tan, S., Zhen, X., Xu, S., Zheng, F., He, Z., et al. (2021). Deep 3d human pose estimation: a review. *Comput. Vis. Image Understand*. 210:103225. doi: 10.1016/j.cviu.2021.103225

Weech, S., Kenny, S., and Barnett-Cowan, M. (2019). Presence and cybersickness in virtual reality are negatively related: a review. *Front. Psychol*. 10:158. doi: 10.3389/fpsyg.2019.00158

Weisstein, E. W. (2000). *L^ 1-norm*. Available online at: https://mathworld.wolfram.com/

Williams, D. (2010). The mapping principle, and a research framework for virtual worlds. *Commun. Theory* 20, 451–470.

Wirth, S., Baraduc, P., Planté, A., Pinède, S., and Duhamel, J.-R. (2017). Gaze-informed, task-situated representation of space in primate hippocampus during virtual navigation. *PLoS Biol*. 15:e2001045. doi: 10.1371/journal.pbio.2001045

Won, A. S., Bailenson, J., Lee, J., and Lanier, J. (2015). Homuncular flexibility in virtual reality. *J. Comput. Mediated Commun*. 20, 241–259. doi: 10.1111/jcc4.12107

Won, A. S., Yu, L., Janssen, J., and Bailenson, J. (2012). "Tracking gesture to detect gender," in *Proceedings of the International Society for Presence Research Annual Conference* (Philadelphia, PA), 24–26.

Yee, N., and Bailenson, J. (2007). The proteus effect: the effect of transformed self-representation on behavior. *Hum. Commun. Res*. 33, 271–290. doi: 10.1111/j.1468-2958.2007.00299.x

Yee, N., Bailenson, J. N., and Ducheneaut, N. (2009). The proteus effect: Implications of transformed digital self-representation on online and offline behavior. *Commun. Res*. 36, 285–312. doi: 10.1177/0093650208330254

Zhao, Z., Han, F., and Ma, X. (2019). "A live storytelling virtual reality system with programmable cartoon-style emotion embodiment," in *2019 IEEE International Conference on Artificial Intelligence and Virtual Reality (AIVR)* (San Diego, CA: IEEE), 102–1027.

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BRIEF RESEARCH REPORT
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User-Agent Bond in Generalizable Environments: Long-Term Risk-Reduction via Nudged Virtual Choices

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Avatars or agents are digitized self-representations of a player in mediated environments. While using agents to navigate through mediated environments, players form bonds with their self-agents or characters, a process referred to as identification. Identification can involve automatic, but temporary, self-concept "shifts in implicit self-perceptions" (Klimmt et al., 2010, p. 323) of the media user by adopting or emphasizing the action choices on behalf of the social expectation of the avatar in the mediated environment. In the current study, we test the possibility that users' identification with video game avatars–a bond built between avatars and players- would account for subsequent behavior changes. We did so by using 3-month longitudinal data involving a narratively-based serious game: Socially Optimized Learning in Virtual Environments (SOLVE), a 3D-interactive game designed to reduce risky sexual behaviors among young men who have sex with men ($n = 444$). Results show that video game identification predicts both the reduction of risky sexual behaviors over time, and reduction in the number of non-primary partners with whom risky sex occurs. And when players identify with the game character, they tend to make healthier choices, which significantly mediates the link between video game identification and reduction of risky behaviors.

Keywords: agent (virtual users), generalizable virtual environments, identification, intervention, risk-reduction behavior, men who had sex with men, virtual choices, video game

INTRODUCTION

Avatars[1], or self-agents, are digital self-representations of a player in mediated environments. Players can form bonds with their self-agents or characters, a process referred to as identification (Klimmt et al., 2010). Identification can involve automatic, but temporary, self-concept "shifts in implicit self-perceptions" (Klimmt et al., 2010, p. 323) of the media user by adopting or emphasizing the type of action choices (e.g., racing, military) of the user's character—given the options available

[1]Technically, agents are a broader category that includes digital representations for the self as well as digital representations of others (whether human or animate) and even includes objects (Lim and Reeves, 2010).

in-context. Identification can be enhanced in a variety of ways, for example, by affording players opportunities to customize their characters (Turkay and Kinzer, 2014) or by enhancing the user's sense of presence (Christy and Fox, 2016)[2]. Furthermore, across a range of experimental studies, meta-analysis indicates that players appear to adjust their attitudes and behaviors to be more in-line with the presumed, mostly physically-based characteristics (e.g., size, gender), of their avatar (Ratan et al., 2020). Together, these findings suggest that for the avatar with whom one identifies, the avatar's situated behaviors, as well as their appearance (e.g., similarity to self), may produce change that might be longer lasting. For example, Birk and Manyk (2019) manipulated customization (or not) of avatars and exposure to an attentional retraining therapy to reduce anxiety. Participants in the training condition, but only those who could customize their avatars, experienced reduced anxiety, although the duration of these effects was unclear.

There has long been interest in using virtual environments (VE) for longer-term behavior change, including for changing health behaviors (e.g., Read et al., 2006; Baranowski et al., 2008). There are numerous reviews of the role of games or virtual environments (Papastergiou, 2009; Lu et al., 2012a,b; Bleakley et al., 2015) in producing behavior change. However, there are relatively few studies examining the role of avatars in health outcomes. One study indicates that avatar choices (e.g., relevant to alcohol or water choice) predict 3-month alcohol use (Wang et al., 2018). The results suggested that avatar choices can have long-term effects in everyday life, but did not include an examination of identification as a factor. There has been no published work, of which we are aware, examining the relationship between the strength of human-avatar bonds (e.g., identification) and longer-term behavior change (e.g., over 3 months), including in the health domain.

In the current study, we proposed and tested whether user's identification with video game avatars (Hefner et al., 2007; Klimmt et al., 2010), indicative of a special bond built between avatars and players, would predict subsequent behavior changes. We did so by using 3-month longitudinal data involving a narratively-based serious game developed by our research team: Socially Optimized Learning in Virtual Environments using Intelligent Technologies (SOLVE-IT) (Miller et al., 2011; Christensen et al., 2013) is a 3D-interactive game designed to reduce risky sexual behaviors among young men who (YMSM) have sex with men[3].

Identity-Bond and Change: Generalizable Virtual Environments

Serious games (Sawyer and Smith, 2008), also known as persuasive games (Bogost, 2007) or game-based learning (Connolly et al., 2012), usually refer to video games that are delivered via VE with the goal of promoting education, training, and behavioral changes (Connolly et al., 2012). In the past, those "games" have long been associated with repetitive drills and simulations. Now, with advances in media technology, an increasing number of serious games are engaging and entertaining, especially those with interactive and narrative elements enabling users to choose their own adventures (Green and Jenkins, 2014) and to be transported to the virtual world (Green and Brock, 2000)" of their avatars' or game characters' (Baranowski et al., 2008). A single team reviewed serious games, first from the earliest up to 2012 (Connolly et al., 2012) and then from 2012 to 2016 (Boyle et al., 2016): In the latter review, four times as many games (20)–incorporating story-lines or narrative structures such as action, adventure, or role-play—were identified. Indeed, through incorporating narrative structures, serious games have morphed and evolved into not just effective, but also fun and enjoyable, interventions (Lu et al., 2012a).

But as far as we know, narrative structures in serious games are often not specifically designed to have generalizability to everyday life (GEL; see Miller et al., 2019a)[4]. That is, while serious games are designed to change people's behaviors/decision making and attitudes, rarely are these serious games designed using representative sampling of the everyday life environments to which one wishes to generalize[5]. Indeed, we probably only need small puzzle games like Fruit Saga to train students to understand math. But, where we are changing—what are sometimes automatic social responses in context—deeply understanding and representing those situations, sequences, etc. and what is emotionally happening in them (in order to change behavior and decision-making in similar contexts in everyday life) is another matter. It is important that participants are "trained" and "practiced" in a virtual environment that is representative of the challenging scenario participants face in everyday life. Indeed, GEL matters because we want those learned response patterns in the virtual environment in response to a situation to transfer to similar situations in those individuals' everyday life (Miller et al., 2019a,b).

Building GEL into virtual environment implementations, as described above, relies on interactive narrative structures. Interactive narratives (IN) in virtual environments are systems affording the user the ability to assume the role of a character in a story (narrative) as that user interacts with other character agents. IN can afford interventions using virtual environments (for brief review see Miller et al., 2019a) by providing the critical cues (e.g., visual, acoustic, etc.) through which users re-imagine and experience trauma triggering events with a trained therapist (see Rizzo et al., 2014; Rizzo and Koenig, 2017) or just work through challenging situations with intelligent agent mentors/guides (e.g., Marsella et al., 2000; Christensen et al., 2013). In reviews of serious games (Connolly et al., 2012; Boyle et al., 2016), an interactive narrative structure (i.e., involving action, adventure,

[2]Social presence has been defined as "a psychological state in which the virtuality of experience is unnoticed (Lee, 2004, p. 494)."

[3]SOLVE-IT builds on theory and methods developed in SOLVE, using interactive video and human actors (Miller and Read, 2005; Read et al., 2006).

[4]The logic of built-in generalizability to everyday life (GEL) is based on sampling theory—including extensive formative research with the target audience and then sampling from the sequences and situations leading up to the risky situations of interest (see Miller et al., 2019a for a detailed description).

[5]In addition to sampling logic, we also conduct virtual validity tests to ensure that patterns of stimulus-responses in the same individuals' everyday life situation are correlated with similar situation-response patterns in the virtual environment (Godoy et al., 2013).

or role-play) was frequently identified. Often, serious games with narrative structures have been found to be not only effective, but fun and enjoyable, interventions (Lu et al., 2012a). This is the case even if the behaviors of interest for their persons of interest in these serious games might not be so "enjoyable," such as eating more fruit and vegetables for children (Baranowski et al., 2003), glucose management for diabetics (Thompson et al., 2010), and reduction of risky sexual behaviors for YMSM in SOLVE (Christensen et al., 2013).

In designing SOLVE (Read et al., 2006), the goal was to place YMSM in an IN virtual environment designed to simulate the emotional, interpersonal and contextual narrative of actual sexual encounters while challenging (with guides) and changing MSM's more automatic patterns of their responses. The SOLVE-IT (SOLVE with intelligent technologies) intervention involves an animated interactive virtual dating narrative game in which users choose their characters' skin coloring, hair color, and make clothing choices for their characters that are then aged to create a "virtual future self (VFS)" that, like SOLVE guides, scaffolds the user in making a series of risky or safe choices in interacting with potential sexual partners, so that "over time, self-regulated learners actively instruct and reinforce themselves, gaining confidence and self-efficacy in their ability to understand and succeed in achieving their goals, while avoiding social and physical harm (Read et al., 2006, p. 2)." The VFS's role as an intervention agent is to optimize the user's self-regulated learning. The VSF does so like a good parent (Nelson, 1993) through interactivity, scaffolding, and VSF (coach) responsiveness, and reframing the ongoing narrative leading up to decisions that may be risky in every component of the process outlined below. These components are theoretically grounded in what we refer to as the *recursive narrative regulatory circuitry* that depends upon the active interaction of the user and socially facilitated processes (Read et al., 2006) and include: (1) encouraging the user to read his and the other's affective cues (e.g., attraction and desire for this man); (2) help user interpret and make inferences for the self and other's affective cues (what they mean- cause, effect, intent); (3) encourage user to clarify their own and the other's interpersonal goals; (4) generate possible solutions: develop plans to optimize goals, taking resources into account; (5) help them weigh and make a decision (6) guide them in acting on the decision to enact behavior. SOLVE was one of the first behavioral interventions to make emotions (and acknowledging them) more central (instead of secondary at best) in the ongoing narrative decision-making process. Thus, the VFS guide provided a kind of "glue" scaffolding and reframing the situation and linking and moving cognitive and affective reactions to promote behavior change (Read et al., 2006) while linking past, current, and future decisions.

In an IN structure, the bonds that form between humans and their avatars (or agents)—that represent them digitally—can be strong. The strength of those bonds can predict an array of outcomes, including positive health effects (Kim and Sundar, 2012; Birk et al., 2016). Avatars (or agents) are virtual digital representations through which a user (i.e., player in a digital game or virtual environment) assumes the role of a character. Nowak and Fox (2018) define avatars as *"digital representations that symbolizes the self in the interaction"* (p. 30). Agents are used in a similar fashion, except that agents can also broadly refer to animate objects (including humans or animals) as well as inanimate objects. Here, by agents we refer to digital representations that either symbolize the *self or others* in the social interaction. These human-avatar (or human/self-agent) bonds have been referred to as "identification" (i.e., Klimmit et al., 2009). Klimmit et al. (2009) define video game identification as "a temporary alteration of media users' self-concept through adoption of perceived character of a media person" (p. 258). Indeed, successfully navigating one's ideal future self in a dating scene could make one form strong bonds with one's own avatar. There is considerable evidence that these bonds are often quite strong. While reviews have shown that increasing game addiction was related to the strong identification bonds between gamers and their avatars (Lemenager et al., 2020), the strength of these bonds could also be used in achieving healthy behavioral changes in serious games (Papastergiou, 2009; Primack et al., 2012; Bleakley et al., 2015).

Therefore, we specify the hypothesis below.

H_1: Identification with one's virtual future self game character is positively associated with subsequent real-life reduction of risky behavior among YMSM who play SOLVE, an IN game designed to enhance safer sexual practices.

How Does Identification Affect Virtual Choice/Behaviors?

The conceptualization of video game identification can also speak to another important aspect of serious games: *virtual choices*. Virtual choices are part of the interactivity features that are offered in video games with the purpose of enhancing media richness such that users may be more likely to explore the mediated interface (Sundar et al., 2013). When offered in video games to entertain, virtual choices may simply be interactive features that only garner players' attention (e.g., "should my avatar take the path to the south," or "should he be wearing a blue or a red shirt today"). However, when offered in serious video games that are created to be representative of real-life situations, virtual choices have applied implications. They are assessment tools of performances or behaviors that are otherwise hard-to-observe in real life situations (Rizzo et al., 2000; Blascovich et al., 2002). Virtual performances such as scientific inquiry abilities (Ketelhut et al., 2010) and surgical skills (Seymour et al., 2002; Grantcharov et al., 2003) in serious games have been used to assess the (likely) subsequent real-life performance of targeted participants. This assessment potential of virtual choices is also applicable to serious games interventions that target real-life challenges. In those cases, participants' "virtual choices themselves may indicate current movement in behavior toward key intervention messages provided by a game character (e.g., a scaffolding mentor or guide) and thus be prognostic of future behavior change" (Wang et al., 2018, p. 4).

Nudged Virtual Choices in Line With Ideal Self or Intervention Goal

Thaler and Sunstein (2009) define a "nudge" as "any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy and cheap to avoid" (p. 6). Participants of the SOLVE-IT game, for example, while walking through a series of dating scenarios, may find themselves at different choice points where they need to make *virtual choices*. Their virtual choice to drink more water in a house party, for example, meets "nudge" criteria: It is a cheap and easy to avoid option (the alternative is to drink alcohol), and indicates their compliance with the persuasive messages embedded in the game. Indeed, Wang et al. (2018) reported significant correlations between virtual choices of non-alcoholic beverages and reductions of actual alcohol intake post SOLVE intervention.

The importance of video game identification can also be evaluated by its associations with virtual choices such that serious games with greater potential in eliciting identification are more likely to induce more desirable in-game virtual behaviors. To be specific, the richness of interactive features that are offered by video games, players' "temporary alteration of self-concept" may enable them to act upon the perspectives of the game character. As Klimmit et al. (2009) suggested, players of a first-person shooting game who are subconsciously integrating the identity of a soldier would perceive themselves as being "more courageous, stressed, cautious, aggressive, violent, dutiful, etc., than they would be under "normal" circumstances" (2009, p. 358). Since they are "soldiers" in the game, they would also be acting more courageous, vigilantly, cautiously, and aggressively in shooting, sniping, or flanking the enemy in the game. Similarly, players can be influenced by an ideal virtual future self (i.e., VFS mentor that is like one's self character but "aged" and wiser in making safer sex choices) that is designed in serious games like SOLVE-IT. Given the VFS, participants may alter their virtual self-concepts in line with the VFS, therefore making healthier virtual choices based on their avatar's desired identity. They may choose to act, virtually, in more responsible ways such as choosing a safer way of sex or reducing their beer intake because they are identified with their ideal version of themselves [in a game designed to "*nudge*" (Thaler and Sunstein, 2009) individuals toward safer choices]. Therefore, we can expect significant associations between video game identification with the VFS and virtual choices, which could also subsequently predict behavior changes, or the efficacy of serious game interventions.

H_2: Virtual choices mediate the relationship between video game identification with the virtual future self (VFS) mentor and subsequent behavior change.

METHOD

Study Design and Participants

Study design and participant's data for this analysis were drawn from the SOLVE-IT intervention. In the original design, YMSM were randomly assigned to the game or a waitlist control condition ($N = 934$). As video game identification could only be accessed for those who played the game, our analysis focused on just those in the experimental condition ($N = 444$). Those participants have a mean age of 22.13, with 76.1% identified as white/Caucasian, 12.4% as Latino/Hispanic, and 11.5% as Black/African American. Recruitment criteria and more detailed social economic backgrounds are also described elsewhere (see Christensen et al., 2013; Wang et al., 2018) and, as relevant, below.

"Participants were recruited nationwide in the United States through banner advertisements placed on Craigslist, blogs, and gay interest websites. Criterion for inclusion were (1) receiving a prior HIV-negative test result, (2) living in the United States, (3) being 18–24 years of age, and (4) engaging in CAI [condomless anal intercourse] *with a non-primary male partner during the three-month period prior to enrollment in the study. "Non-primary partner" refers to a male partner with whom the participant was not, at the time, engaged in a romantic relationship (for additional details see Christensen et al., 2013). This study was approved by the university's institutional review board (IRB). Participants were only identified by email address to enhance confidentiality. Email addresses were subsequently deleted upon study completion (Wang et al., 2017, p. 15)."*

Each participant played the SOLVE-IT game at least once during the intervention, though a few were shown to have played multiple times. Participants began their game by customizing their avatar (customizing hair color, skin color, eye color, clothes, shoes, etc.) who was then "aged" for all players to become the user's VFS.

Measures

Risky Behaviors

Unsafe sexual behaviors in real life were operationalized in two ways (i.e., within a period of time, numbers of non-primary partners with whom had unsafe sex; total count of unsafe sex). First, we examined the number of Non-Primary Partners with whom participants had condomless anal intercourse (CAI). This was a composite measure that added the number of partners with whom participants had condomless receptive anal sex and those with whom they had condomless insertive anal sex. At baseline, participants reported the number of non-primary partners with whom they had engaged in CAI in the past 90 days. Participants gave a report of the same measure at a 3-month follow-up, and this afforded a measure of behavior change. Second, we assessed the actual count of CAI incidents in the past 90 days (a composite of responses for insertive CAI and receptive CAI) at baseline and 3-month follow-up affording a second measure of behavior change. Virtual Safe-Sex Choices.

Virtual sexual behaviors were operationalized in terms of the number of choices made by the participants during two levels of game play. Decisions were categorized and recorded based on their consequences in leading specifically to either safe or risky sexual intercourse (see **Figure 1**). Participants made from 0 to 6 safe choices, with higher values indicating more safe choices.

Video Game Identification

Three items were created to evaluate video identification with the Virtual Future Self (VFS) character to fit with the SOLVE design. Sample items included, "I could identify with the Virtual Future Self character," "The virtual future-self character was trustworthy," and "The virtual future-self character was

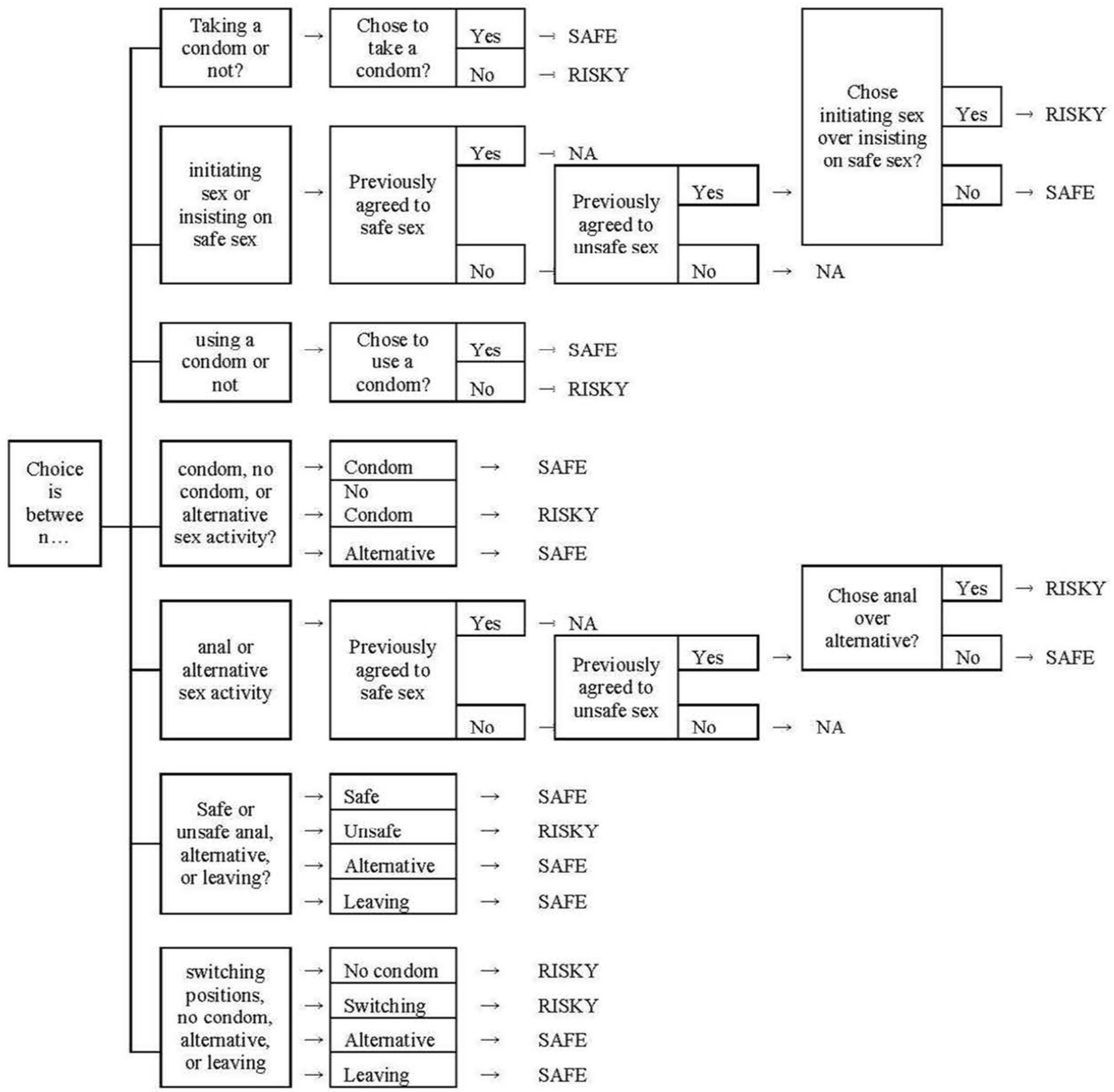

FIGURE 1 | Risk choice and safe sex procedures. This figure shows the procedures used to determine whether a sexually risky decision choice is safe or risky in the SOLVE game by taking into account the context of the choice. "NA" indicates a particular choice is not relevant to sexual risk-taking at all. This figure also appeared in the work by Smith et al. (2018). Authors are licensed to use this material, License number: 5047310486925.

believable." Participants rated game involvement items on a 1 (strongly disagree) to 10 (strongly agree) scale ($\alpha = 0.92$).

RESULT

Preliminary Data Analysis

Following Christensen et al. (2013), we used residualized change scores in order to eliminate dependency between simple difference scores and baseline values (MacKinnon, 2012; Muthen and Muthen, 2012) and potential problems with reliability of measurement (Rogosa et al., 1982; Tisak and Smith, 1994; McFarland and Ryan, 2000; Edwards, 2001). Higher scores on variables indicate more game identification, safer choices, more CAI and numbers of partners over time. **Table 1** shows the bivariate correlations of each variable of interest. As we have hypothesized, video game identification was significantly correlated to all our outcomes of interests.

TABLE 1 | Bivariate correlations of variables of interests.

	1	2	3	4	*M*	*SD*
1. Video game identification	1	-	-	-	7.66	1.86
2. Virtual choice	0.45**	1	-	-	5.56	3.07
3. Changes in non-primary Partners to have CAI over 3 months	−0.23**	−0.20**	1	-	0.16	8.77
4. Changes in CAI over 3 months	−0.35**	−0.26**	0.80**	1	0.1	6.65

[**]Correlation is significant at the 0.01 level (2-tailed).
Higher scores for mean more identification, more virtual safer choices, and more partners and more unprotected coondomless anal sex over 3 months. Therefore, negative correlations reflect the role of 1 and 2 in reducing CAI and partners over time.

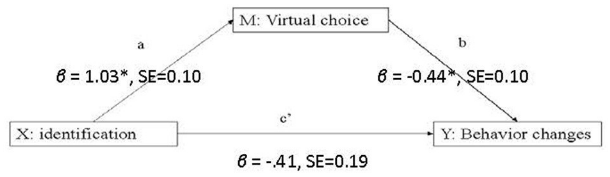

FIGURE 2 | Statistical model for analysis. The current figure shows the Hayes mediation model, and an example of how X: identification affects M: Virtual Choices and Y: Behavior Changes (i.e., change of Non-primary CAI partners). *$p < 0.05$.

TABLE 2 | Path coefficients, SE, and 95% CI.

			95% CI	
	Coeff.	**SE**	**Upper**	**Lower**
Y: CAI changes				
a	0.76	0.09	0.59	0.93
b	−0.63	0.05	−0.97	−0.3
c'	−0.56	0.29	−1.14	−0.01
Indirect effect of virtual choice				
	−0.48	0.13	−1.14	−0.01
Y: Changes in non-primary CAI partners				
a	1.03*	0.1	0.84	1.23
b	−0.44**	0.1	−0.64	−0.24
c'	−0.41	0.19	−0.77	−0.03
Indirect effect of virtual choice				
	−0.45	0.11	−0.69	−0.25

*a, b, and c' corresponds to the paths legend in **Figure 2**, X: Identification, M: Safe choices, Y: real-life behavior changes (CAI and changes in Non-primary CAI partners). *$p < 0.05$, **$p < 0.01$.*

Main Analyses

To test H_1 and H_2, we used ordinary least squares (OLS) regression provided by the SPSS macro PROCESS (Preacher and Hayes, 2008; Hayes, 2009) using model 4, shown in **Figure 2** (here, simple mediation with one mediator per outcome). **Table 2** shows the detailed results for each hypothesis. H_1 posits that video game identification contributes to behavior change in serious games over 3 months. This hypothesis is supported. Identification significantly reduced the amount of CAI, $\beta = -0.56$, SE = 0.29, 95% CI: (−1.14, −0.01), and reduced the number of non-primary partners with whom CAI happened: $\beta = -0.41$, SE = 0.19, 95% CI: (−0.77, −0.03). H_2 posits that virtual choices mediate the relationship between identification and behavioral change. This is supported as well. We saw an indirect effect of virtual choices mediating the relationship between identification and changes of CAI, $\beta = -0.48$, SE = 0.13, 95% CI: (−0.74, −0.24), and this mediation model explained a significant proportion of variance in the reduction of non-primary CAI partners, $R^2 = 0.20$, $p < 0.001$. Similarly, we saw an indirect effect of virtual choices mediating the relationship between identification and change of CAI partner counts, $\beta = -0.45$, SE = 0.11, 95% CI: (−0.69, −0.25). This mediation model explained a significant proportion of variance in the reduction of non-primary CAI partners, $R^2 = 0.18$, $p < 0.001$.

DISCUSSION

Results of this study were consistent with previous studies regarding the importance of video game identification (Lu et al., 2012b) in demonstrating positive behavioral change. We found that game virtual future self (VFS) identification significantly related to the reduction of risky behaviors. Our results have shown that video game identification predicted not only the reduction of CAI, but the number of non-primary partners with whom CAI occurs. Results of this study call for closer attention in designing more engaging serious games, and perhaps including VFS, with which and whom players can identify. In subsequent studies, it is therefore important to further consider various means to enhance video game identification to create more effective interventions for behavior change.

This study also found support for the role of video identification's influence on virtual choices. As our results have shown, when players identify with the VFS game character, they tend to make more desirable (healthier) choices. Indeed, a representatively designed real-life-based serious game can not only serve as a means of observation, but could also be utilized as a means of creating behavioral change to facilitate safer sex. With multiple interventions reporting the effectiveness of serious game interventions and targeted campaigns, including SOLVE-IT, on reducing risky behaviors (especially risky sexual behaviors) of YMSM, enhancing video game identification in health settings creates the potential of creating more specialized communication-based interventions.

Limitations and Future Directions

While demonstrating the potential diagnostic application of virtual choices, this study has certain limitations. First, we had to rely on participants' self-report of their past risky behaviors and involvement. Indeed, there was a lack of biobehavioral measures (e.g., HIV tests; STD tests) in the SOLVE intervention. However, such measures have been rare in other studies on serious games or in other HIV prevention interventions due to their significant cost, especially in a large national sample. If future work can more rigorously measure risky behavior, it may provide a more accurate assessment of behavioral change. Second, because of the design of SOLVE, which had built-in messages—within the game—to remind participants of the potential risk involved in certain behaviors, we could not manipulate the levels of video game identification and therefore compare the "dosage" of identification. In the future, if researchers can create different versions of serious games to enable such comparison, we can gain more knowledge regarding the best ways to enhance video game identification to create more effective interventions.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by USC IRB. The ethics committee waived the requirement of written informed consent for participation.

AUTHOR CONTRIBUTIONS

LW and LM lead the writing team for this manuscript. LW, LM, JC, DJ, SR, and TG were responsible for an initial draft, research design, and ideas in conceptualizing the analysis of the data. LW, BS, TG, ML, and LM were responsible for research and revisions. JC suggested the VFS initially and JC, PA, LM, and SR developed the idea of the virtual future self (VFS) and identification measures for the VFS for SOLVE-IT used in the current manuscript. PA, JC, SR, and LM contributed to game formative research, systematic representative design, and development and all measurement choice and construction initially. PA managed and orchestrated the overall NIH funded SOLVE-IT project, day-to-day operations, and all data collection. LM, JC, PA, SR, DJ, LW, and TG also contributed more recently to systematic representative design discussions relevant to the current work. LW was responsible for analyzing the data, tables and figures, and in writing up result drafts and changes. JC provided supplementary art from SOLVE-IT. All authors contributed to the article and approved the submitted version.

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REFERENCES

Baranowski, T., Baranowski, J., Cullen, K. W., Marsh, T., Islam, N., Zakeri, I., et al. (2003). Squire's quest!: dietary outcome evaluation of a multimedia game. *Am. J. Prev. Med.* 24, 52–61. doi: 10.1016/S0749-3797(02)00570-6

Baranowski, T., Buday, R., Thompson, D. I., and Baranowski, J. (2008). Playing for real: video games and stories for health-related behavior change. *Am. J. Prev. Med.* 34, 74.e10–82.e10. doi: 10.1016/j.amepre.2007.09.027

Birk, M. V., Atkins, C., Bowey, J. T., and Mandryk, R. L. (2016). "ostering intrinsic motivation through avatar identification in digital games," in *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (San Jose, CA: Association for Computing Machinery), 2982–2995.

Birk, M. V., and Manyk, R. L. (2019). Improving the efficacy of cognitive training for digital mental health interventions through avatar customization: crowdsourced quasi-experimental study. *J. Med. Internet Res.* 21:e10133. doi: 10.2196/10133

Blascovich, J., Loomis, J., Beall, A. C., Swinth, K. R., Hoyt, C. L., and Bailenson, J. N. (2002). TARGET ARTICLE: immersive virtual environment technology as a methodological tool for social psychology. *Psychol. Inq.* 13, 103–124. doi: 10.1207/S15327965PLI1302_01

Bleakley, C. M., Charles, D., Porter-Armstrong, A., McNeill, M. D. J., McDonough, S. M., and McCormack, B. (2015). Gaming for health: a systematic review of the physical and cognitive effects of interactive computer games in older adults. *J. Appl. Gerontol.* 34, NP166–NP189. doi: 10.1177/0733464812470747

Bogost, I. (2007). *Persuasive Games the Expressive Power of Videogames*. MIT Press.

Boyle, E. A., Hainey, T., Connolly, T. M., Gray, G., Earp, J., Ott, M., et al. (2016). An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games. *Comput. Educ.* 94, 178–192. doi: 10.1016/j.compedu.2015.11.003

Christensen, J. L., Miller, C., L., Appleby, P. R., Corsbie-Massay, C., Gustavo Godoy, C., et al. (2013). Reducing shame in a game that predicts HIV risk reduction for young adult MSM: a randomized trial delivered nationally over the web. *J. Int. AIDS Soc.* 16(3 Suppl. 2):18716. doi: 10.7448/IAS.16.3.18716

Christy, K. R., and Fox, J. (2016). Transportability and presence as predictors of avatar identification within narrative video games. *Cyberpsychol. Behav. Soc. Netw.* 19, 283–287. doi: 10.1089/cyber.2015.0474

Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., and Boyle, J. M. (2012). A systematic literature review of empirical evidence on computer games and serious games. *Comput. Educ.* 59, 661–686. doi: 10.1016/j.compedu.2012.03.004

Edwards, J. R. (2001). Ten difference score myths. *Org. Res. Methods* 4, 265–287. doi: 10.1177/109442810143005

Godoy, C., Miller, L., Corsbie-Massay, C., Christensen, J. L., Appleby, P., Read, S. J., et al. (2013). Virtual validity: mHealth simulation games, diagnostic indicators, and behavior change. *J. Mobile Technol. Med.* 2:17. doi: 10.7309/jmtm.2.4S.14

Grantcharov, T. P., Kristiansen, V. B., Bendix, J., Bardram, L., Rosenberg, J., and Funch-Jensen, P. (2003). Randomized clinical trial of virtual reality simulation for laparoscopic skills training. *BJS* 91, 146–150. doi: 10.1002/bjs.4407

Green, M. C., and Brock, T. C. (2000). The role of transportation in the persuasiveness of public narratives. *J. Pers. Soc. Psychol.* 79:701.

Green, M. C., and Jenkins, K. M. (2014). Interactive narratives: processes and outcomes in user-directed stories. *J. Commun.* 64, 479–500.

Hayes, A. F. (2009). Beyond Baron and Kenny: statistical mediation analysis in the New Millennium. *Commun. Monogr*. 76, 408–420. doi: 10.1080/03637750903310360

Hefner, D., Klimmt, C., and Vorderer, P. (2007). "Identification with the player character as determinant of video game enjoyment," in *Entertainment Computing—ICEC 2007* (Berlin, Heidelberg: Springer), 39–48.

Ketelhut, D., Nelson, B., Clarke, J., and Dede, C. J. (2010). A multi-user virtual environment for building higher order inquiry skills in science. *Br. J. Educ. Technol.* 41, 56–68. doi: 10.1111/j.1467-8535.2009.01036.x

Kim, Y., and Sundar, S. S. (2012). Visualizing ideal self vs. actual self through avatars: Impact on preventive health outcomes. *Comput. Hum. Behav.* 28, 1356–1364. doi: 10.1016/j.chb.2012.02.021

Klimmit, C., Dorothée, H., and Peter, V. (2009). The video game experience as "true" identification: a theory of enjoyable alterations of players' self-perception. *Commun. Theory* 19, 351–373. doi: 10.1111/j.1468-2885.2009.01347.x

Klimmt, C., Hefner, D., Vorderer, P., Roth, C., and Blake, C. (2010). Identification with video game characters as automatic shift of self-perceptions. *Media Psychol.* 13, 323–338. doi: 10.1080/15213269.2010.524911

Lee, K. M. (2004). Why presence occurs: evolutionary psychology, media equation, and presence. *Presence Teleop. Virt. Environ.* 13, 494–505. doi: 10.1162/1054746041944830

Lemenager, T., Neissner, M., Sabo, T., Mann, K., and Kiefer, F. (2020). "Who Am I" and "How Should I Be": a systematic review on self-concept and avatar identification in gaming disorder. *Curr. Addict. Rep.* 7, 166–193. doi: 10.1007/s40429-020-00307-x

Lim, S., and Reeves, B. (2010). Computer agents versus avatars: responses to interactive game characters controlled by a computer or other player. *Int. J. Hum. Comput. Stud.* 68, 57–68. doi: 10.1016/j.ijhcs.2009.09.008

Lu, A. S., Baranowski, T., Thompson, D., and Buday, R. (2012a). Story immersion of videogames for youth health promotion: a review of literature. *Games Health J.* 1, 199–204. doi: 10.1089/g4h.2011.0012

Lu, A. S., Thompson, D., Baranowski, J., Buday, R., and Baranowski, T. (2012b). Story immersion in a health videogame for childhood obesity prevention. *Games Health J.* 1, 37–44. doi: 10.1089/g4h.2011.0011

MacKinnon, D. (2012). "Additional approaches to identifying mediating variables," in *Introduction to Statistical Mediation Analysis* (Routledge), 371–394.

Marsella, S. C., Johnson, W. L., and LaBore, C. (2000). "Interactive pedagogical drama," in *Proceedings of the Fourth International Conference on Autonomous Agents–AGENTS'00* (Barcelona).

McFarland, L. A., and Ryan, A. M. (2000). Variance in faking across noncognitive measures. *J. Appl. Psychol.* 85, 812–821. doi: 10.1037/0021-9010.85.5.812

Miller, L. C., Marsella, S., Dey, T., Appleby, P. R., Christensen, J. L., Klatt, J., et al. (2011). "Socially optimized learning in virtual environments (SOLVE)," in *Springer Lecture Notes in Computer Science (LNCS) "Interactive Storytelling" Series*, eds M. Si and D. Thue (Berlin; Heidelberg: Springer-Verlag), 182–192.

Miller, L. C., and Read, S. J. (2005). "Virtual sex: creating environments for reducing risky sex," in *Virtual Decisions: Digital Simulations for Teaching Reasoning in the Social Sciences and Humanities*, eds S. Cohen, K. E. Portney, D. Rehberger, and C. Thorsen (Mahwah, NJ: Lawrence Erlbaum Associates Publishers), 137–159.

Miller, L. C., Shaikh, S. J., Jeong, D. C., Wang, L., Gillig, T. K., Godoy, C. G., et al. (2019a). Causal inference in generalizable environments: systematic representative design. *Psychol. Inq.* 30, 173–202. doi: 10.1080/1047840X.2019.1693866

Miller, L. C., Wang, L., Jeong, D. C., and Gillig, T. K. (2019b). "Bringing the real world into the experimental lab: technology-enabling transformative designs," in *Social-Behavioral Modeling for Complex Systems*, eds P. K. Davis, Angela A. O'Mahony, and J. Pfautz (Hoboken, NJ: John Wiley and Sons, Ltd), 359–386.

Muthen, L. K., and Muthen, B. O. (2012). *Mplus User's Guide, 7th Edn*. Los Angeles, CA: Muthén & Muthén.

Nelson, G. (1993). Risk, resistance, and self-esteem: a longitudinal study of elementary school-aged children from mother custody and two-parent families. *J. Divorce Remarriage* 19, 99–120.

Nowak, K. L., and Fox, J. (2018). Avatars and computer-mediated communication: a review of the definitions, uses, and effects of digital representations. *Rev. Commun. Res.* 6, 30–53. doi: 10.12840/issn.2255-4165.2018.06.01.015

Papastergiou, M. (2009). Exploring the potential of computer and video games for health and physical education: a literature review. *Comput. Educ.* 53, 603–622. doi: 10.1016/j.compedu.2009.04.001

Preacher, K. J., and Hayes, A. F. (2008). "Contemporary approaches to assessing mediation in communication research," in *The SAGE Sourcebook of Advanced Data Analysis Methods for Communication Research*, 13–54. doi: 10.4135/9781452272054.n2

Primack, B. A., Carroll, M. V., McNamara, M., Klem, M. L., King, B., Rich, M., et al. (2012). Role of video games in improving health-related outcomes: a systematic review. *Am. J. Prev. Med.* 42, 630–638. doi: 10.1016/j.amepre.2012.02.023

Ratan, R., Beyea, D., Li, B. J., and Graciano, L. (2020). Avatar characteristics induce users' behavioral conformity with small-to-medium effect sizes: a meta-analysis of the proteus effect. *Media Psychol.* 23, 651–675. doi: 10.1080/15213269.2019.1623698

Read, S. J., Miller, L. C., Appleby, P. R., Nwosu, M. E., Reynaldo, S., Lauren, A., et al. (2006). Socially optimized learning in a virtual environment: reducing risky sexual behavior among men who have sex with men. *Hum. Commun. Res.* 32, 1–34. doi: 10.1111/j.1468-2958.2006.00001.x

Rizzo, A., Hartholt, A., Grimani, M., Leeds, A., and Liewer, M. (2014). Virtual reality exposure therapy for combat-related posttraumatic stress disorder. *Computer* 47, 31–37. doi: 10.1109/MC.2014.199

Rizzo, A., and Koenig, S. T. (2017). Is clinical virtual reality ready for primetime? *Neuropsychology* 31:877. doi: 10.1037/neu0000405

Rizzo, A. A., Buckwalter, J. G., Bowerly, T., Van Der Zaag, C., Humphrey, L., Neumann, U., et al. (2000). The virtual classroom: a virtual reality environment for the assessment and rehabilitation of attention deficits. *Cyberpsychol. Behav.* 3, 483–499. doi: 10.1089/10949310050078940

Rogosa, D., Brandt, D., and Zimowski, M. (1982). A growth curve approach to the measurement of change. *Psychol. Bull.* 92, 726–748. doi: 10.1037/0033-2909.92.3.726

Sawyer, B., and Smith, P. (2008). "Keynote address," in *Proceedings for the Second European Conference on Games-Based Learning* (Barcelona: Curran Associates, Inc.), 16–17.

Seymour, N. E., Gallagher, A. G., Roman, S. A., O'Brien, M. K., Bansal, V. K., Andersen, D. K., et al. (2002). Virtual reality training improves operating room performance. *Ann. Surg.* 236, 458–464. doi: 10.1097/00000658-200210000-00008

Smith, B. J., Xue, F., Droutman, V., Barkley-Levenson, E., Melrose, A. J., Miller, L. C., et al. (2018). Virtually "in the heat of the moment": insulaactivation in safe sex negotiation among risky men. *Soc. Cogn. Affect. Neurosci.* 13, 80–91. doi: 10.1093/scan/nsx137

Sundar, S. S., Oh, J., Kang, H., Sreenivasan, A., Dillard, J. P., and Shen, L. (2013). "How does technology persuade? Theoretical mechanisms for persuasive technologies," in *The Sage Handbook of Persuasion: Developments in Theory and Practice*, eds J. P. Dillard and L. Shen (Thousand Oaks, CA: Sage Publications, Inc), 388–404.

Thaler, R. H., and Sunstein, C. R. (2009). *Nudge: Improving Decisions About Health, wealth, and Happiness*. London: Penguin.

Thompson, D., Baranowski, T., Buday, R., Baranowski, J., Thompson, V., Jago, R., et al. (2010). Serious video games for health how behavioral science guided the development of a serious video game. *Simul. Gaming* 41, 587–606. doi: 10.1177/1046878108328087

Tisak, J., and Smith, C. S. (1994). Defending and extending difference score methods. *J. Manage*. 20, 675–682. doi: 10.1016/0149-2063(94)90010-8

Turkay, S., and Kinzer, C. K. (2014). The effects of avatar-based customization on player identification. *Int. J. Gaming Comput. Mediat. Simul.* 6, 1–25. doi: 10.4018/ijgcms.2014010101

Wang, L., Christensen, J. L., Jeong, D. C., and Miller, L. C. (2018). Virtual prognostication: when virtual alcohol choices predict change in alcohol consumption over 6-months. *Comput. Human Behav*. 90, 388–396. doi: 10.1016/j.chb.2018.08.025

Wang, L., Jeong, D. C., Gillig, T. K., Christensen, J. L., Appleby, P. R., Read, S., et al. (2017). "Virtual prognostication: towards an integrated paradigm," in *International Communication Association Meeting. Presented at the International Communication Association Meeting* (San Diego, CA).

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Player-Character Relationship and Game Satisfaction in Narrative Game: Focus on Player Experience of Character Switch in *The Last of Us Part II*

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While player characters (PCs) are the key element in engaging players in narrative games, the experience and relationship of the player with the PC have received scarce attention from the perspective of the subjective player experience. The diversity of players and the importance of the PC in the game suggests meaningful connections between how players relate to their PC and the resulting satisfaction with the game. We, therefore, investigated in this study how the player-character relationship influences satisfaction of the player with the game. We performed semi-structured in-depth interviews with 12 players of *The Last of Us Part II*, a game that has elicited highly polarized reactions in relation to how players responded to a switch of the PC in the game. Through thematic analysis, three themes were found, illustrating the connection between aspects of the player-character relationship and the overall game satisfaction. The themes are "Tolerance of forced character switch", "Malleability of character image" and "Flexibility of character attachment". We discuss how those findings should be taken into consideration when designing diverse and meaningful gaming experiences.

Keywords: player character, player-character relationship, game satisfaction, player experience, *The Last of Us*, video games

1. INTRODUCTION

Video games are continuously gaining popularity not only as an entertainment medium, but also in fields such as art (Folkerts, 2010; Devine, 2017; Chew and Mitchell, 2020), education (Klopfer et al., 2009), and health (Baranowski et al., 2008; Colder Carras et al., 2018). As the effects of games on players have been mixed (Ferguson, 2007; Prot et al., 2012), it is necessary to gain a deeper understanding of how players engage with games. One of the most important game elements when engaging the player in the game is the player character or avatar (Mallon, 2008; Tychsen et al., 2008; Lankoski, 2011). The player character (PC) is the in-game character which is controlled by the player and through which the player can act in the game world (Vella, 2016). It is useful to distinguish in this study a PC from an avatar. While those terms have been defined inconsistently, an avatar broadly refers to a digital representation of a user (Nowak and Fox, 2018). We understand the main difference therefore as the avatar is to at least some degree customizable, as seen, for example in Massively Multiplayer Online Role-Playing Game (MMORPG) genres, whereas in the narrative genre, the story and features of the PC are to a high degree predefined by the developers.

The majority of research investigating the player experience concerning the PC has been conducted in the context of the MMORPG genre and avatars (Blinka, 2008; Banks, 2015; Banks et al., 2019). This is possibly due to the more obvious involvement of the player in the creation, customization and development of an avatar compared with the mainly predefined PCs. In particular, Jaime Banks has studied the player-avatar relationship in several works (Banks and Bowman, 2013, 2016; Banks, 2015; Banks et al., 2019). In one study (Banks, 2015), she introduces a spectrum of sociality on which the player-avatar relationship can be placed. This spectrum includes four types of player-avatar relationships, namely, seeing the avatar as an object, me, symbiote or social other. The sociality is measured along the dimensions of self-differentiation, emotional intimacy and perceived agency. This model has also been applied to specific game cases (Loyer, 2015). In another study, Banks and Bowman (2016) introduce a metric including ludic and social measures of the player-avatar relationship, which in its refined version (Banks et al., 2019) exhibits the dimensions of relational closeness, anthropomorphic autonomy, critical concern, and sense of control. Since not only in the context of MMORPGs and avatars but also in narrative games and PCs the involvement of the player is central (Drennan et al., 2004; Lankoski, 2011; Vella, 2016), the perspective of the player on PCs is worth further inquiry.

In the context of narrative or story-driven games, the PC takes on a dual role as the controlled figure of the player in the game and a narrative device for the game developers (Lankoski and Bjork, 2008; Jørgensen, 2010). The latter role has received considerable attention in previous research. For example Jørgensen (2010) shows how the game character can be used in different ways by developers to bring across the narrative of the game. Furthermore, Lankoski and Bjork (2008) provide a game design method in which the game-play reflects traits and personality of the character (Lankoski and Bjork, 2008). Lankoski (2011) also studied PC design extensively in relation to player engagement. He proposes a structure of how PCs engage the player in the game, which includes the concepts of recognition, alignment, and allegiance. Recognition is how a player constructs an image of the character based on cues within the game, alignment is the way the information conveyance is structured, and allegiance is related to the moral evaluation of the PC by the player (Lankoski, 2011). While the previously mentioned studies have a theoretical approach in Drennan et al. (2004)'s work focus group interviews with actual players are performed. Their target was to find themes to consider when designing engaging game characters in general, not PCs in particular. The themes were consistency with context, player expectations, social interactions, and consistency with the environment (Drennan et al., 2004). As illustrated, research taking on a design perspective of PCs is extensive; however studies investigating the perspective and experience of the player with PCs are scarce.

While studies on the player-character relationship itself are lacking, there are several works that investigate particular variables of the player-character relationship, such as character attachment (Lewis et al., 2008; Burgess and Jones, 2017; Bopp et al., 2019) or identification (Shaw, 2011; Boudreau, 2012). In Lewis' work, a measurement of character attachment is introduced, encompassing the dimensions of identification/friendship, suspension of disbelief, control, and responsibility (Lewis et al., 2008). Furthermore, the perception of characters in games has been studied by Calleja (2009) who introduces the notion of an alterbiography. An alterbiography describes how the players create their own narrative about the subject in the game through making sense of narrative clues and elements presented in the game (Calleja, 2009). Finally, Burgess and Jones (2017)'s work is interesting as it investigated character attachment and agency in a specific game case study of a controversy surrounding the ending of *Mass Effect 3*. They performed a thematic analysis of online reviews and the resulting themes point to the importance of the player-character relationship in the overall satisfaction of the game. They additionally propose further work to address the found differences across players in character attachment (Burgess and Jones, 2017). While those approaches are valuable, they are limited to the variable in question and do not take into consideration the broader player experience.

One attempt to more comprehensively capture the subjective experience of the player in the creation of a player-character relationship is Ong (2018)'s work where it is attempted to understand the processes through which the relationship with a PC is created (referred to as avatar in the work, but due to no customization or choice option can be understood as PC). However, a more thorough understanding of how the players relate to their PCs is needed, particularly how this relationship influences game satisfaction. One theory that attempts to explain the satisfaction of a media experience in relation to characters in a narrative is disposition theory from drama studies. It states that the affective disposition of a spectator to a character and outcome of that character in the narrative predicts enjoyment of the media experience (Raney, 2004). Such research however does not consider the game context and more complex player-character relationships. Our research thus aims to provide more valuable insights into the nature of the player-character relationship itself and the resulting satisfaction of the player with the game.

We chose to perform a study that aims to explore how the player-character relationship connects to the overall game satisfaction in a narrative game. Particularly, we looked into the context of a game titled *The Last of Us Part II*. In this game, the player is forced to switch PCs midway during the game, to a character who has previously been introduced as an antagonist character and who killed the previous protagonist PC. This game mechanic led to greatly polarized reactions and game satisfaction. It, therefore, seemed an excellent opportunity to explore the link between the player-character relationship and game satisfaction. To gain a deep understanding of the diverse and rich player experience, we chose a qualitative approach, inquiring a sample of a diverse player-base. We performed in-depth semistructured interviews with 12 players of *The Last of Us Part II*. We asked them about their overall game satisfaction, playing experience, and how they engaged with the PCs of the game. Through thematic analysis, we formed themes about the relevant aspects of the player-character relationship in connection to the resulting differences in game satisfaction. The study is structured as follows. In the first section, we introduce methods of the study,

TABLE 1 | Study participants.

Participant	Age range	Nationality	Occupation	Game satisfaction
P1	20–25	Switzerland	Student	Mixed
P2	20–25	Philippines	Student	Positive
P3	20–25	England	Student	Positive
P4	30–35	Ecuador	Student	Mixed
P5	30–35	USA	Accountant	Positive
P6	40–45	South Korea	Professor	Positive
P7	30–35	South Korea	CEO	Positive
P8	30–35	South Korea	Professor	Negative
P9	25–30	South Korea	Office worker	Positive
P10	20–25	South Korea	Student	Negative
P11	20–25	South Korea	Student	Positive
P12	20–25	South Korea	Marketing worker	Negative

such as participants, data analysis, and the game choice. In the next section, we present our results in the form of the themes concerning the player-character relationship and its connection to overall game satisfaction. In the last section, we discuss and conclude our findings including limitations of the study and ideas for future work.

2. METHODS

2.1. Participants and Recruitment

We recruited 12 participants, 7 male and 5 female, with ages ranging from 20 to 40 years, as illustrated in **Table 1**. Our participants had various nationalities with the majority being South Korean. We purposely recruited participants with diverse nationalities and differing game satisfaction, to capture the variety of possible ways players engaged with the game and PCs. The recruitment took place over posts on university forums, as well as through personal contacts of the researchers, using the snowball principle. The conditions to take part in the study were having played both games *The Last of Us* and *The Last of Us Part II*, or, in case of having quit playing the second game, having watched play-videos of the story until the end. The interviews were compensated with 30 USD or an equivalent in the local currency. The recruitment process and ethical considerations have been approved by the institutional review board of the institute of the authors.

2.2. Interviews and Thematic Analysis

To explore the richness and diversity of ways to relate to the PCs in the game and to capture all relevant variables related to the game satisfaction, we chose to perform semi-structured in-depth interviews. This approach allowed us to explore different variables of the PC relationship which might be relevant in connection to the game satisfaction and capture the complex context of the playing experiences. The interviews took approximately 1 h and were performed over the online conference system Zoom[1], due to the Covid-19 pandemic. The interviews were conducted in either English or Korean, with two researchers present, except in one case of P5, where only one researcher was present. After explaining the consent form, the interview was started. First, general questions concerning the background of the participant in playing video games were asked. Next, we inquired about the context and expectations of the players before starting *The Last of Us Part II*. The main part was comprised of questions concerning the relationship and perception of the three main player-characters Joel, Ellie, and Abby such as “How did you like this character, how did you like playing as him/her?” “How would you describe your relationship to that character?”, “Did something change in the way you think about the characters?”. The full question list is provided in the **Supplementary Material**. The questions sought to elicit responses concerning the impression of the character on the player, their reaction to specific game events (Joel’s death, PC switch, finale) and their perceived relationship with the PCs. While we inquired about the experiences of the players in both game parts 1 and 2, we focused more on part 2, since the game satisfaction of this game was more polarized.

The interviews were transcribed and a thematic analysis was performed, using inductive coding in line with Terry et al. (2017). The first author, who can speak in a proficient level of English and advanced level of Korean, coded five interviews in English and one interview in Korean and created an initial coding library. After debriefing and discussion on the coding library, four native Korean coders independently coded the remaining interviews in Korean using the software Nvivo. All coders wrote, shared, and discussed notes. Then, the themes were iteratively revised through discussions between the three authors to triangulate findings and eventually finalized into three themes concerning the player-character relationship and game satisfaction. The quotes from the Korean interviews which are introduced in this study were translated into English.

2.3. Game Choice

The Last of Us Part II (Naughty Dog, 2020) is a PS4 console game and the continuation of *The Last of Us* (Naughty Dog, 2013). The game can be described as a story-driven action-adventure shooting game, where the player controls mainly two player-characters Ellie and Abby, in the third perspective. The player has no control over the story, which is mainly depicted in cut-scenes and using story-cues in the environment. The player takes on the fighting and moving part of the PC.

The game had very polarized reactions and game satisfaction. On one hand, it received the most ‘Game of the Year’ awards in history (Stedman, 2020; Calvin, 2021) and was praised by critics and many players. On the other hand, players “review bombed” the game on the game-rating platform Metacritic[2] (Nunneley, 2020), leaving furious reviews. The distribution of user scores on Metacritic shows the polarization concerning this game well, since out of all user reviews on Metacritic only around 5% were mixed, the rest was divided into positive and negative, thus showing slightly more positive reviews[3]. This variety in

[1]https://www.zoom.us/

[2]www.metacritic.com

[3]https://www.metacritic.com/game/playstation-4/the-last-of-us-part-ii/user-reviews?dist=positive (accessed April 13, 2021).

reactions promised to be illustrative of how players can vary in their engagement with the PC. The focus on the story and complex characters of the game as well as the players' main complaints related to the PCs were indicative that the experiences of the players of this game can provide valuable insights into the different ways players connect to the PCs. For those reasons, we chose this game to perform a case study on how players engage differently with PCs and how this relates to the overall game satisfaction.

The story of the games takes place in a post-apocalyptic America, where half of the population is infected by a disease turning them into zombie-like cannibals. In the first part, the main PC Joel, a man in his forties, has the mission to take the 12 years old Ellie, who happens to be immune to the disease, to a hospital across the country, in an attempt to find a vaccine for the infection. They form a close bond and after he finds out that the operation to develop a vaccine would kill Ellie, he saves her from the operation table, killing several medical staff and allies. He then lies about what happened to Ellie.

The second part takes place 5 years later, where the player mainly controls Ellie who lives peacefully in the safe town of Jackson. Then, the character Abby appears and brutally kills Joel. Ellie goes after Abby with her girlfriend Dina. After killing several of Abby's friends, Ellie faces Abby, who kills and injures some of Ellie's friends. After a cut-scene, the player now controls Abby and learns that Abby's father was the surgeon who Joel (the player) killed in the previous game. Then, the player plays as Abby for the same 3 days until the face-off with Ellie, and continues controlling Abby in fighting Ellie, but after gaining the upper hand in the fight Abby spares Ellie and Dina. Back in Jackson, the player controls Ellie again, who hears about Abby's location and decides to go after her once more, against Dina's will. She finds Abby worn out and captured by another group, and after the last fight, lets her go and returns to an empty home.

3. RESULTS

We illustrate our findings in the following sections. We first illustrate the found differences in overall game satisfaction as well as the more specific player reactions to the game. We then present our themes concerning three aspects of the player-character relationship which were found to be related to the differences in game satisfaction and reactions. **Figure 1** illustrates the relationships among the game satisfaction, player reaction, and the themes concerning the player-character relationship.

3.1. Differences in Game Satisfaction and Player Reactions

3.1.1. Game Satisfaction

Players varied greatly in whether or how much they were satisfied with *The Last Of Us Part II*. The game satisfaction of the player was often either very high or very low with only a few mixed cases, as illustrated in **Table 1**. Players who were highly satisfied with the game would describe their experience similar to P5: *"My overall feeling is this is one of the greatest games I've ever played. It's one of the bravest narratives I think I've ever interacted with."* On the contrary, other players outed their frustration similar to P12: *"I played this emotionally abusive trash game for nothing."* Two players had mixed feelings about the game and would acknowledge positive and negative aspects like P4 did: *"It was really well done but, it already came with a baggage right, expectations from players (...) it was, narratively speaking, (...) badly structured."* To understand the differences in the overall game satisfaction better, we looked at more specific player reactions toward the game, as described in the next section.

3.1.2. Player Reactions

The differences in game satisfaction were visible in how the players reacted to the game. There were some clear commonalities in how players who did or did not like the game reacted to certain game events and elements. Those events and elements are (1) the reactions of the players to being forced to play as the Abby character and (2) the perceptions of the players of the different PCs. First, almost all players initially showed great reluctance, confusion, and anger when having to control the Abby character, as she was the character who brutally killed the previous PC Joel. However, the way in which players coped with the continuous obligation to play Abby differed across players. Players with low game satisfaction continuously showed great resistance and either finished the game very reluctantly or all over quit the game. The players who later voiced great appreciation for the game mentioned that they slowly accepted this game-mechanic and started to engage with the new PC. Second, the way players would perceive and describe the three main PCs in the game varied greatly. Players who did not like the game would critique how the actions of the character are illogical, not human-like, and how Abby appears as a tool of the game developer to convey a message. On the other hand, players who greatly valued the game mentioned how the PCs were interesting, complex, and human. This contrast in player's reactions points to underlying factors in how players interacted with the game. In the following, the three themes related to the differences in game satisfaction and player reactions are presented.

3.2. Player-Character Relationship

We now present the three themes which were found in relation to how the participants related to their PCs. We present each theme in the following section illustrating how each aspect of the player-character relationship was related to the players' reactions and overall game satisfaction. **Figure 2** illustrates the relationship of the themes in each of low satisfaction and high-satisfaction scenario.

3.2.1. Theme1: Tolerance of Forced Character Switch

The probably most controversial part about *The Last Of Us Part II* is that the player is forced to play as the Abby character midway during the game. The player has no choice but to play as her, to keep progressing in the game. This led to furious reactions in our participants, but not everyone was as resistant to this game mechanic. Some players who had a high game satisfaction valued this forced change of perspective in hindsight, as it enabled them to change their view on the Abby character.

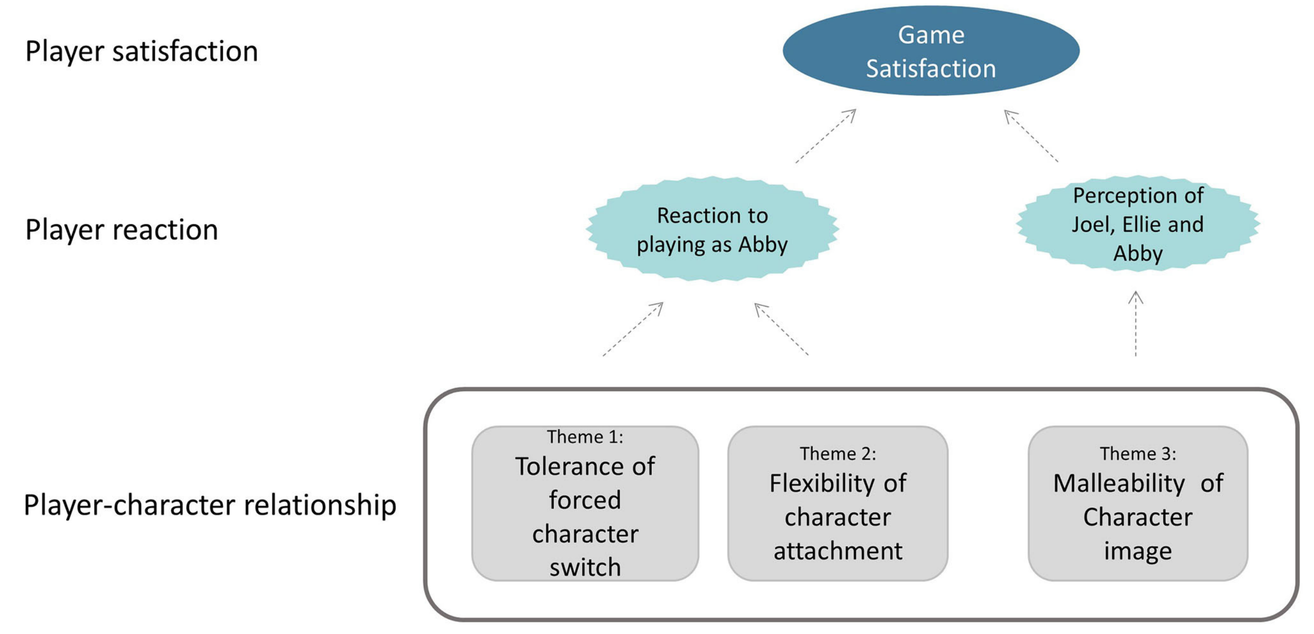

FIGURE 1 | Overview of relationship between game satisfaction, player reactions, and themes concerning player-character relationship.

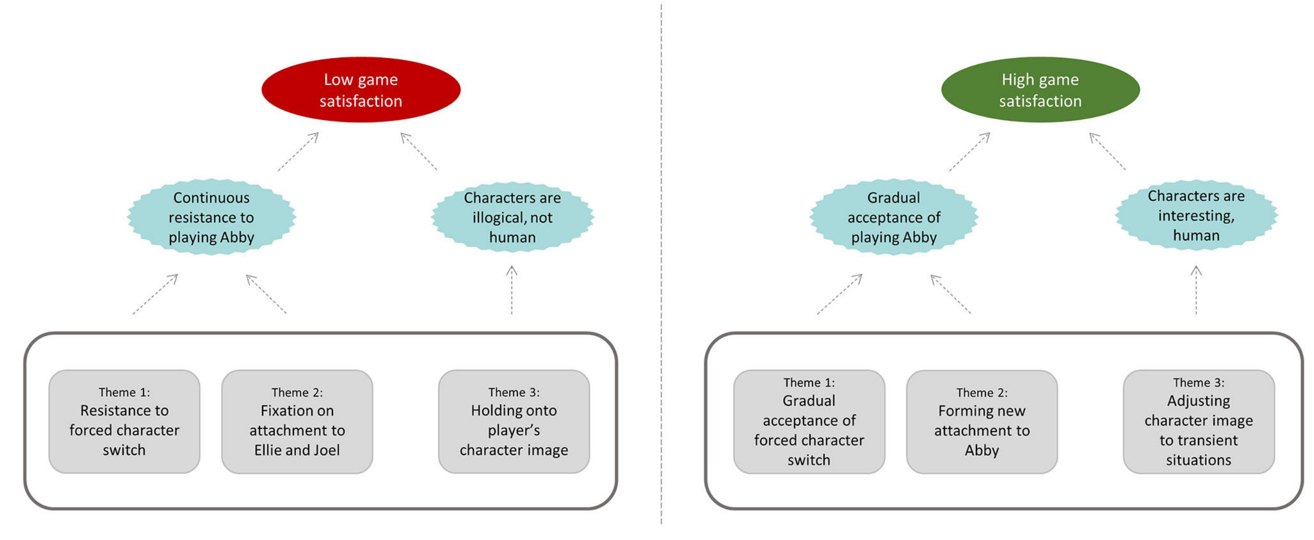

FIGURE 2 | Relationship of themes to high and low game satisfaction.

3.2.1.1. Resistance to Forced Character Switch

All but two participants were initially very reluctant to being forced to play as Abby. Of the reluctant participants, five did not appreciate the part as Abby until the end of gameplay. Those players showed a strong reluctance to being forced by the game to play in a way they did not want and having no choice. Particularly, the role of the developer who made them do this was strongly emphasized and the anger was also directly aimed at the development. P8 explains how the Abby character felt like the tool of the developer with which he wants to teach the player something. This created great reluctance in the player so that any engagement with the game was made impossible as P8 stated.

> P8: "Every time I played as Abby, it was really tormenting. (...) She was Neil Druckmann's avatar. The character, Abby. So, I keep feeling that Neil Druckmann is trying to convey the game's message through Abby, but it doesn't feel somehow natural like in [part]1, I always felt like he was trying to artificially force it onto me. So I couldn't get any positive feelings for the Abby character even if I wanted to. That's why it was tormenting and exhausting to play her. No sense of immersion at all."

P8 further mentioned that particularly being forced to directly play Abby made it impossible for him to relate to the character, whereas through other means of story-telling an engagement would, theoretically, have been possible:

> P8: "If Abby came up not as a playable character, but always on the other side and the situation would have played out in a cinematic way or so I think I would have been able to relate at least a bit (...) but because the user was forced directly I felt repulsive."

It can therefore be understood that the forceful play itself, the removal of the agency of the player as a separate element was rejected strongly by the dissatisfied players. The theme is therefore closely related to the continued resistance to playing Abby. This rejection also correlated strongly with the evaluation of the player and eventual satisfaction of the game, as P1 put it: *"When you don't want to do what the game wants you to do it's just not a good game."* In broader terms, the players did not accept forced gameplay as a narrative tool, as it seemed to go against their understanding of what a game is or should be. This is in contrast to the experiences of the remaining participants of our study, as explained in the following section.

3.2.1.2. Gradual Acceptance of Forced Character Switch

Most of the participants who had high satisfaction with the game were first also very reluctant to being forced to control the Abby character. However, other than the dissatisfied players, the participants started to change their view on the Abby character and the decision to make the player play Abby against their will was appreciated as a bold and effective narrative device, as explained by P5.

> P5: "I was furious with Abby up until I had to play as Abby, I mean even through that, the first few scenes of playing as Abby I felt I don't really want to play as her, I hate her, she's awful, she's ruining the life of the person I've really come to enjoy and now I have to play as her. But I think that's genius storytelling. I think it is a risk to tell a story like that to kind of force the player into a perspective that they don't really want to be in. That's gutsy and I appreciate that, not everyone likes that but I really like that. But that way of telling it, by kind of rewinding the clock, loved it I think that's a really smart way of doing it."

Another participant expressed fascination with how the game medium can be used to make players understand and experience characters differently than in other media, such as literature.

> P6: "I was really surprised. Of course in literature there is also attempts like that, but it's really hard to create stories where A kills B and then make them understand that from A's perspective. That's really hard but I thought oh so but through a game that's possible, I often thought that's somehow the game's unique ability. (...) The story isn't like good or bad but it's just those two people's unavoidable encounter and mismatch. How the story was resolved like that was really surprising and great."

In summary, the forceful deprivation of the agency of the player was not appreciated immediately, by almost any of the participants. However, the satisfied players started to value this forced character play as an effective narrative tool to make them change their minds about the PC, which they considered a meaningful playing experience. For the dissatisfied players, however, their agency seemed a more central part of their gaming experience, which is in direct conflict with the freedom of the developer to use the PC as a story-telling device. Therefore, in their eyes, the developers took not only the agency of the player, but also their game enjoyment to convey their own message. This resulted in strong anger against the developers. An additional factor adding to the players' frustration was that since the game was a sequel to a game without such harsh deprivation of agency, many players did not expect such an experience, and by the time they realized what kind of game *The Last Of Us Part II* is, they had already bought it. The reaction to the forced game play also likely had an influence on the subsequent perception of the PCs by the player, as will be described in Theme 3 and is illustrated in **Figure 1**.

3.2.2. Theme 2: Flexibility of Character Attachment

This theme concerns how participants formed attachments to the PCs. We show how dissatisfied players fixated on their strong attachment to the PCs, Joel and Ellie, from part one and how other players created an additional attachment to the new PC, Abby. This provided the latter players with a meaningful emotional playing experience which led to high game satisfaction.

3.2.2.1. Fixation on Attachment to Ellie and Joel

While all participants reported having a close attachment to the PCs of the first game, for some of the players this attachment directly interfered with their willingness to form a new attachment to the Abby PC. First, participants reported that they connected to the PCs of the first game through a gradual built up of an emotional bond that was not felt for the Abby character.

> P7: "I think it's because I can't ignore the attachment I got for the first game. And as I said before, you can really emphasize with the small emotional changes of Joel who is first just annoyed at Ellie and then gradually starts opening up and getting warmer. But I didn't get that feeling of delicate emotional development from Abby."

Furthermore, in contrast to satisfied players who would describe their relationship to the character as one of a close friend or movie character, most players who were very dissatisfied with the game mentioned that they immersed or projected themselves into the PC or saw the PC as their alter-ego as described by P12.

> P12: "Joel is my alter ego while playing this game. Since I need to occupy that character while playing and since it moves as I do, it's my alter ego which I feel like I can control directly and it gives me the ability to act within the game even though I can't make choices about the story in the game."

This close connection to the PC could subsequently not be transferred to another PC from another side, which P8 elaborates.

> P8: "Anyways since I always have an emotional bond while playing from the perspective of Joel, even if I play Ellie, since Ellie is on Joel's side you can play as her and share that emotional bond. But if you go to the complete opposite side you can't share that emotional bond anymore. Why should I play as her? I don't see any justification for playing as her."

3.2.2.2. Forming New Attachment to Abby

For the remaining participants, it seemed possible to keep the attachment to Ellie and Joel and still form a new attachment to the Abby character. It was clear that after playing the game the players had an attachment to both main PCs Ellie and Abby at the same time, and this conflicting attachment was one of the core meaningful experiences for which the players reported to appreciate the game for. The degree to which the attachment to Abby was achieved varied; however, a commonality between satisfied players was that they all had some degree of attachment to Abby. P9 explains how this inner conflict of attachment solidifies in the final fight of the game between Ellie and Abby.

> P9: "I think this fight might be the real climax of the game. At that time I can really emphasize with Ellie's sadness but I also can roughly understand Abby's life and her changed ideology, so it would be so hard to watch any of the two die"

The ways through which the participants related to the character varied, but frequently mentioned topics were the relationships of Abby with the Yara and Lev character as well as moments where Abby appeared flawed, or vulnerable as illustrated in the following two quotes.

> P3: "But then in the second game, once I think the turning point really was once you meet Yara and Lev because that just, brings out Abby's humanity (...) So when then these extra people come and save her and then in turn she goes like she owes them.

> P5: "One thing that really struck me as Abby and I love this about the game, is that Abby is terrified of heights. I am also terrified of heights and the game did this so well where they would illustrate her fear when you know she looked down (...) As someone who's afraid of heights I have a similar reaction, so to hear that and to see it depicted so realistically, was another moment of empathy for me and her."

To summarize, dissatisfied players only had one strong attachment to Joel and Ellie, while the satisfied players had all formed an attachment to the Abby PC to some degree. The former participants immersed or projected themselves strongly into PCs of the first part and were therefore unable to form new attachments while the latter players connected to Abby through her new relationships or hardships.

3.2.3. Theme 3: Malleability of Character Image

The last theme concerns how the players construct and adjust their own mental image of the PC. We found interesting differences in how some participants would see certain actions of the character as "not making sense" and based on that, they criticized the realism or logic of the game, while other players would actively create their own interpretations of why characters acted in the ways they did.

3.2.3.1. Holding Onto Character Image of the Player

A frequent criticism of participants who were disappointed in the game was how illogical the story was, particularly, how the actions of the characters do not make sense. Especially when that character in question was the player's favorite PC, and the actions related to a less positive character representation, this led to strong negative reactions and a negative evaluation of the game as a whole. This is illustrated by P12 who was strongly criticizing the logic of how Joel changed in *The Last Of Us Part II* compared to the first part.

> P12: "What I couldn't understand the most was that originally in part 1 Joel was more wary of people than zombies and if he was so strong and able to survive under any circumstances, then the fact that he was too weak to do anything in 2 and gets killed by Abby's group and he was beaten so helplessly to the degree that it made me think it might have been a setting error, made me so angry. (...) It wasn't the Joel I know."

Note how the last sentence "It wasn't the Joel I know" implies that the representation of the character was deviating from a mental image she had constructed about the PC. Also, inconsistencies in actions of negatively evaluated PCs were criticized, as seen when P8 explains how he got upset by the inconsistent actions of Abby when she spares the NPC Dina.

> P8: "Why is she [Abby] acting like this here? If she would act like what is common sense and what she showed us last time, it would have been normal for her to make a massacre ending, but now you don't kill that thing? This feeling of estrangement, based on the first impression she was a terminator who would kill everything, but actually she's a nice person."

The participant goes on to explain that he felt this inconsistency was due to the developers wanting to bring across their point of Abby actually being a nice character, but this being represented unnaturally in the game.

3.2.3.2. Adjusting Character Image According to Transient Situations

On the other hand we had participants who would flexibly adjust their character image based on new information provided in the game, and create their own interpretation for the underlying reason for the actions of the PC. A great example is P6, who contrary to P12 as discussed above, interpreted Joel's change in behavior as him starting to gain the ability to trust people thanks to Ellie and thereby saw it as character progression.

> P6: "In Joel's case, it's just my interpretation, but in Joel's case, it seems that he eventually started to believe in humanity. He believed in humans and built a community. Originally, starting as a very distrustful person, he met Ellie, started to trust Ellie, and while starting to depend on Ellie got to join a community. I understood that this is some kind of growth from his point of view, and that's why I interpret it as him starting to trust people. Of course, looking at the game's realism you can interpret it as Joel

just becoming so weird. But Joel now got a deep trust, got to be a person who deeply trusts people."

P6 continues to explain how he never questions the "logic" or "realism" of a character and his way of approaching game or literary character is that he likes to reason about the underlying motives which move a character.

P6: "Rather than thinking from the outside, in this piece of work this person doesn't make sense, it's not realistic, I'm the type who thinks more about the inside of the person, why did this person have to act in that way? That's why I never really thought things like what's wrong with this person. I don't think those things and there is also a lot of hidden meaning, it's the same with real humans. Why is person A acting like that, that person will have a reason, you don't say that person's action is unrealistic. That's kind of how I see it. (...) I think I treat it like they are real human beings."

Overall, this can be seen as a stark contrast in how the character image is constructed in players. It is mainly a difference in how players create and adjust their own mental image of the character in contrast to what is represented in the game. Participants who were part of the former type of players were usually the ones with a negative evaluation of the game representation of the game characters, mentioning how the characters do not make sense and exhibited an overall dissatisfaction with the game, while the latter type of players praised the game for it is interesting and complex characters and had high overall game satisfaction. This tendency is likely dependent on individual differences in the player. However, we can also assume that the willingness of the player to create narratives in their mind justifying the characters actions, is strongly influenced by the players' reaction to the forced gameplay and resulting overall attitude toward the game.

4. DISCUSSION

4.1. Connection to Related Theories

We discuss how our findings relate to the existing literature of player-character relationship and game satisfaction. A simple way to predict the game satisfaction in relation to connections with a media character is disposition theory (Raney, 2004), a theory originally from drama studies which states that the enjoyment of a media experience is based on an individual's affective disposition toward a certain media character and that character's fate within the narrative (Raney, 2004). In the case of *The Last Of Us Part II*, this can explain why the players who only had affection for Ellie and Joel until the end did not have a high enjoyment of the game, since those characters did not have good outcomes in the narrative. However, this theory does not explain why some participants formed an affective disposition to Abby and some did not. Similarly, the concept of allegiance from Lankoski (2011)'s work and its relation to accepting a PC's goal in the narrative can explain the players' reluctance to play as Abby, but not why some players could overcome this reluctance. To better understand those polarities, we must look more closely at the nature of and individual differences in the player-character relationship itself.

Concerning the differences in relating to the PC, we found interesting connections of our findings with the work of Banks (2015). The social spectrum of the player-avatar relationship (PAR) introduced for the context of Avatars in MMORPGs shows some parallels to the context of PCs in *The Last Of Us Part II*, a game with completely predefined characters and story. We found that the participants with a low game satisfaction possibly saw the PC of Joel more as "Me," while the players with a high satisfaction would see the PC more as a "Social other," for the following reasons. As illustrated in Theme 1, the disappointed players were very resistant to the forced character switch, since they valued their agency in the game. Even though all players had the same amount of agency in the game, some players likely had a higher perceived agency or valued their agency more. The higher player agency would place the player more toward the "unsocial PAR" side of the spectrum toward "Me" and "Object" (Banks, 2015). In addition, if the player sees the PC as herself, the loss of the agency over "oneself" should be much more shocking and unacceptable than losing agency over a social other.

Furthermore, in Banks and Bowman (2013), the PAR spectrum has been put in relation with the dimensions of character attachment of Lewis et al. (2008). This provides interesting connections to our second theme about the flexibility of character attachment. They show how in "Avatar as Me" identification is high and in "Avatar as Other" sense of care and responsibility is high (Banks and Bowman, 2013). This can explain how both dissatisfied, as well as satisfied players could have a high attachment to the Joel and Ellie character, but this attachment was likely different in nature. Therefore, only the satisfied players who saw the PC as a "Social other" could build an attachment to Abby as an additional "Social other," while the dissatisfied players could not create a relationship to an additional "Me." Even though an attachment to an additional "Social other" was possible for several players, the high value in sense of care and responsibility toward Joel and Ellie would suggest helping the PC "get the things it needs in his/her world," (Banks and Bowman, 2013, p. 2), but those goals were in direct conflict with the goals of the Abby character. This hindered the creation of an attachment but overcoming this inner conflict eventually led to higher game satisfaction.

To understand the differences found in the malleability of the character image, it will be fruitful to consult Calleja (2009)'s work. He explains that players construct a so-called alterbiography, a narrative created during game-play in response to the written narrative and the different game elements. It is the interplay of presented narrative and game mechanics of the designers and the players' subjective sense-making process in the game. The alterbiography is therefore inevitably different from the sole narrative represented in the game and is also different across players. The subject or focalization of the alterbiography can be either a miniature, entity, or the self. Miniature refers to multiple or non-specific entities, and entity and self both refer to single entities in the game, where the differentiation between entity and self is solely dependent on the disposition of the player. The alterbiography is a mental construct that is built up by segments of syntheses, which are the conscious mental efforts of the players to make sense of the game and narrative elements (Calleja, 2009).

The differences we found in our study concerning the creation of an character image might be explained by differences in focalization and the approach of the player to synthesis. For example, as described in section 3.2.3.1, P12 describes her reluctance to accept the changed image of Joel, and she also mentioned earlier in the interview that she saw Joel as her alter-ego, which suggests a focalization on the self and might thereby contribute to a higher reluctance to adjust an alterbiography as it somehow refers to a version of oneself. In addition, P8 outed his frustration about the inconsistent actions of Abby. Other players would bridge this ambiguity through their own interpretations, but the degree to which the player is willing to put effort into forming a synthesis varies and this might also be related to the expectation of the player of how much ambiguity developers should leave in the game. The game satisfaction was, therefore, lower for players who had pertaining conflicts of their existing alterbiography and the presented information in the game.

4.2. Implications, Contributions, and Future Work

In our study, we could see that controlling a PC in a narrative game includes more than just the mere mechanical steering of a virtual figure. It can mean to take on and project oneself into a given role in a fixed narrative or closely following a character through their story. The mechanisms involved in the player-character relationships in narrative games are complex and distinct from other genres such as MMORPGs or other media such as film. We could observe in this work how switching the PC can lead to strong reactions, whose causes are likely twofold. First, as our theme 1 illustrates, switching out the PC intrudes the only agency the player has in the game, namely, the control of the PC. Second, the player has to accept to take on the perspective of a new character whose personality, characteristics, and goals might not align with their own preferred outcome of the narrative. Therefore, the reaction to a character switch is highly dependent on how the PC is presented and written. For example, character switches from Joel to Ellie in parts 1 and 2 were quite readily accepted while the new antagonist character Abby initially received strong negative reactions. This illustrates the power of a character switch as a narrative tool, which can bring about highly different outcomes in terms of game satisfaction based on individual differences in the underlying player-character relationship.

Our findings carry several implications about how player-character relationships can be used to convey certain experiences. We found that using a character switch can lead to meaningful and highly valued playing experiences by making the player change their perception about the PC. However, when using the game character as a narrative tool, the following factors should be taken into consideration. First, even though the game does not provide the player with a high degree of direct agency on the story or character creation, players might still highly value their agency of player control. Second, since some players may refer to the PC as a version of themselves and others more as a social other, manipulations of the PC relationship will result in very different player experiences and eventual game satisfaction. Last, the degree to which the game designer's intended picture of a character and the player's alterbiography of that character correspond should never be overestimated, and the willingness of the player to adjust those felt differences is also highly variant.

In this paper, we studied the player-character relationship in a narrative game which includes the switch of a PC. We showed how the experience of the player can differ even in games with a highly predefined narrative and how those differences relate to the game satisfaction. Specifically, we found the themes of "Tolerance of forced character switch," "Malleability of character image," and "Flexibility of character attachment." We illustrated that even though there is a very limited agency in relation to the PC, the players can have perceived agency which they value and are not willing to give up, and there are players who project themselves into the PC, even though the personality of the PC and story are predefined. We also showed how the willingness of the player to adjust their image of the PC varies depending on how much they project themselves into it and how much they are willing to actively create interpretations about the characters, which leads to different receptions of unexpected character actions. Finally, we showed how our findings relate to existing theoretical models, such as the player-avatar relationship from the genre of MMORPG and the concept of alterbiographies.

Our study has several limitations. Due to the relatively small sample and exploratory nature of the study, the depth of insights for each variable of the PC relationship is limited and provides a great avenue for future inquiry. In addition, while we tried to balance the opinions about the game in our participant sample, it might be slightly biased toward the positive, due to the possible reluctance of disappointed players to take part in an interview. Furthermore, as the first author did not code all transcripts herself there might be a loss of information, however, she repeatedly consulted all transcripts and discussed with the involved researchers.

There are several opportunities for future research inquiry. Our themes could be applied to other game cases of character switches. For example, a study of *Metal Gear Solid 2* (Konami, 2001) could show how despite the game receiving high appraisals for the gameplay and story, the character switch was rather controversial. Even though in *Metal Gear Solid 2* the switch is not from protagonist to antagonist, there seems a varying tolerance of the character switch and there are players who strongly reject an intrusion into their agency of controlling their favorite character[4]. Further, the flexibility of the character attachment seems different among players, since in some positive reviews the new character is readily accepted ("He"s ok with me."[5]) and in some positive and most negative reviews the character is rejected ("[he] truly destroys

[4]https://www.metacritic.com/game/playstation-2/metal-gear-solid-2-sons-of-liberty/user-reviews?dist=negative

[5]https://www.metacritic.com/game/playstation-2/metal-gear-solid-2-sons-of-liberty/user-reviews?dist=positive, Ivanm. Nov 15, 2009.

this game."[6]), mentioning his non-attractive and contrasting personality in comparison to the original "cool" PC. This could imply variances in how those players are attached to their PC. Finally, differences in the malleability of the character image could be seen in how the negative reviews complained about how "confusing[7]" and "ridiculous[8]" the story is, hinting at difficulties adjusting to changes in the story and character image. Such tentative observations could be investigated through future in-depth analyses.

Our exploratory qualitative work can also be extended with quantitative studies on each dimension lined out by the three themes presented in this study. A quantitative inquiry will verify or disprove the current findings and provide stronger evidence for the proposed themes. For example, concerning the flexibility of character attachment, a survey using measures of character attachment and the perception of sociality of the PC can provide more solid evidence for the relation between different kinds of character attachments and game satisfaction. Cross-genre studies could further help to position player-character relationships in narrative games within the broader context of gaming experiences.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because participants did not agree to share their private interview data to the public. Requests to access the datasets should be directed to Young Yim Doh, yydoh@kaist.ac.kr.

[6]https://www.metacritic.com/game/playstation-2/metal-gear-solid-2-sons-of-liberty/user-reviews?dist=negative, Kyle B. Nov 14, 2002.
[7]https://www.metacritic.com/game/playstation-2/metal-gear-solid-2-sons-of-liberty/user-reviews?dist=negative, DeanR. Dec 29, 2008.
[8]https://www.metacritic.com/game/playstation-2/metal-gear-solid-2-sons-of-liberty/user-reviews?dist=negative, CarlosFromPeru, Aug 4, 2007.

ETHICS STATEMENT

This study involving human participants was reviewed and approved by the KAIST Institutional Review Board. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

VE conducted, transcribed, and coded all interviews in English, coded one interview in Korean, and wrote the manuscript. SL conducted all interviews in Korean, coded two Korean interviews and revised the manuscript. YYD supervised the work, consulted the research process, and revised the manuscript. All authors participated in the conceptualization and design of this research and the iterative creation of the themes.

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SUPPLEMENTARY MATERIAL

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REFERENCES

Banks, J. (2015). Object, me, symbiote, other: a social typology of player-avatar relationships. *First Monday* 20. doi: 10.5210/fm.v20i2 5433

Banks, J., and Bowman, N. D. (2013). *Close Intimate Playthings? Understanding Player-Avatar Relationships as a Function of Attachment, Agency, and Intimacy*. AoIR Selected Papers of Internet Research. Retrieved from: https://journals.uic.edu/ojs/index.php/spir/article/view/8498

Banks, J., and Bowman, N. D. (2016). Emotion, anthropomorphism, realism, control: validation of a merged metric for player avatar interaction (PAX). *Comput. Hum. Behav*. 54, 215–223. doi: 10.1016/j.chb.2015.07.030

Banks, J., Bowman, N. D., Lin, J.-H. T., Pietschmann, D., and Wasserman, J. A. (2019). The common player-avatar interaction scale (cPAX): Expansion and cross-language validation. *Int. J. Hum. Comput. Stud*. 129, 64–73. doi: 10.1016/j.ijhcs.2019.03.003

Baranowski, T., Buday, R., Thompson, D. I., and Baranowski, J. (2008). Playing for real: video games and stories for health-related behavior change. *Am. J. Prev. Med*. 34, 74.e10–82.e10. doi: 10.1016/j.amepre.2007.09.027

Blinka, L. (2008). The relationship of players to their avatars in MMORPGs: differences between adolescents, emerging adults and adults. *Cyberpsychology* 2:5. Retrieved from: https://cyberpsychology.eu/article/view/4211 (accessed September 08, 2021).

Bopp, J. A., Müller, L. J., Aeschbach, L. F., Opwis, K., and Mekler, E. D. (2019). "Exploring emotional attachment to game characters," in *CHI PLAY '19* (New York, NY: Association for Computing Machinery), 313–324.

Boudreau, K. (2012). *Between Play and Design: The Emergence of Hybrid-Identity in Single-Player Videogames*. Ph.D. thesis, University of Montreal, Canada.

Burgess, J., and Jones, C. M. (2017). "Is it too much to ask that we're allowed to win the game?": character attachment and agency in the Mass Effect 3 ending controversy. *Bull. Sci. Technol. Soc*. 37, 146–158. doi: 10.1177/0270467618819685

Calleja, G. (2009). "Experiential narrative in game environments," in *Digital Games Research Association (DiGRA) 2009 Conference, West London*. Retrieved from: https://www.um.edu.mt/library/oar/handle/123456789/26653 (accessed September 08, 2021).

Calvin, A. (2021). *The Last of Us Part 2 Has More Game of the Year Awards Than The Witcher 3, the Previous Record Holder*. Available online at: https://www.vg247.com/2021/01/26/last-us-part-2-witcher-3-awards (accessed April 11, 2021).

Chew, E. C., and Mitchell, A. (2020). Bringing art to life: Examining poetic gameplay devices in interactive life stories. *Games Culture* 15, 874–901. doi: 10.1177/1555412019853372

Colder Carras, M., Van Rooij, A. J., Spruijt-Metz, D., Kvedar, J., Griffiths, M. D., Carabas, Y., et al. (2018). Commercial video games as therapy: a new research agenda to unlock the potential of a global pastime. *Front. Psychiatry* 8:300. doi: 10.3389/fpsyt.2017.00300

Devine, T. C. (2017). Integrating games into the artworld: a methodology and case study exploring the work of Jason Rohrer. *Games Cult*. 12, 671–695. doi: 10.1177/1555412015596105

Drennan, P., Viller, S., and Wyeth, P. (2004). "Engaging game characters: Informing design with player perspectives," in *International Conference on Entertainment Computing* (Berlin; Heidelberg: Springer), 355–358.

Ferguson, C. J. (2007). The good, the bad and the ugly: a meta-analytic review of positive and negative effects of violent video games. *Psychiatr. Q*. 78, 309–316. doi: 10.1007/s11126-007-9056-9

Folkerts, J. (2010). "Playing games as an art experience: How videogames produce meaning through narrative and play," in *Emerging Practices in Cyberculture and Social Networking*, eds D. Riha and A. Maj (Leiden: Brill; Rodopi), 97–117.

Jørgensen, K. (2010). Game characters as narrative devices. A comparative analysis of dragon age: origins and mass effect 2. Eludamos. *J. Comput. Game Culture* 4, 315–331. Retrieved from: https://www.eludamos.org/index.php/eludamos/article/view/101 (accessed September 08, 2021).

Klopfer, E., Osterweil, S., Salen, K., et al. (2009). *Moving Learning Games Forward*. Cambridge, MA: The Education Arcade.

Konami (2001). *Metal Gear Solid 2*. Tokio: Game [PS2,3].

Lankoski, P. (2011). Player character engagement in computer games. *Games Cult*. 6, 291–311. doi: 10.1177/1555412010391088

Lankoski, P., and Bjork, S. (2008). "Character-driven game design: Characters, conflicts and gameplay," in *GDTW, Sixth International Conference in Game Design and Technology* (Liverpool), 59–66.

Lewis, M. L., Weber, R., and Bowman, N. D. (2008). "They may be pixels, but they're MY pixels:" developing a metric of character attachment in role-playing video games. *Cyberpsychol. Behav*. 11, 515–518. doi: 10.1089/cpb.2007.0137

Loyer, E. (2015). Parasocial and social player-avatar relationships: social others in Thomas Was Alone. *Press Start* 2, 21–32. Retrieved from: http://press-start.gla.ac.uk/index.php/press-start/article/view/18 (accessed September 08, 2021).

Mallon, B. (2008). Towards a taxonomy of perceived agency in narrative game-play. *Comput. Entertain*. 5, 1–15. doi: 10.1145/1324198.1324202

Naughty Dog (2013). *The Last of Us*. Santa Monica, CA: Game [PS3,4].

Naughty Dog (2020). *The Last of Us Part II*. Santa Monica, CA: Game [PS4].

Nowak, K., and Fox, J. (2018). Avatars and computer-mediated communication: a review of the definitions, uses, and effects of digital representations. *Rev. Commun. Res*. 6, 30–53. doi: 10.12840/issn.2255-4165.2018.06.01.015

Nunneley, S. (2020). *The Last of Us: Part 2 Has Been Review Bombed on Metacritic*. Available online at: https://www.vg247.com/2020/06/19/last-us-part-2-review-bombed-metacritic/ (accessed April 11, 2021).

Ong, J. (2018). *Investigating the Mechanisms and Processes of Player-Avatar Relationship Construction : A Dual Process of Experiential and Psychological Interpretation During Game Play*. Master's thesis, Nanyang Technological University, Singapore.

Prot, S., McDonald, K. A., Anderson, C. A., and Gentile, D. A. (2012). Video games: good, bad, or other? *Pediatr. Clin*. 59, 647–658. doi: 10.1016/j.pcl.2012.03.016

Raney, A. A. (2004). Expanding disposition theory: reconsidering character liking, moral evaluations, and enjoyment. *Commun. Theory* 14, 348–369. doi: 10.1111/j.1468-2885.2004.tb00319.x

Shaw, A. (2011). "He could be a bunny rabbit for all I care": Exploring identification in digital games," in *Proceedings From DiGRA 2011: Think Design Play: The Fifth International Conference of the Digital Research Association (DIGRA)* (Hilversum).

Stedman, A. (2020). *The Game Awards 2020: Complete Winners List*. Available online at: https://variety.com/2020/digital/news/the-game-awards-winners-list-2020-1234850547/ (accessed April 11, 2021).

Terry, G., Hayfield, N., Clarke, V., and Braun, V. (2017). *Thematic Analysis. In The Sage Handbook of Qualitative Research in Psychology, Chapter 2* (London: SAGE), 17–37.

Tychsen, A., Hitchens, M., and Brolund, T. (2008). Character play: the use of game characters in multi-player role-playing games across platforms. *Comput. Entertain*. 6, 1–24. doi: 10.1145/1371216.1371225

Vella, D. (2016). A structural model for player-characters as semiotic constructs. *Trans. Digit. Games Res. Assoc*. 2, 79–121. doi: 10.26503/todigra.v2i2.37

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Exercising With a Six Pack in Virtual Reality: Examining the Proteus Effect of Avatar Body Shape and Sex on Self-Efficacy for Core-Muscle Exercise, Self-Concept of Body Shape, and Actual Physical Activity

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This study investigates the Proteus effect from the first-person perspective and during avatar embodiment in actual exercise. In addition to the immediate measurements of the Proteus effect, prolonged effects such as next-day perception and exercise-related outcomes are also explored. We theorized the Proteus effect as altered perceived self-concept and explored the association between virtual reality (VR) avatar manipulation and self-concept in the exercise context. While existing studies have mainly investigated the Proteus effect in a non-VR environment or after VR embodiment, we aim to contribute to the literature by addressing this concern to explore how the Proteus effect works in actual VR exercise. Through a 2 (avatar body shape: with a six pack vs. normal) × 2 (sex: male vs. female) between-subject experiment, the results partially support the Proteus effect. Regarding actual physical activity, embodying an avatar with a six pack during exercise creates fewer body movements. No significant effect was found for perceived exertion. We also explored the role of sex as a potential moderator in the association of the Proteus effect on exercise outcomes. The Proteus effect was supported by immediate and next-day self-efficacy for core-muscle exercise only among female participants. The between-subject design allowed us to probe how avatar manipulation of muscular body shape with a six pack as opposed to normal body shape influences participants' self-concept and exercise outcomes, as limited VR studies have employed within-subject comparisons. This also contributes to the literature by providing an upward comparison (e.g., muscular with a six pack vs. normal) as opposed to the previous downward comparison regarding body fitness (e.g., normal vs. obese). The overall results supported the Proteus effect in the context of core-muscle exercise when comparing normal and ideal body shape avatars. However, the Proteus effect as an altered self-concept and its effects on self-efficacy for exercise were supported among females but not males. Whereas the female participants who embodied avatars with a six pack associated themselves more with the muscular concept than other people, the male participants who embodied avatars with a six pack perceived themselves as more normal than others. Theoretical and practical implications are discussed.

Keywords: avatar body shape, self-concept, self-efficacy, female and male, Proteus effect, virtual reality, virtual reality exercise, physical activity

INTRODUCTION

Embodiment in virtual reality (VR), also termed the body ownership illusion (BOI) (Slater, 2009), is the illusion by which healthy people perceive an avatar's virtual body as if it were their own physical body even though they know it cannot be (Maselli and Slater, 2013). Unlike other media, in which audiences view the avatar from the third-person view or through the computer screen, embodiment in VR allows one to perceive the virtual body as his/her own. Several empirical examinations of virtual body illusions have indicated that one demonstrates attitudes or behaviors that are consistent with the traits of virtual avatars during and after virtual avatar embodiment, termed the Proteus effect (Yee and Bailenson, 2007; Yee et al., 2009). Although not every relevant study adopts the term Proteus effect, research on the effects of embodiment has examined the basic concept: how do users behave and what is their attitude after embodying a virtual avatar with assigned traits?

Although the original study that coined the term Proteus effect tested this effect in VR, subsequent studies have examined this effect in digital games and console games that present avatars from a first-person or third-person view on the screen. The results are inconsistent, with some supporting the effect (Peña et al., 2009) and others unable to replicate it (Sylvia et al., 2014). In this study, we discuss the Proteus effect in VR only from a first-person perspective, which provides the full BOI and its effects. Among published VR studies, most have confirmed the Proteus effects. For example, a 40-year-old woman who embodied the virtual body of a 4-year-old girl later overestimated object size (Banakou et al., 2013), supporting the Proteus effect. Users who embody a coral (Ahn et al., 2016) experiencing ocean acidification perceive themselves to be closer to nature and thus are more motivated to pay attention to environmental issues.

With VR equipment becoming more accessible and easier to use, for example via standalone VR goggles, using VR to exercise has become a trend, especially during the COVID-19 pandemic (Hart, 2021; Siani and Marley, 2021). Existing applications provide various content for users to engage in boxing, dancing, or aerobic exercises, but none of these incorporate virtual body elements. What effect is had by exercising with a six pack? Will we be more motivated to exercise and perceive ourselves to have strong core muscles? No research has examined the Proteus effect in the context of VR exercise from a first-person perspective, as existing studies mostly project the avatar appearance on a mirror in the VR environment (Kocur et al., 2020) or present the avatar from the third-person view (Fox and Bailenson, 2009; Bailenson and Segovia, 2010). Examining the Proteus effect in the context of VR exercise from the embodiment perspective can shed light on the literature and practical design.

In the current study, we examined the Proteus effect through avatar manipulation of body shapes in VR, including a body with six packs and a normal-shaped body, among male and female participants in the context of promoting core-muscle exercise. We also examined the automatic self-concept as the theoretical underlying mechanism of the Proteus effect.

Avatar Manipulation in an Exercise Context

Using communication technology to promote exercise efficacy and behavior has consistently received scholarly attention. Existing studies testing avatar manipulation in the context of exercise have mostly employed digital games such as those available on the Nintendo Wii and other video game interfaces (Peña et al., 2016; Navarro et al., 2020). Although the avatar manipulation was not conducted in VR, these studies suggested that they were testing the Proteus effect. Most of these studies manipulated avatars' body shapes, such as normal versus obese body shape, and examined the effect on exercise intention and physical activity. For example, Joo and Kim (2017) assigned participants to 2 (obese vs. normal avatar body shape) × 2 (healthy vs. unhealthy lifestyle) groups in Sims 4 to examine how these avatar traits affected the participants' exercise (i.e., stepping machine) and actual cookie consumption after the virtual game experience. The results indicated that neither the avatar shape nor the lifestyle affected the participants' exercise behaviors or unhealthy eating behaviors. However, they found an interaction effect on exercise behavior. Among the participants playing Sims 4 with a normal-weight avatar, those who had a healthy lifestyle avatar engaged in more steps on the stepping machine than those with an unhealthy lifestyle avatar. They suggested that the participants did not want to learn from obese avatars and that avatars with an ideal body shape and positive lifestyle influenced the participants' exercise behaviors. The Proteus effect was not significant but was effective in certain conditions.

In another study (Li et al., 2014), overweight children aged 9–12 years old were assigned to 2 (avatar shape: normal vs. overweight) × 2 (stereotype threat messages: present vs. absent) conditions to play Wii games. The results supported the Proteus effect in that overweight children playing the game through normal body size avatars had greater exercise attitudes, general exercise motivation, exercise motivation using Wii, and game performance than those assigned avatars with an overweight body shape. A conditional Proteus effect was identified in which overweight children with a stereotype threat absent condition reported greater exercise attitude and motivation than those with an avatar of normal body shape. This indicated that the

Proteus effect can have different effects depending on the context and message frame.

The Proteus effect also occurs in the downward comparison condition in exercise when an opponent embodies a less ideal body than the participant in a competition requiring physical activity. Scholars (Peña et al., 2016) examined how avatar body size and opponent body size affected male participants' physical activity during a competitive exergame. They found a main effect of the Proteus effect: male participants operating normal body size avatars demonstrated greater physical activity than those operating obese avatars. They also found an interaction effect in which participants demonstrated decreased physical activity when the opponent avatar's body was perceived as more obese than their own avatar's. In addition, if the participants perceived their own avatar to be more obese than their opponent's, they showed decreased physical activity. These results showed that the social comparison of body size influenced the participants' physical activity through different processes. The study did not measure the underlying mechanisms, which may explain such moderated differences in physical activity.

In another study, Navarro et al. (2020) examined whether avatar clothes (sports or formal clothes) and faces (self or strangers' faces) affected participants' physical activity. The results showed an interaction effect in that the participants operating avatars with their own faces and with sport clothes demonstrated greater physical activity than those in the other conditions. In addition, those who operated avatars with a stranger's face and formal clothes demonstrated decreased physical activity. This indicated that even the clothes on the avatar affected the participants' physical activity.

Proteus Effect in Virtual Reality

Since the Proteus effect was first identified in virtual reality (Yee and Bailenson, 2007), scholars have interpreted Proteus effects through various approaches, such as self-perception (Yee and Bailenson, 2007), priming (Peña et al., 2009), or schema activation (Ratan and Dawson, 2016). Despite the various interpretations, scholars commonly agree that the Proteus effect is a top-down avatar induced "attitudinal and behavioral change through self-perception" among users (Ratan et al., 2020, p. 654). Empirical evidence indicates that when users embody an avatar with characteristics different from their own, they hold attitudes and exhibit behaviors consistent with the traits of the avatars. For example, individuals who embody a taller avatar are more willing to turn down unfair offers than those who embody a shorter avatar (Yee and Bailenson, 2007), indicating that embodying taller avatars enables participants to be more confident in their decisions.

A meta-analysis (Ratan et al., 2020) shows that the Proteus effect through avatars is larger than other media effects, such as the aggression or prosocial effects of video games, found by studies that focus on the effect of media content on audiences. This indicates that persuasive characteristics through embodied avatars exert a stronger influence on users than other types of media since users interact with digital content through the representation of the avatar. The inconsistent results regarding the Proteus effect in the literature may be due to avatar induction being accomplished through multiple approaches, including digital games, console games, or VR. The distinctive difference between VR embodiments and others lies in individuals being able to look down at their own virtual body as if it were their own. This first-person no-distance view provides a strong BOI, which results in greater effects than other modes (Yee and Bailenson, 2009; Ahn et al., 2016). Therefore, we focused on the Proteus effect in VR in the current study.

Among VR studies examining the Proteus effect, most studies have confirmed the Proteus effect. Banakou and colleagues examined avatar manipulation in various contexts and found that individuals change their attitude and behavior and conform to the traits of embodied avatars. For example, Caucasian participants who embodied an African American dark-skinned avatar demonstrated a significant reduction in racial bias (i.e., viewing themselves as closer to an African American outgroup) according to the Implicit Association Test (IAT; Banakou et al., 2016) compared to Caucasian participants who embodied a white-skin avatar or purple-skin avatar (as a control group). In another study, 40-year-old women who embodied 4-year-old girl avatars subsequently spoke at a higher frequency, which indicates conforming to the child's high frequency speech (Tajadura-Jiménez et al., 2017). Seinfeld et al. (2018) invited participants with a history of domestic violence to embody female victim avatars to experience abuse. They found that this embodiment allowed these male participants to experience physical and verbal abuse first hand in VR, and these participants reported a greater reduction in bias to recognize fear emotions than those in the control groups. Although the above scholars never used the term Proteus effect in any of their research, the work regarding virtual embodiment provides ample evidence to support the Proteus effect (Yee and Bailenson, 2007): the top-down avatar traits affected individuals' attitudes and behaviors and made them consistent with the assigned traits through embodiment.

In addition to manipulating individuals' traits through virtual avatars, research has also examined embodying individuals in non-human organisms. Ahn et al. (2016) invited participants to embody a coral to see the coral's arms (as if they were the participants' arms) falling due to ocean acidification. Participants who embodied a coral in VR experienced greater inclusion of nature in the self through embodiment than those who watched a video, and the inclusion of nature in the self further led to greater issue involvement through a decrease in perceived temporal distance. In another experiment (Ahn et al., 2016), participants embodying a cow in VR had greater spatial presence and embodiment than those who watched a video, and embodiment mediated the effects of VR on the inclusion of nature in the self. These results indicated that VR embodiment has greater effects than video embodiment, and such effects are not limited to human traits but extend to non-human living organisms through the perception of the inclusion of others in the self.

Proteus Effect in Virtual Reality Exercise

Most existing studies examining the Proteus effect in VR have focused on the context of social interaction or issue persuasion (Ahn et al., 2016; Banakou et al., 2016), and research has only recently employed VR embodiment in the context of

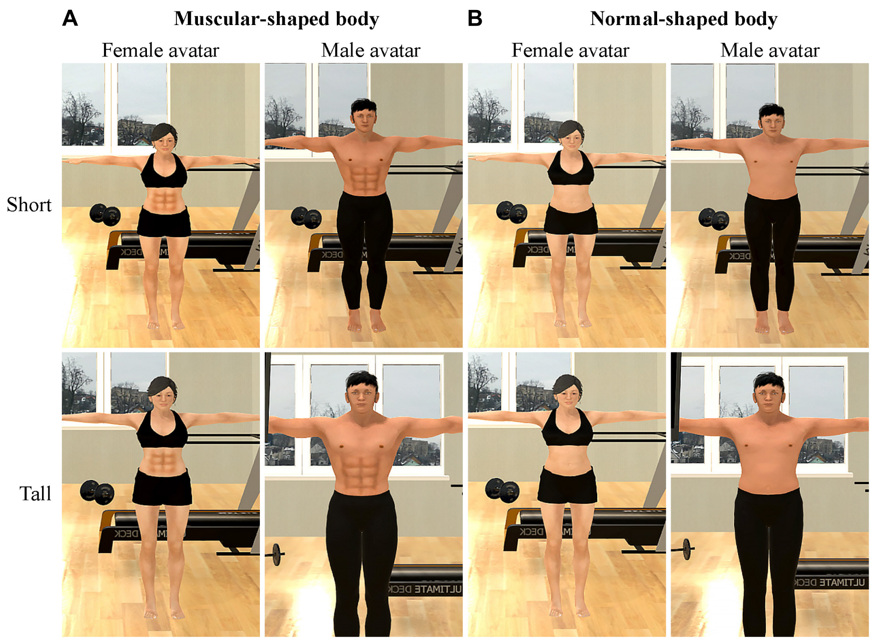

FIGURE 1 | Avatars. **(A)** The female and male avatars with muscular-shaped bodies. **(B)** The female and male avatars with normal-shaped bodies. (The upper row shows the short avatars for the participants who were shorter, and the lower row shows the tall avatars for the participants who were taller).

exercise (Kocur et al., 2020). With the increasing popularity and affordability of VR equipment via standalone machines, users can easily use VR goggles and engage in exercise. This is especially useful in the context of pandemics, such as COVID-19, that require social and physical distancing. Existing research (Peña et al., 2016) has shown that avatar manipulation affects players' exercise outcomes, and we hypothesize that the Proteus effect could increase users' exercise motivation through avatar manipulation in VR. Specifically, VR enables the BOI among users in which they perceive the avatar's body as their own because they can look down at it as their own (Slater, 2009).

Two studies have examined Proteus effects during VR exercise. Reinhard et al. (2020) examined whether the age of participants' avatars (old versus young) affected their walking speed in VR, and they found that the Proteus effect diminished quickly. The participants who previously embodied an older avatar required more time to walk the same set distance after the embodiment than those who previously embodied younger avatars and those in the control group (i.e., non-VR group). However, this effect occurred only in the first session after the stimulus and not the second section. In the second session, all three groups displayed similar times. This could be because the study tested walking behavior *after* embodiment with virtual avatars rather than testing walking speed *during* embodiment. Therefore, the after-stimulus effect diminished quickly.

The second study (Kocur et al., 2020) examined the Proteus effect during VR avatar embodiment. In this exploratory study with 30 participants (15 male and 15 female) and a within-subject design, the authors examined the effect of avatar muscularity (three levels: non-muscular, medium, and muscular body) on the participants' physical performance and perceived exertion. They found a Proteus effect of the avatar's muscular appearance on the participants' perceived exertion, in which the participants embodying muscular avatars reported a lower perceived exertion (i.e., perceived the task to not be that hard) than when they embodied non-muscular avatars. In addition, they found a Proteus effect of the avatar's muscular appearance on the participants' grip strength, but this effect occurred only among male participants, indicating sex to be a moderator. They suggested that the Proteus effect in the context of a muscular avatar appearance can decrease participants' perceived effort and increase grip strength. This study provided an initial examination of the Proteus effect *during* avatar embodiment. However, the participants performed short physical strength tasks, such as lifting a physical weight and putting it back, rather than actual exercise. It is unclear how and how long Proteus effects work during avatar embodiment in actual exercise sessions. In addition, the within-subject design in which each of the 15 participants embodied each of the three avatar types and reported all perceptions repetitively could introduce bias and increase type II errors. More research on the Proteus effect during and after avatar embodiment in an actual exercise context using a between subject experimental design is needed.

The Outcomes of the Proteus Effect in Virtual Reality Exercise

There are important physical and psychological outcomes of exercise. Research regarding Proteus effects on exercise focus on physical outcomes including the physical activity (Reinhard et al., 2020) and perceived exertion (Kocur et al., 2020). Physical activity is the actual movement one engages during exercise, and can be objectively measured by an accelerometer or subjectively reported by participants, such as by using the IPAQ questionnaire (Dyrstad et al., 2014). Accelerometer-measured physical activity captures the objective physical movements one engages in through measuring the vector magnitude of movements in three axes (Dyrstad et al., 2014): the *X*-axis representing horizontal dimension when the participant moves right and left, the *Y*-axis reflecting up and down movements, and the *Z*-axis representing back and forth movements. Counts of physical movements determine one's intensity of physical activity in a certain frame (Peng et al., 2015), and can reflect one's lifestyle considering the sedentary time in a longer period of time (Troiano et al., 2008; Peng et al., 2015). In the current experiment, we focus on the actual body movements in a short period of time to reflect physical activity. Perceived exertion is the perceived level of effort committed to an exercise and estimates the "effort and exertion, breathlessness, and fatigue during physical work" (Borg, 1998, p. v; Williams, 2017, p. 404). Perceived exertion is usually measured by the self-reported Borg rating of perceived exertion. Accelerometer data provide an objective report of one's actual physical activity, whereas perceived exertion reflects one's perceived effort devoted to the exercise (Borg, 1998; Peng et al., 2015).

The psychological outcomes of exercise center on the motivation to exercise regularly (McAuley and Blissmer, 2000; Thøgersen-Ntoumani and Ntoumanis, 2006; Cataldo et al., 2013). Based on a core construct in social cognitive theory, self-efficacy is defined as "the belief in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p. 3). In the context of exercise, exercise self-efficacy is the belief that one is capable of exercising and is willing to perform the assigned action (i.e., exercise) in the future. Exercise self-efficacy is an important predictor of the adoption and maintenance of exercise behaviors (Fletcher and Banasik, 2001). High exercise self-efficacy leads to higher initiation and continuation of exercise behaviors.

In this study, we aimed to investigate the Proteus effect from the first-person perspective and during avatar embodiment in actual exercise. In addition, next-day perception and exercise-related outcomes were also explored. We chose the context of core-muscle exercise and examined how an avatar's muscularity (cues that elicit the Proteus effect) affects participant exercise outcomes. In the context of engaging in core-muscle exercise, if one has muscular core muscles, one has the core power to maintain balance and limit extraneous movements around when performing related exercises. For example, when one performs squats, which exercises core and other muscles, if one has strong core muscles, one can stably perform such a task with fewer extraneous body movements than those with weak core muscles. Therefore, muscular participants require only certain physical motions to complete the exercise. Similarly, muscular participants should perceive lower exertion when performing related exercises (Kocur et al., 2020). Therefore, we proposed the following hypotheses based on the Proteus effect. We refer to normal-body avatars as avatars without core muscles and avatars with obvious core muscles as muscular-body avatars.

H1: Participants embodying normal-body avatars will engage in greater physical activity than participants embodying muscular-body avatars.

H2: Participants embodying normal-body avatars will report greater perceived exertion than participants embodying muscular-body avatars.

Other than the physical outcomes, how does the Proteus effect during VR exercise affect psychological reactions to the exercise? Does embodying an avatar with an ideal body image increase or decrease the sense of self-efficacy for exercise? According to the existing literature, body image may be either positively or negatively associated with exercise efficacy and motivation. Ouyang et al. (2020) indicated that positive body image can enhance self-efficacy for exercise and increase sports participation. In another study, Song et al. (2011) found that seeing the unsatisfactory self-image on a screen while playing the exergame may decrease exercise self-efficacy because the self-image reminds oneself of the discrepancies between self and the ideal image. However, plenty of studies found that negative body image or the intention to improve the self-image (i.e., trying to appear toned or fit) motivates people to exercise more (Conroy et al., 2000; Hausenblas et al., 2004; Brudzynski and Ebben, 2010). Based on the inconsistent evidence in the literature, we developed two competing hypotheses:

H3-1: Participants embodying muscular-body avatars will report greater (a) immediate self-efficacy and (b) next-day self-efficacy for core-muscle exercise than participants embodying normal-body avatars.

H3-2: Participants embodying normal-body avatars will report greater (a) immediate self-efficacy and (b) next-day self-efficacy for core-muscle exercise than participants embodying muscular-body avatars.

Proteus Effect as an Altered Automatic Self-Concept

Scholars have theorized associations between avatars and players in digital games (i.e., character identification, Klimmt et al., 2009) and in VR (i.e., Proteus effect, Yee and Bailenson, 2007). Several theories have been employed to explain the Proteus effect. Yee and Bailenson suggested that in VR, avatar traits are limited cues associated with the self, so the first-person perspective embodiment changes one's self-perception. Other scholars have suggested the Proteus effect to be due to a priming mechanism (Peña et al., 2009) or schema-activation mechanism (Ratan and Dawson, 2016), and both stressed that individuals form their self-concept based on the limited cues from the embodied avatar.

Regardless of the underlying mechanism, the above theoretical arguments center on the result that players form an altered perceived self-concept based on the assigned avatar cues and traits. Existing empirical evidence has implicitly provided support for the argument that VR embodiment produces an altered self-concept. Tajadura-Jiménez et al. (2017) found that older women who embodied a 4-year-old girl VR avatar reported a younger perceived self-concept than those who embodied a 60-year-old VR avatar. In another experiment (Hasler et al., 2017), white participants embodied a black VR avatar and treated black people as a novel in-group and thus reported decreased racial bias toward black people compared with those who embodied white VR avatars. Although Slater and his colleagues did not use the term Proteus effect in any of their studies, their results show that virtual body ownership results in self-concept changes. Therefore, here, we argue that the Proteus effect is due to an altered automatically perceived self-concept. We thus propose the following hypotheses:

> H4: Participants embodying muscular-body avatars will perceive their own body as being more muscular than participants embodying normal-body avatars.

Sex as a Moderator

Previous literature has suggested that responses toward idealized body shape and body image vary with sex, with women being more inclined than males to internalize an idealized body image and more likely to experience body-related schema activation from viewing thin-ideal images (Hargreaves and Tiggemann, 2003). The literature also indicates that women view thin as well as thin and muscular (i.e., toned) bodies but not hypermuscular bodies as ideal (Benton and Karazsia, 2015). Sex is a potential moderator of the Proteus effect on altered self-concept and should be explored.

The above concept of ideal body is derived from the Western standard. In the Taiwanese context, weight training has become popular in recent years and having a six pack with a thin body has been glorified as an ideal body shape by several women celebrities (Song and Huang, 2020; Ciao, 2021). Weight training for core-muscle exercise is also emphasized among society, and university students adopt this as their exercise routine (Taiwan Sports Administration, 2020; Taiwan Health Promotion Administration, n.d.; Zhou, n.d.). The consensus in Taiwanese society is that having a six-pack core is an ideal body condition regardless of sex. Although ideal body shape depends on individual preferences, core-muscle training to form a six pack is equally empathized for both sexes in Taiwan. Therefore, in this study, we explore potential sex difference in the Proteus effect when participants embody an avatar with a six pack.

In addition to different responses toward the level of muscularity, male and female participants also report different patterns toward exercise and exercise self-efficacy. Female participants in exercise normal interventions report increased aerobic exercise efficacy compared with other conditions, but this does not occur among male participants (Barha et al., 2017). Moreover, initial exploration via small-sample VR studies (Kocur et al., 2020) also showed that the Proteus effect on grip strength occurred only among male participants, indicating potential sex differences in the Proteus effect toward avatars with various muscularity levels. Therefore, sex is likely to moderate the association of avatar muscularity with exercise outcomes. However, very few studies have explored the role of sex on the Proteus effect in VR avatar embodiment (Kocur et al., 2020), and existing studies suffer from the use of a within-subject design and small sample sizes, which limit sex comparisons. Moreover, the direction of the moderation is unknown and should be explored. We thus propose the following research questions:

> RQ1: How does sex moderate the relationship between avatar body shape and physical activity?
> RQ2: How does sex moderate the relationship between avatar body shape and perceived exertion?
> RQ3: How does sex moderate the relationship between avatar body shape and (a) immediate self-efficacy of core-muscle exercise and (b) next-day self-efficacy of core-muscle exercise?
> RQ4: How does sex moderate the relationship between avatar body shape and altered self-concept?

Lastly, we positioned perceived body shape, body mass index (BMI), and BOI as covariates of all the analyses to control each participant's perception of their own body shape, their BMI, and the degree they perceive that they embody the virtual body (i.e., BOI) (Maselli and Slater, 2013).

MATERIALS AND METHODS

To test the hypotheses, we employed a 2 (muscular body with a six pack vs. normal body) × 2 (male vs. female) between-subject factorial design experiment. Recruitment invitations were issued through the daily campus announcement email of a national university in northern Taiwan. Students who signed up for this study were asked to complete a screening questionnaire on their daily exercise behaviors, height, body weight, and perceived body shape (1 as not muscular at all and 7 as very muscular). Those who did not perceive their own body as muscular (under 5 points) were invited to the laboratory to participate in the experiment. A total of 96 participants (51 females) participated in this study and were randomly assigned to one of four conditions. The participants embodied a same-sex muscular body with a six pack or a normal body according to the condition to which they were assigned and exercised following a workout video in a virtual gym.

Stimulus

A virtual scene depicting a gym with a mirror wall with a television screen hung on the upper left side of the mirror wall was created using the Unity engine[1]. The participants viewed the virtual world using an HTC VIVE head-mounted display (HMD). The participants' actual bodies were replaced with a same-sex virtual body in the virtual scene. They could see their virtual body from the first-person point of view or in the mirror in front of them. We employed a Microsoft Xbox One Kinect Sensor to track the participants' actual body postures and movements and mapped those movements onto the virtual body so they could see virtual body movements in accordance with their actual body movements in real time.

[1] https://unity.com/

FIGURE 2 | The environment of the virtual gym. The participants could see their virtual body from a first-person perspective and in the mirror.

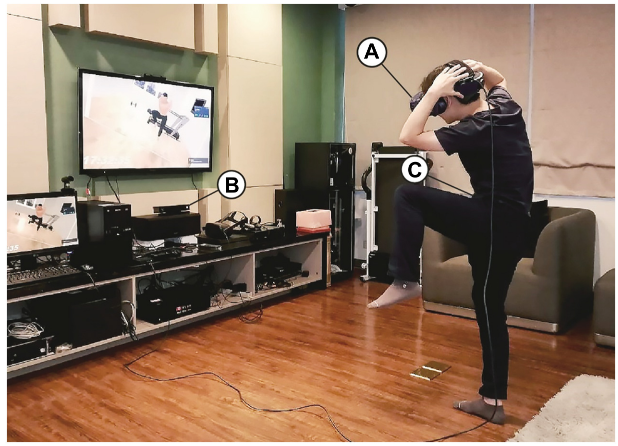

FIGURE 3 | Experimental setup. **(A)** HTC VIVE head-mounted display (HMD). **(B)** Microsoft Xbox One Kinect Sensor for actual body movements tracking. **(C)** ActiGraph GT3X accelerometer for recording physical activity.

The avatars were created using MakeHuman[2]. The muscular-shaped body avatars had obvious abdominal muscles (i.e., six pack), while the normal-shaped body avatars did not. To prevent the unexpected effects caused by height differences between the virtual body and the real body, eight avatars were created–male/female avatar with a tall and muscular body, male/female avatar with a short muscular body, male/female avatar with a tall normal body, and male/female avatar with a short normal body (**Figure 1**) – and assigned to participants according to their actual height. Male participants who were taller than 5′9′′ feet and female participants who were taller than 5′5′′ feet were assigned tall avatars, and other participants were assigned short avatars.

The scenario began with the participant standing in a gym facing the mirror wall with a television screen on the mirror wall playing a core workout video. The participants were asked to observe and move their virtual body first and then exercise following the video on the screen (**Figure 2**).

Procedure

On arriving at the laboratory, the participants signed an informed consent form. Then, research staff directed the participants to a cleared floor space (approximately 3 × 2.5 m) and helped them put an ActiGraph GT3X accelerometer unit on their waist to record continuous physical activity. Afterward, research staff assisted the participants in wearing the HTC VIVE HMD and informed the participants that they would have a VR experience. The participants were asked to follow the prerecorded voice instructions in the virtual scene (**Figure 3**).

At the beginning of the VR experience, the participants found themselves in a virtual gym facing a large mirror wall. The voice instructions guided them to look around and observe their virtual bodies by looking down and looking in the mirror. Then, they were instructed to perform a series of movements, such as knee lifts and arm waves, to help them associate their physical body movements with the avatars' movements. This phase lasted 40 s. Next, a video featured a series of standing core workouts played on the TV screen, and the participants were instructed to exercise following the video (**Figure 4**). The workout video lasted for 3 min and 48 s, followed by a free practice session for 2.5 min. The participants were told that they could keep exercising, practice the workouts in the video freely or hang out in the virtual gym until the time was up.

After that, the research staff helped the participants remove the HMD and accelerometer and asked the participants to rate their perceived exertion immediately. Then, the participants were guided to sit in front of the computer and complete the IAT and the rest of the study measures. A follow-up questionnaire link was sent out 24 h after the participant left the laboratory and asked about their self-efficacy for exercise.

Measurements

Perceived Body Shape

Perceived body shape (M = 1.74, SD = 1.03) was assessed using a one-item scale developed by this study. The participants rated their body shape on a scale that depicted male/female normal-shape bodies without abdominal muscles at the left end (1 as not muscular at all) and male/female muscular bodies with six-pack muscles at the right end (7 as very muscular).

Perceived Exertion

Perceived exertion (M = 12.16, SD = 2.00) was assessed using the Borg Rating of Perceived Exertion (RPE; Borg, 1998) scale. The scale is a simple numerical list ranging from 6 (no exertion at all) to 20 (maximal exertion). The participants rated their exertion during the activity in the VR experience on the scale, combining all sensations and feelings of their physical stress and fatigue.

Self-Efficacy for Exercise

Self-efficacy for exercise (same day: α = 0.84, M = 4.26, SD = 1.31; next-day: α = 0.84, M = 4.09, SD = 1.19) was measured using a four-item scale modified from Lorig et al. (1996). The participants rated the degree of agreement (1 = strongly disagree and 7 = strongly agree) with statements such as "After the VR experience, I am confident that I can do some simple core

[2]http://www.makehumancommunity.org/

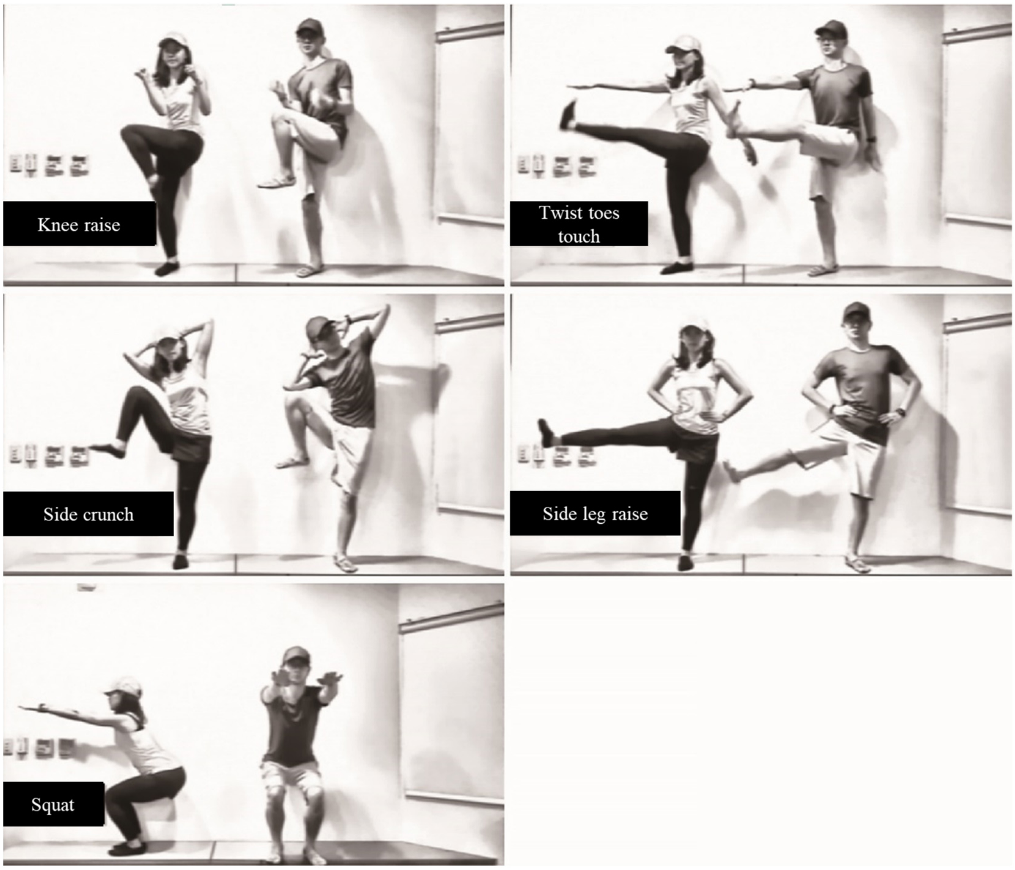

FIGURE 4 | The standing core workouts in the video.

workouts in my daily life" and "In the next 6 months, I am confident that I can do some core workout regularly."

Automatic Self-Concept

Automatic self-concept was assessed using the IAT, which was developed to measure beliefs that people may be unable to report by detecting the strength of associations between concepts with a particular attribute (Greenwald et al., 1998). This test has been successfully used for the assessment of self-concept (Schnabel et al., 2008; Suslow et al., 2014). The participants were asked to quickly sort words related to 2 target concepts (self and others) and 2 attributes (normal body shape and muscular body shape) into categories shown on the left or right sides on the computer screen by pressing the P or Q key. The IAT score (M = 17.58, SD = 215.60) is calculated based on the participants' response times. If participants perceived their figures as more muscular, they performed faster when hitting the response key for highly associated categories (e.g., self + muscular) than for less associated categories (e.g., self + normal figure).

We conducted the IAT using E-prime[3] and following the procedure suggested by Greenwald et al. (1998). The test involved 5 sessions of discrimination tasks. The first two sessions were target-concept and attribute discrimination tasks. The participants practiced sorting words into "self" and "others" categories on the screen in the first session and into "muscular body shape" and "normal body shape" categories in the second session. The third session was a combined task, and the participants sort the words into two combined categories, each including one target and one attribute concept and using the same key in the preceding two steps. After that, the participants practiced another target-concept discrimination task with reversed key assignments in the fourth session. Then came a reversed combined task using the same response key assignments as the second and fourth sessions. The words used for the discrimination tasks are shown in **Table 1**. The orders of Session 2–3 and Session 4–5 were counterbalanced. The IAT score was obtained from the difference in mean response times between the two combined tasks with reversed combinations of concepts (i.e., Session 3 and Session 5). Before starting the calculation, those trials with a response time greater than 3,000 ms were recoded to 3,000 ms, and those that were less than 300 ms were recoded to 300 ms. The participants with error rates higher than 20% were dropped from the IAT analysis. The IAT score was interpreted in accordance with the notion that the more negative (or less positive) a person's IAT score is, the greater their association of normal body shape with the self; on the

[3]https://pstnet.com/products/e-prime/

TABLE 1 | The words used for the Implicit Association Test (IAT).

Target concepts	Self	我 (I)
		自己 (Me)
		本人 (Oneself)
		自身 (Myself)
	Others	他 (He)
		她 (She)
		他們 (They)
		他人 (Other people)
Attributes	Muscular body shape	結實 (Wiry)
		精壯 (Strong)
		健美 (Body building)
		肌肉 (Muscular)
	Normal body shape	普通身材 (Normal figure)
		平凡身材 (Ordinary body)
		中等身材 (Medium build)
		一般身材 (Average body)

The test was conducted in Chinese, so we listed the original Chinese words used in the test and tried to translate them into English words with similar meanings.

other hand, the more positive (or less negative) a person's IAT score is, the greater their association of muscular body shape with the self.

Physical Activity

Physical activity was collected using the ActiGraph GT3X accelerometer and ActiLife software, as these are established measurements (Dyrstad et al., 2014). The sampling rate was set to 100 per second, and the epoch was set to 10 s, which means that it integrated 1,000 samples every 10 s to produce one data point. The filtering and exporting process was performed using ActiLife software. The exported motion data were vector magnitudes ($M = 5274.45$, $SD = 2181.69$), that is, the total amount of movements on the three axes, which is calculated from the square root of the sum of the squares of all three axes."

Body Ownership Illusion

Body ownership illusion ($\alpha = 0.74$, $M = 4.2$, $SD = 0.94$) was measured using an 8-item scale modified from Hasler et al. (2017) and Grechuta et al. (2019)The items included "Although the virtual body did not look like me, I had the sensation that the virtual body I saw in the mirror was mine," "Although the virtual body did not look like me, when looking down at my body I had the sensation that it was mine," and "When I looked down, it seemed as if I had more than one body (reverse coded item)."

RESULTS

To examine the hypothesis and research questions, we employed 2 (avatar body shape: muscular with a six pack vs. normal) × 2 (sex: male vs. female) between-subject ANCOVA analyses on physical activity, self-efficacy, RPE and IAT reaction time data, with participants' perceived body shape, BMI, and BOI in VR as covariate variables. Among all 96 participants, 25 males and 23 females were assigned to the muscular avatar with a six pack group, and 20 males and 28 females were assigned to the normal avatar group. The average age of our sample was 21.56, ranging from 18 to 42 years, and an independent t-test showed no significant difference in the mean age between the two groups, $t(94) = 0.42$, $p > 0.05$.

H1 and RQ1 concern the relationship between avatar body shape and users' physical activities among male and female participants. An ANCOVA analysis of accelerometer data showed that during the follow-along workout session, there was a significant group main effect on physical activity [vector magnitude: $F(1,89) = 5.77$, $p < 0.05$, $\eta^2 = 0.06$], the participants in the normal avatar group made more movements (adjusted $M = 5748.67$, $SD = 285.53$) than those in the muscular avatar with a six pack group (Adjusted $M = 4761.97$, $SD = 284.50$). Although no other significant effects were found during the follow-along workout session or free practice session, these results did provide some evidence for H1; players with a normal avatar body shape displayed more physical activity than those with a muscular body shape with a six pack.

The participants also reported the RPE scale to estimate their subjective physical exertion. An ANCOVA analysis of the RPE score was conducted to test H2, which anticipates RPE differences between the normal avatar group and the muscular avatar with a six pack group. Nevertheless, neither main effects of avatar body shape [$F(1,89) = 0.53$, $p > 0.05$, $\eta^2 = 0.01$] and sex [$F(1,89) = 0.02$, $p > 0.05$, $\eta^2 < 0.01$] nor interaction [$F(1,89) = 0.11$, $p > 0.05$, $\eta^2 < 0.01$] were significant on the participants' RPE scores. Thus, H2 was not supported, as different avatar body shapes did not affect the players' perceived exertion.

Regarding immediate self-efficacy for core-muscle exercise (H3a and RQ3a), the ANCOVA showed a nearly significant interaction between avatar body shape and sex, $F(1,89) = 3.87$, $p = 0.052$, $\eta^2 = 0.04$ (**Figure 5**). We further conducted a *post hoc* analysis and found that the effect of avatar body shape existed only in females, $F(1,89) = 5.22$, $p < 0.05$, $\eta_p^2 = 0.06$; those who embodied normal avatars demonstrated higher self-efficacy (adjusted $M = 4.78$, $SE = 0.25$) than their muscular avatar with a six pack counterparts (adjusted $M = 3.99$, $SE = 0.26$). We also found a significant sex difference in the normal avatar group, $F(1,89) = 5.50$, $p < 0.05$, $\eta_p^2 = 0.06$, and females showed higher self-efficacy (adjusted $M = 4.78$, $SE = 0.25$) than males (adjusted $M = 3.94$, $SE = 0.28$).

Similar results were found in next-day self-efficacy (H3b and RQ3b). Although the interaction between avatar body and sex was not significant [$F(1,89) = 3.71$, $p = 0.057$, $\eta^2 = 0.04$] we still observed a simple main effect of avatar body shape in females [$F(1,89) = 4.49$, $p < 0.05$, $\eta_p^2 = 0.05$] and a sex difference in the normal avatar group [$F(1,89) = 7.70$, $p < 0.01$, $\eta_p^2 = 0.08$]. Similar to immediate self-efficacy, the female participants in the normal avatar group demonstrated higher next-day self-efficacy (adjusted $M = 4.60$, $SE = 0.23$) than the female participants in the muscular avatar with a six pack group (adjusted $M = 3.94$, $SE = 0.24$) and the male participants in the normal avatar group (adjusted $M = 3.70$, $SE = 0.25$; **Figure 6**). We also conducted a three-way mix designed ANCOVA (with avatar body shape and sex as between subject variables and measure date as within-subject variable) to probe the change of self-efficacy in 2 days; the results showed neither a main effect [$F(1,89) = 1.46$, $p > 0.10$,

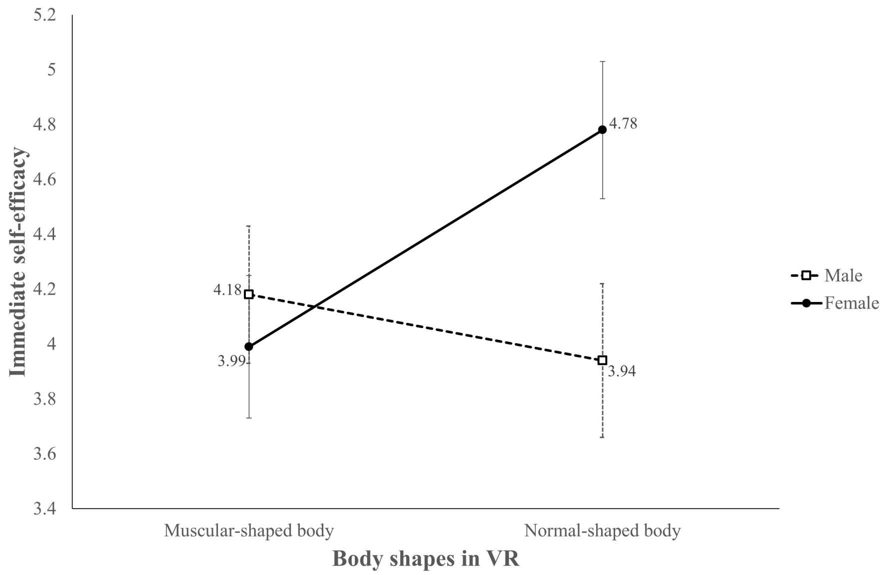

FIGURE 5 | Adjusted mean score of immediate self-efficacy for core workouts.

$\eta_p^2 = 0.02$] nor any interaction of measure date (all Fs < 1, ps > 0.10), suggesting that participants' self-efficacy did not change during two measured time regardless of avatar body shape and sex. According to these results, participants who embodied a normal body shape avatar will display more self-efficacy for core-muscle exercise, yet this effect appears only among female users.

To understand the influence of avatar body shape on users' automatic self-concept (H4) and the potential moderating effect of sex (RQ4), we used the IAT to probe the participants' automatic self-concepts. Following the procedure (Greenwald et al., 1998), the IAT score was derived by subtracting the average reaction time (RT) of session 3 (other-normal and self-muscular combination) from the average RT of session 5 (other-muscular and self-normal combination). A negative score indicates that the linkage between self and normal was stronger than the linkage between others and normal, and a positive IAT score indicates the opposite relation.

A two-way interaction was found in the ANCOVA analysis, $F(1,89) = 4.93$, $p < 0.05$, $\eta^2 = 0.05$. Automatic self-concept differed males and females in the muscular avatar with a six pack group, $F(1,89) = 4.23$, $p < 0.05$, $\eta^2 = 0.05$, while there was no significant difference in the normal avatar group (**Figure 7**). In the muscular avatar with a six pack group, males connected the concept of "normal body" with "self" more strongly than with "others," yet females showed a reverse pattern: they connected "normal body" with "others" more strongly than with "self". No main effects were found. In other words, a muscular avatar with a six pack did not trigger the participants' positive self-concept, and H4 was not supported. However, the effect of avatar body shape on the participants' self-concepts was moderated by sex, with female participants associating themselves more with the muscular avatar with a six pack and the male participants associating themselves more with the normal-body avatar (RQ4).

DISCUSSION

This study aimed to investigate the Proteus effect from a first-person perspective and during avatar embodiment in actual exercise. In addition to the immediate measurements of the Proteus effect, prolonged effects such as next-day perception and exercise-related outcomes were also explored. We also theorized the Proteus effect as occurring due to an altered perceived self-concept and explored the association between VR avatar manipulation and self-concept in the exercise context. While the existing literature has mainly investigated the Proteus effect in a non-VR environment or explored the effect after VR embodiment, we aimed to contribute to the literature by addressing this concern by exploring how the Proteus effect works in actual VR exercise. In addition, we explored the role of sex as a potential moderator in the association of the Proteus effect on exercise outcomes. Furthermore, the between-subject design of the study allowed us to investigate how avatar manipulation of muscular body shape with a six pack as opposed to normal body shape influenced participants' self-concept and exercise outcomes, as limited VR studies have employed within-subject comparisons. The findings also contribute to the literature by providing an upward comparison (e.g., muscular vs. normal) as opposed to the previous downward comparison regarding body fitness (e.g., normal vs. obese).

Through a 2 (avatar body shape: muscular vs. normal) × 2 (sex: male vs. female) between-subject experiment, the results partially support the Proteus effect. The participants embodying a normal-body avatar demonstrated more physical activity than those with a muscular avatar when performing core-muscle exercise during avatar embodiment. This may support our hypothesized Proteus effect that embodying a muscular avatar with a six pack results in a firmer position during exercise and limits extraneous body movements. However, physical

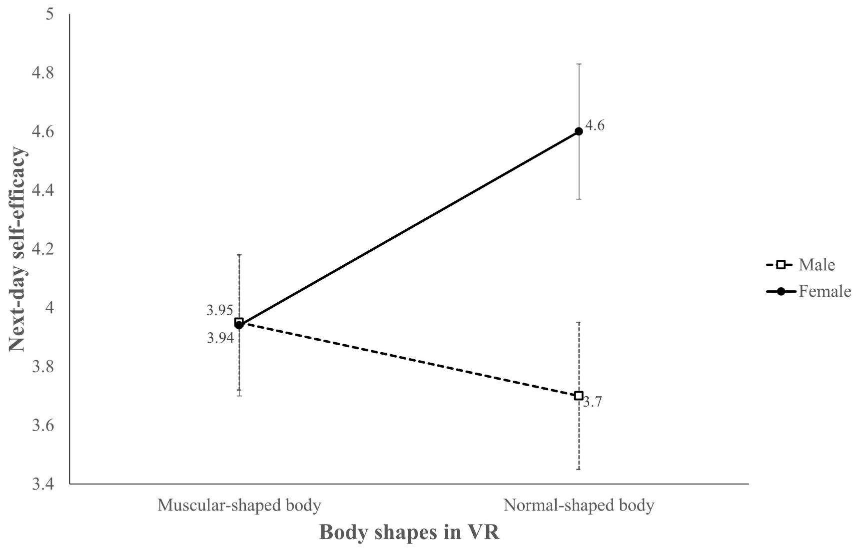

FIGURE 6 | Adjusted mean score of next-day self-efficacy for core workouts.

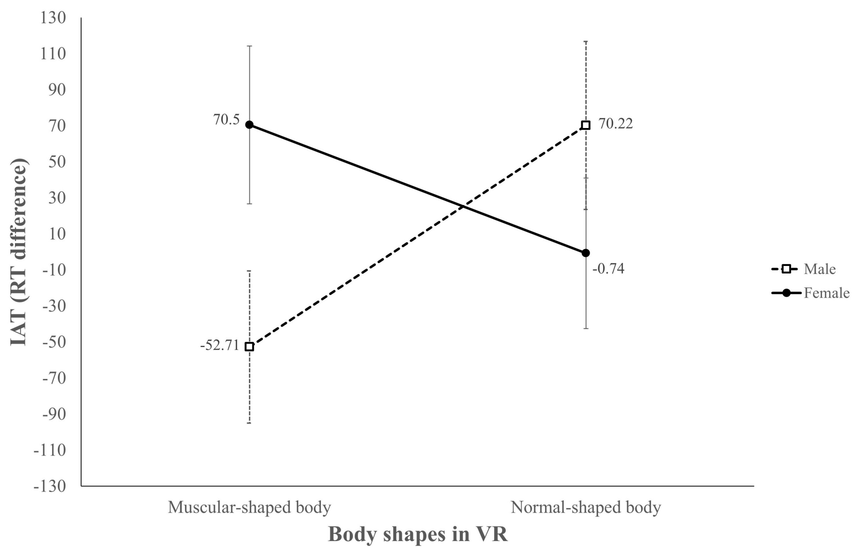

FIGURE 7 | Interaction between avatar body shape and sex of participants in predicting participants' self-concept after the VR experience.

activity might also reflect that one performs the exercise less effectively. In other words, participants who embodied the avatar with the six pack might perceive themselves as not needing to exercise that much, resulting in fewer physical movements (e.g., underperformance). Not knowing the exact rationale and psychological processes, we can only provide our observation that most participants followed the instructions in the video to engage in the exercise seriously during the teaching time (which is the main analysis conducted) and underperformance should not be an issue. Nevertheless, more detailed effects on their physical activity should be probed in future research.

Avatar manipulation of body shape in VR did not affect the participants' perceived exertion during the core-muscle training exercise. This conflicts with the findings of Kocur et al. (2020), in which participants perceived lower exertion when embodying a muscular avatar. Two reasons may explain the lack of effect found in this study. First, the participants engaged in several core-muscle training exercises in our study, and thus, they paid more attention to following the exercise movements during the embodiment. Kocur et al. (2020) allowed participants to lift weights or flex their muscles while looking at their virtual body, which may highlight the importance of avatar body shape. Another reason may be that these exercises do not provide much variance in exertion. The participants may not have perceived the exercises as difficult. More research is needed to further examine this issue.

The Proteus effect occurs in not only the physical dimension (i.e., physical activity) but also the psychological dimension (i.e., self-efficacy). Regarding immediate self-efficacy, the Proteus effect was found among female participants but not male participants. The immediate the next-day self-efficacy for core-muscle exercise had the same pattern, with female participants who embodied normal avatars reporting greater self-efficacy. This suggested that the female participants who embodied the normal avatars might have perceived the avatar body shape as closer to their actual body and as needing more exercise to improve it, and the workout following the video session in VR increased their knowledge and confidence for pursuing this goal, resulting in greater self-efficacy. On the contrary, the female participants who embodied muscular with a six pack avatars might have perceived their bodies as good enough and therefore lack sufficient motivation to exercise more. These results also indicated that the Proteus effect occurs not only immediately after avatar embodiment but lasts until the next-day. Whereas Reinhard et al. (2020) reported the Proteus effect after avatar embodiment, we further showed that it lasts until the next-day. This is important for the theory of the Proteus effect because the underlying mechanism is key for the outcomes and important for practitioners to efficiently boost exercise motivation through VR muscular avatar embodiment.

Self-concept was explored in this experiment, and it was an important outcome of the Proteus effect. However, the impact of the effect on self-concept was only partially supported because the outcomes varied by sex: the Proteus effect, as altered self-concept, was found among females but not males. In addition, whereas the female participants associated the muscular with a six pack concept with themselves more than with other people, the male participants perceived their self as more normal than other people. This showed that the upward comparison of avatar body shape or more ideal body may have backfired for the male participants. As having a six pack (Hoyt and Kogan, 2001; Drummond and Drummond, 2014; McNeill and Firman, 2014) was heavily emphasized as an attribute of an ideal and muscular body, it may have triggered the male participants' body stereotypes and thus increased awareness or reactance to this persuasion tactic. In other words, the "obvious" persuasive cue may remind them of their real body shape without a six pack. Another explanation is that people can feel their core muscles, but merely seeing the embodied avatar having a six pack without feeling those muscles flex may serve as an inconsistency between the virtual and actual body, which may break the Proteus effect and trigger a sense of disbelief (Banks et al., 2019). As a sense of disbelief dampens the player-avatar relationship (Banks et al., 2019), the inconsistency requires further investigation.

The results also showed that sex is an important moderator of the VR Proteus effect, specifically in the exercise context. The female and male participants showed distinctive patterns and even opposite perceptions of self-concept and exercise outcomes. Existing studies have examined the Proteus effect among only male or female participants (e.g., Fox et al., 2013) or suffer from a sample size for both sexes that was insufficient for comparing the effects (e.g., Yee et al., 2009) in the VR embodiment context. Our study is the first to examine the role of sex differences in VR embodiment from the first-person perspective during actual exercise. We found that consistent with an argument in the literature (e.g., Hargreaves and Tiggemann, 2003; Levine and Murnen, 2009), the female participants internalized idealized body image more than the male participants. More precisely, although current Taiwanese society positions muscular body shape with a six pack as ideal, we further found that the female participants internalized muscular body shape more than the male participants, regardless of their preferred ideal body shape. Our results showed that the female participants who embodied the muscular avatar perceived themselves as more muscular than others. The muscular body shape with a six pack served as a cue for the female participants in the exercise context but served as a cue that may have triggered reactance or dissonance among the male participants, thus leading to the counter effect of perceiving themselves as having a more normal body shape than others. Simply put, sex differences exist in motivation outcomes such as self-efficacy and perceived self-concept, as the muscular avatar shape resulted in opposite effects for the female and male participants. Future research should investigate sex differences in the Proteus effect and the underlying mechanisms in various contexts.

The physical movement results of the accelerometer are the only significant evidence that supported the Proteus effect in this study. The same pattern with only partial support also occurred in another study exploring participants' walking speed after avatar embodiment (Reinhard et al., 2020). These results indicate that the Proteus effect may have complicated underlying psychological processes, especially in the exercise context, and thus providing partial positive evidence of the effect. More research is needed.

When interpreting the above results, several limitations exist. First, the duration of avatar embodiment for exercise during the follow-along and the free practice session was short, less than 10 min. In addition, the series of movements for the core-muscle exercise was moderate-difficult, so these movements may not provide much variance in perceived exertion. Future research should replicate this study and choose the more intense movements that require more effort to examine the Proteus effect on perceived exertion as an exercise outcome. Second, some participants did not know what to do in the practice session, whereas other participants engaged in rigorous training, such as pushups or planks. The participants' knowledge of or habits for core-muscle training are potential covariates for future research. In addition, the necessity of including a practice session in the experimental design requires more discussion and empirical evidence. Third, we did not measure the individual's ideal body shape as a control variable in our study. As each person may have a different preferred body shape, a virtual body with a six pack may not represent the ideal body shape for the participants. Nevertheless, thanks to the nature of the random assignment in the experimental method, individual differences should be equally distributed across conditions. We do not take this as an excuse; rather, we suggest that future research should determine participants' ideal body shape to further examine underlying psychological processes. Fourth, with our limited technique in creating the virtual avatars, we were able to create only tall and short avatars for this research. Dynamical scaling of the participant's height or 3D body scans (Thaler et al., 2018; Pujades et al., 2019) are recommended to create virtual avatars for future research. Last, we employed the motion tracking system through a Kinect camera to mirror the participants' physical movements so that they could freely move their bodies without having to wear sensors on their knees, ankles, and wrists. Although we have done our best to ensure this freedom, some participants indicated that the VR experience was not smooth because the avatar did not always reflect their detailed movements without delay. We have addressed this issue by including the BOI as a covariate in our analysis. We still recommend that future research employ tracking suits or advanced tracking systems to examine the Proteus effect in VR exercise.

CONCLUSION

We contributed to the literature by examining the Proteus effect in first-person perspective avatar embodiment in the context of exercise. In addition, the participants engaged in actual aerobic exercise as opposed to merely walking or lifting weights. Both immediate and prolonged effects were explored in this study to assess the potential next-day presence of the Proteus effect, and we found a prolonged effect only for self-efficacy and only among female participants. We further demonstrated that sex differences were important factors to consider in research on the Proteus effect in the exercise context. Specifically, the female participants demonstrated more positive exercise motivation after embodying normal avatars than after embodying muscular avatars. Previous studies examining the effects of an avatar's body shape on healthy intentions and behaviors mainly focused on comparing a normal body against an obese body and indicated that compared to the obese avatar, using a more ideal-shaped avatar has more positive outcomes (Li et al., 2014; Peña et al., 2016; Joo and Kim, 2017). This study adds new insights to the literature by providing an upward comparison of the avatar's body shape (i.e., normal vs. muscular with an emphasis of a six pack) and found that the effects of embodied exercise in VR did not yield better effects for the more ideal figure embodied. Compared to the muscular-shaped avatar, the normal-shaped avatar has more positive effects on self-efficacy for exercise among female participants. Moreover, the female participants who embodied the muscular avatars demonstrated a more positive self-concept than those who embodied the normal avatars. This result suggested that the Proteus effect was present when using a muscular avatar with a six pack and altered the female participants' self-concept and boosted their body image; however, it may also have hindered their motivation for future exercise participation. These factors need to be considered in the design of sports-related experiences in the future. Further, the muscular avatar shape resulted had opposite effects on altering self-concept among male participants, indicating that the Proteus effect was effective among the female participants when using muscular body shapes for persuasion, but such persuasion was not present for the male participants. Persuasive mechanisms and reactance toward the body-shape-related Proteus effect may vary by sex. Future research should examine these important sex variations and differences in exercise outcomes.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the National Chengchi University IRB. The patients/participants provided their written informed consent to participate in this study. The individual(s) provided their written informed consent for the publication of any identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

J-HL designed the study and wrote the entire manuscript (except for the method and results section). D-YW executed the entire experiment and assisted with partial manuscript drafting. J-WY assisted in analyzing the data and wrote the results section. All authors contributed to the article and approved the submitted version.

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REFERENCES

Ahn, S. J., Bostick, J., Ogle, E., Nowak, K. L., McGillicuddy, K. T., and Bailenson, J. N. (2016). Experiencing nature: Embodying animals in immersive virtual environments increases inclusion of nature in self and involvement with nature. *J. Comp. Med. Comm.* 21, 399–419. doi: 10.1111/jcc4.12173

Bailenson, J. N., and Segovia, K. Y. (2010). "Virtual doppelgangers: psychological effects of avatars who ignore their owners," in *Online Worlds: Convergence of the Real and the Virtual*, ed. W. S. Bainbridge (London: Springer), 175–186.

Banakou, D., Groten, R., and Slater, M. (2013). Illusory ownership of a virtual child body causes overestimation of object sizes and implicit attitude changes. *Proc. Natl. Acad. Sci.* 110, 12846–12851. doi: 10.1073/pnas.1306779110

Banakou, D., Hanumanthu, P. D., and Slater, M. (2016). Virtual embodiment of white people in a black virtual body leads to a sustained reduction in their implicit racial bias. *Front. Hum. Neurosci.* 10:601. doi: 10.3389/fnhum.2016.00601

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY: W H Freeman.

Banks, J., Bowman, N. D., Lin, J.-H. T., Pietschmann, D., and Wasserman, J. A. (2019). Thecommon player-avatar interaction scale (cPAX): Expansion and cross-language validation. *Internat. J. Hum.-Comp. Stud.* 129, 64–73. doi: 10.1016/j.ijhcs.2019.03.003

Barha, C. K., Davis, J. C., Falck, R. S., Nagamatsu, L. S., and Liu-Ambrose, T. (2017). Sex differences in exercise efficacy to improve cognition: A systematic review and meta-analysis of randomized controlled trials in older humans. *Front. Neuroendocr.* 46, 71–85. doi: 10.1016/j.yfrne.2017.04.002

Benton, C., and Karazsia, B. T. (2015). The effect of thin and muscular images on women's body satisfaction. *Body Image* 13, 22–27. doi: 10.1016/j.bodyim.2014.11.001

Borg, G. (1998). *Borg's perceived exertion and pain scales*. Champaign, IL: Human Kinetics.

Brudzynski, L. R., and Ebben, W. (2010). Body image as a motivator and barrier to exercise participation. *Internat. J. Exerc. Sci.* 3, 14–24.

Cataldo, R., John, J., Chandran, L., Pati, S., and Shroyer, A. L. W. (2013). Impact of physical activity Intervention programs on self-efficacy in youths: A systematic review. *ISRN Obesity* 2013:586497. doi: 10.1155/2013/586497

Ciao (2021). 徐若瑄練出腹肌 貴婦名媛搶體驗*! [Online] Ciao*. Available: http://www.ciaotw.com/2021/04/27/0928-2 [Accessed July 12 2021]

Conroy, D. E., Motl, R. W., and Hall, E. G. (2000). Progress toward construct validation of the self-presentation in exercise questionnaire (SPEQ). *J. Sport Exerc. Psychol.* 22:21. doi: 10.1123/jsep.22.1.21

Drummond, M., and Drummond, C. (2014). It's all about the six-pack: Boys' bodies in contemporary Western culture. *J. Child Health Care* 19, 423–431. doi: 10.1177/1367493514538128

Dyrstad, S. M., Hansen, B. H., Holme, I. M., and Anderssen, S. A. (2014). Comparison of self-reported versus accelerometer-measured physical activity. *Med. Sci. Sports Exerc.* 46, 99–106. doi: 10.1249/MSS.0b013e3182a0595f

Fletcher, J. S., and Banasik, J. L. (2001). Exercise self-efficacy. *Clin. Excell. Nurse Pract.* 5, 134–143. doi: 10.1054/xc.2001.24203

Fox, J., and Bailenson, J. N. (2009). Virtual self-modeling: The effects of vicarious reinforcement and identification on exercise behaviors. *Media Psychol.* 12, 1–25. doi: 10.1080/15213260802669474

Fox, J., Bailenson, J. N., and Tricase, L. (2013). The embodiment of sexualized virtual selves: The Proteus effect and experiences of self-objectification via avatars. *Comput. Hum. Behav.* 29, 930–938. doi: 10.1016/j.chb.2012.12.027

Grechuta, K., Ulysse, L., Rubio Ballester, B., and Verschure, P. F. M. J. (2019). Self beyond the body: Action-driven and task-relevant purely distal cues modulate performance and body ownership. *Front. Hum. Neurosci.* 13:91. doi: 10.3389/fnhum.2019.00091

Greenwald, A. G., McGhee, D. E., and Schwartz, J. L. K. (1998). Measuring individual differences in implicit cognition: The implicit association test. *J. Personal. Soc. Psychol.* 74, 1464–1480. doi: 10.1037/0022-3514.74.6.1464

Hargreaves, D. A., and Tiggemann, M. (2003). Female "thin ideal" media images and boys' attitudes toward girls. *Sex Roles* 49, 539–544. doi: 10.1023/A:1025841008820

Hart, L. (2021). *One year into the pandemic, is it VR's time to shine? [Online] blooloop*. Available: https://blooloop.com/technology/opinion/vr-after-covid/ (accessed March 23, 2021).

Hasler, B. S., Spanlang, B., and Slater, M. (2017). Virtual race transformation reverses racial in-group bias. *PLoS One* 12:e0174965. doi: 10.1371/journal.pone.0174965

Hausenblas, H. A., Brewer, B. W., and Van Raalte, J. L. (2004). Self-presentation and exercise. *J. Appl. Sport Psychol.* 16, 3–18. doi: 10.1080/10413200490260026

Hoyt, W. D., and Kogan, L. R. (2001). Satisfaction with body image and peer relationships for males and females in a college environment. *Sex Roles* 45, 199–215. doi: 10.1023/A:1013501827550

Joo, Y. K., and Kim, K. (2017). When you exercise your avatar in a virtual game: The role of avatars' body shape and behavior in users' health behavior. *Interact. Comp.* 29, 455–466. doi: 10.1093/iwc/iwx003

Klimmt, C., Hefner, D., and Vorderer, P. (2009). The video game experience as "true" identification: A theory of enjoyable alterations of players' self-perception. *Comm. Theory* 19, 351–373. doi: 10.1111/j.1468-2885.2009.01347.x

Kocur, M., Kloss, M., Schwind, V., Wolff, C., and Henze, N. (2020). "Flexing muscles in virtual reality: Effects of avatars' muscular appearance on physical performance," in *Proceedings of the Annual Symposium on Computer-Human Interaction in Play*, (Virtual Event, Canada: Association for Computing Machinery).

Levine, M. P., and Murnen, S. K. (2009). "Everybody knows that mass media are/are not [pick one] a cause of eating disorders": a critical review of evidence for a causal link between media, negative body image, and disordered eating in females. *J. Soc. Clin. Psychol.* 28, 9–42. doi: 10.1521/jscp.2009.28.1.9

Li, B. J., Lwin, M. O., and Jung, Y. (2014). Wii, myself, and size: The influence of proteus effect and stereotype threat on overweight children's exercise motivation and behavior in exergames. *Games Health J.* 3, 40–48. doi: 10.1089/g4h.2013.0081

Lorig, K., Stewart, A., Ritter, P., Gonzalez, V., Laurent, D., and Lynch, J. (1996). *Outcome measures for health education and other health care interventions*. Thousand Oaks: SAGE Publications.

Maselli, A., and Slater, M. (2013). The building blocks of the full body ownership illusion. *Front. Hum. Neurosci.* 7:83. doi: 10.3389/fnhum.2013.00083

McAuley, E., and Blissmer, B. (2000). Self-efficacy determinants and consequences of physical activity. *Exerc. Sport Sci. Rev.* 28, 85–88.

McNeill, L. S., and Firman, J. L. (2014). Ideal body image: A male perspective on self. *Austral. Market. J.* 22, 136–143. doi: 10.1016/j.ausmj.2014.04.001

Navarro, J., Peña, J., Cebolla, A., and Baños, R. (2020). Can avatar appearance influence physical activity? User-avatar similarity and Proteus effects on cardiac frequency and step counts. *Health Comm.* 2020, 1–8. doi: 10.1080/10410236.2020.1834194

Ouyang, Y., Wang, K., Zhang, T., Peng, L., Song, G., and Luo, J. (2020). The influence of sports participation on body image, self-efficacy, and self-esteem in college students. *Front. Psychol.* 10:3039. doi: 10.3389/fpsyg.2019.03039

Peña, J., Hancock, J. T., and Merola, N. A. (2009). The priming effects of avatars in virtual settings. *Comm. Res.* 36, 838–856. doi: 10.1177/0093650209346802

Peña, J., Khan, S., and Alexopoulos, C. (2016). I am what I see: how avatar and opponent agent body size affects physical activity among men playing exergames. *J. Comp-Med. Comm.* 21, 195–209. doi: 10.1111/jcc4.12151

Peng, W., Pfeiffer, K. A., Winn, B., Lin, J.-H., and Suton, D. (2015). A pilot randomized, controlled trial of an active video game physical activity intervention. *Health Psychol.* 34(Suppl.), 1229–1239. doi: 10.1037/hea0000302

Pujades, S., Mohler, B., Thaler, A., Tesch, J., Mahmood, N., Hesse, N., et al. (2019). The virtual caliper: Rapid creation of metrically accurate avatars from 3D measurements. *IEEE Transact. Vis. Comp. Graph.* 25, 1887–1897. doi: 10.1109/TVCG.2019.2898748

Ratan, R., Beyea, D., Li, B. J., and Graciano, L. (2020). Avatar characteristics induce users' behavioral conformity with small-to-medium effect sizes: a meta-analysis of the proteus effect. *Media Psychol.* 23, 651–675. doi: 10.1080/15213269.2019.1623698

Ratan, R. A., and Dawson, M. (2016). When Mii is me: A psychophysiological examination of avatar self-relevance. *Comm. Res.* 43, 1065–1093. doi: 10.1177/0093650215570652

Reinhard, R., Shah, K. G., Faust-Christmann, C. A., and Lachmann, T. (2020). Acting your avatar's age: Effects of virtual reality avatar embodiment on real life walking speed. *Media Psychol.* 23, 293–315. doi: 10.1080/15213269.2019.1598435

Schnabel, K., Asendorpf, J. B., and Greenwald, A. G. (2008). "Using Implicit Association Test for the assessment of implicit personality self-concept," in *Handbook of Personality Theory and Assessment Vol. 2: Personality Measurement and Testing*, eds G. J. Boyle, G. Matthews, and D. H. Saklofske (Wiltshire, UK: SAGE Publications), 508–528.

Seinfeld, S., Arroyo-Palacios, J., Iruretagoyena, G., Hortensius, R., Zapata, L. E., Borland, D., et al. (2018). Offenders become the victim in virtual reality: impact of changing perspective in domestic violence. *Sci. Rep.* 8:2692. doi: 10.1038/s41598-018-19987-7

Siani, A., and Marley, S. A. (2021). Impact of the recreational use of virtual reality on physical and mental wellbeing during the Covid-19 lockdown. *Health Tech.* 11, 425–435. doi: 10.1007/s12553-021-00528-8

Slater, M. (2009). Place illusion and plausibility can lead to rea listic behaviour in immersive virtual environments. *Philosoph. Trans. R. Soc. B* 364, 3549–3557. doi: 10.1098/rstb.2009.0138

Song, H., Peng, W., and Lee, K. M. (2011). Promoting exercise self-efficacy with an exergame. *J. Health Comm.* 16, 148–162. doi: 10.1080/10810730.2010.535107

Song, Y. M., and Huang, R. L. (2020).「最美小龍女」曬馬甲線 擁六塊肌身材好 *[Online]. Taipei: Chinese Television System*. Available: https://news.cts.com.tw/cts/entertain/202005/202005172000710.html [Accessed July 12 2021].

Suslow, T., Lindner, C., Kugel, H., Egloff, B., and Schmukle, S. C. (2014). Using Implicit Association Tests for the assessment of implicit personality self-concepts of extraversion and neuroticism in schizophrenia. *Psychiatry Res.* 218, 272–276. doi: 10.1016/j.psychres.2014.04.023

Sylvia, Z., King, T. K., and Morse, B. J. (2014). Virtual ideals: The effect of video game play on male body image. *Comp. Hum. Behav.* 37, 183–188. doi: 10.1016/j.chb.2014.04.029

Taiwan Health Promotion Administration, (n.d.). 運動類型三合一. *[Online]*. Available: https://www.hpa.gov.tw/Pages/Detail.aspx?nodeid=571&pid=9778 [Accessed July 12 2021]

Taiwan Sports Administration (2020). 健康防疫新生活 體育署邀社區民眾動起來.. *[Online]*. Available: https://www.sa.gov.tw/News/NewsDetail?Type=3&page=30&id=2820&n=92 [Accessed July 12 2021]

Tajadura-Jiménez, A., Banakou, D., Bianchi-Berthouze, N., and Slater, M. (2017). Embodiment in a child-like talking virtual body influences object size perception, self-identification, and subsequent real speaking. *Sci. Rep.* 7:9637. doi: 10.1038/s41598-017-09497-3

Thaler, A., Piryankova, I., Stefanucci, J. K., Pujades, S., de la Rosa, S., Streuber, S., et al. (2018). Visual perception and evaluation of photo-realistic self-avatars from 3D body scans in males and females. *Front. ICT* 5:18. doi: 10.3389/fict.2018.00018

Thøgersen-Ntoumani, C., and Ntoumanis, N. (2006). The role of self-determined motivation in the understanding of exercise-related behaviours, cognitions and physical self-evaluations. *J. Sports Sci.* 24, 393–404. doi: 10.1080/02640410500131670

Troiano, R., Berrigan, D., Dodd, K., Masse, L., Tilert, T., and McDowell, M. (2008). Physical Activity in the United States Measured by Accelerometer. *Med. Sci. Sports* Exercise 40, 181–188. doi: 10.1249/mss.0b013e31815a51b3

Williams, N. (2017). The Borg Rating of Perceived Exertion (RPE) scale. *Occupat. Med.* 67, 404–405. doi: 10.1093/occmed/kqx063

Yee, N., and Bailenson, J. (2007). The Proteus effect: The effect of transformed self-representation on behavior. *Hum. Comm. Res.* 33, 271–290. doi: 10.1111/j.1468-2958.2007.00299.x

Yee, N., and Bailenson, J. N. (2009). The difference between being and seeing: The relative contribution of self-perception and priming to behavioral changes via digital self-representation. *Med. Psychol.* 12, 195–209. doi: 10.1080/15213260902849943

Yee, N., Bailenson, J. N., and Ducheneaut, N. (2009). The Proteus effect: Implications of transformed digital self-representation on online and offline behavior. *Comm. Res.* 36, 285–312. doi: 10.1177/0093650208330254

Zhou, S. M. (n.d.) 核心肌群的重要與核心復健運動 *[Online]*. Taiwan: Catholic Mercy Hospital. Available: https://www.mercy.org.tw/?aid=94&pid=51&iid=2 [Accessed July 12 2021]

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Corrigendum: Exercising With a Six Pack in Virtual Reality: Examining the Proteus Effect of Avatar Body Shape and Sex on Self-Efficacy for Core-Muscle Exercise, Self-Concept of Body Shape, and Actual Physical Activity

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A Corrigendum on

Exercising With a Six Pack in Virtual Reality: Examining the Proteus Effect of Avatar Body Shape and Sex on Self-Efficacy for Core-Muscle Exercise, Self-Concept of Body Shape, and Actual Physical Activity
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In the original article, there was a mistake in **Figure 5**, **Figure 6**, and **Figure 7** as published. The labels of the horizontal axis were incorrectly typed as "bpdy shapes in VR." This should be corrected as "body shapes in VR." The corrected **Figure 5**, **Figure 6**, and **Figure 7** appear below.

The authors apologize for this error and state that this does not change the scientific conclusions of the article in any way. The original article has been updated.

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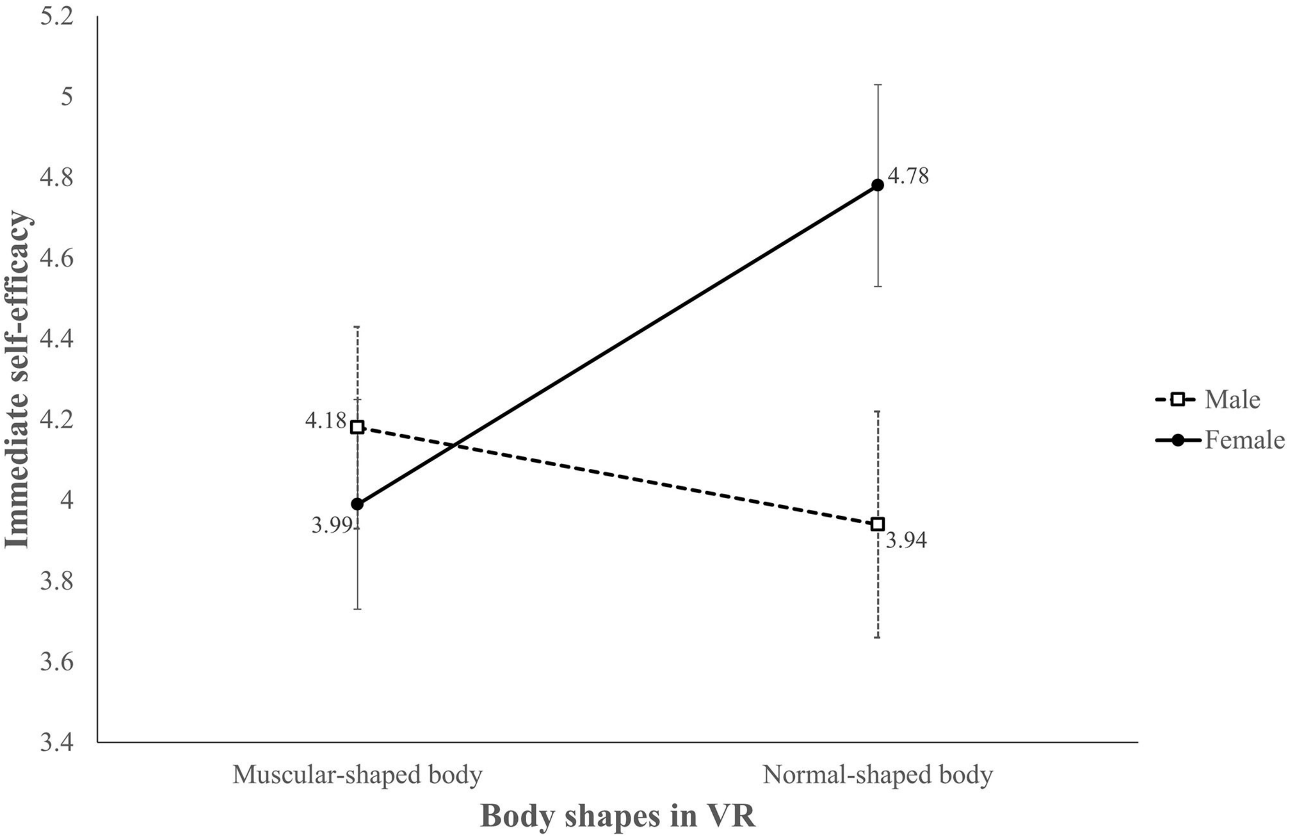

FIGURE 5 | Adjusted mean score of immediate self-efficacy for core workouts.

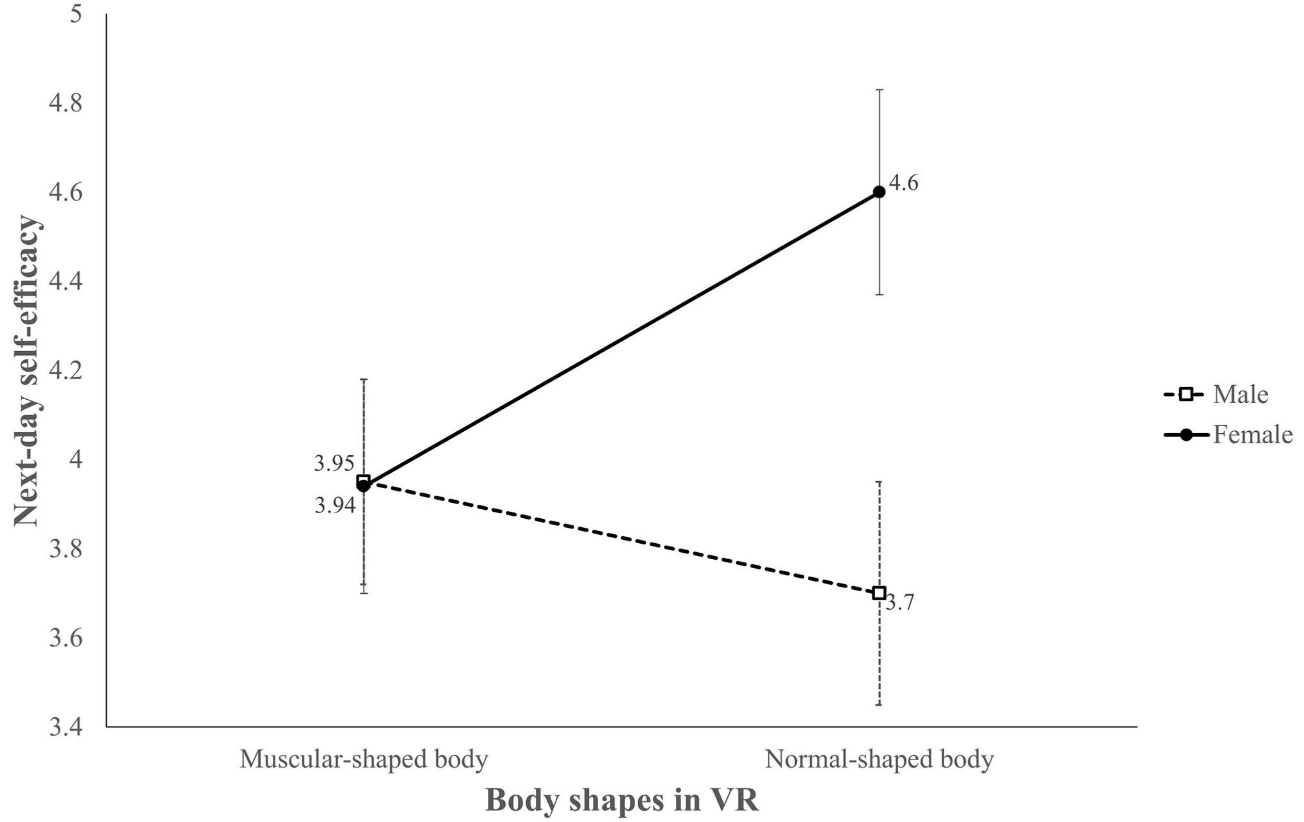

FIGURE 6 | Adjusted mean score of next-day self-efficacy for core workouts.

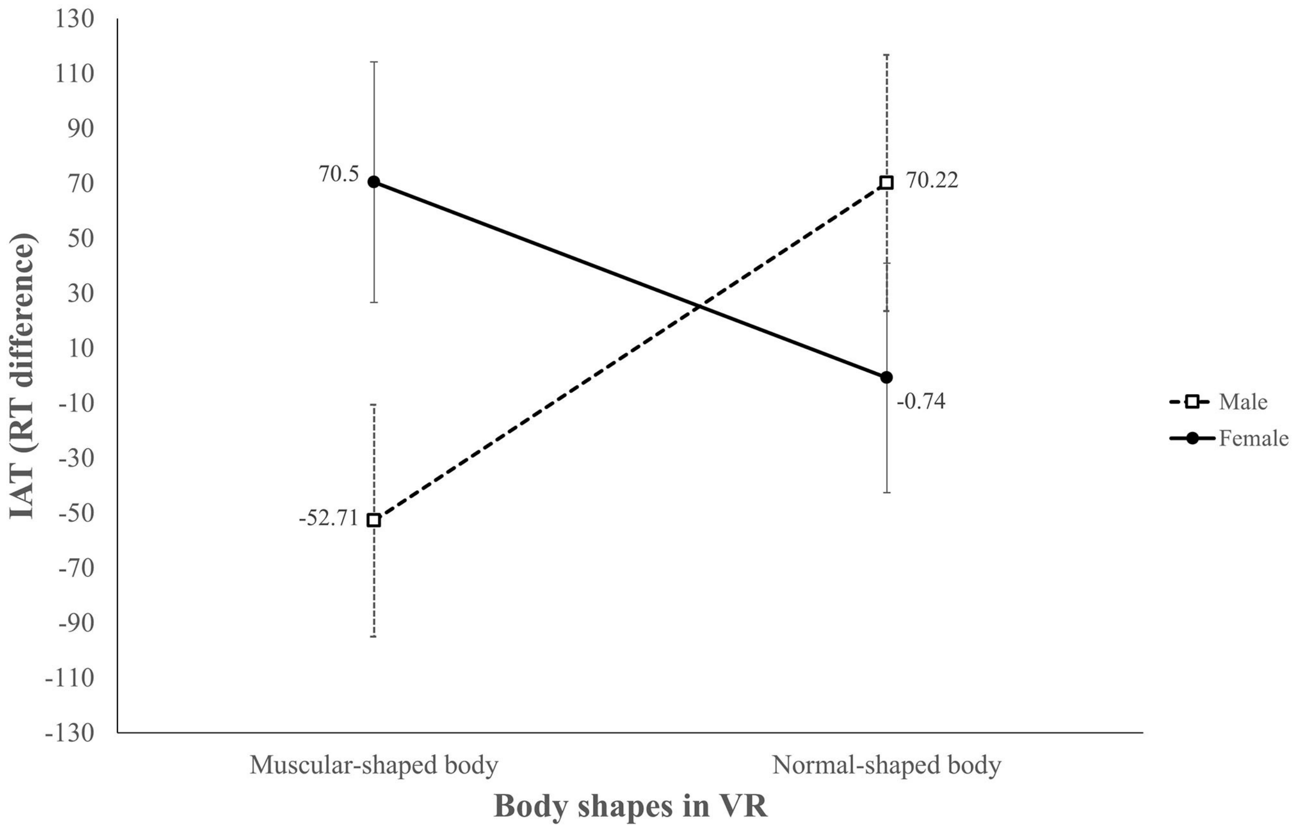

FIGURE 7 | Interaction between avatar body shape and sex of participants in predicting participants' self-concept after the VR experience.

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The Effect of VR Avatar Embodiment on Improving Attitudes and Closeness Toward Immigrants

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Past research has discussed how the embodiment of an outgroup avatar in virtual reality (VR) can reduce intergroup bias. However, little is known about the mechanisms and boundary conditions that shape this effect. This study examines how the embodiment of both outgroup and ingroup VR avatars in different orders influences attitudes and perceived closeness toward a co-ethnic immigrant outgroup in Singapore. It also investigates the role of empathy and social identity orientation (SIO) in this relationship. An experiment with four avatar embodiment conditions (ingroup-then-outgroup, outgroup-then-ingroup, ingroup-only, and outgroup-only) was carried out with 171 participants from a public university in Singapore. Results showed that embodying an outgroup avatar alone, compared to embodying an ingroup avatar alone, significantly improves both attitudes and closeness toward an immigrant outgroup. The order of embodiment matters to an extent, suggesting the greater effectiveness of outgroup-first over ingroup-first embodiment in reducing bias. Empathy mediates the effect of all three outgroup embodiment conditions on improved attitudes and closeness toward immigrants. It was also found that the stronger one's SIO is, the more effective embodiment is in improving perceived closeness with the outgroup *via* empathy. Theoretical implications of these findings are discussed.

Keywords: avatar embodiment, virtual reality, empathy, social identity orientation, intergroup bias, anchoring

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INTRODUCTION

The last few years have precipitated a surge in media coverage of intergroup conflicts, including xenophobic online sentiments and hate crimes in the wake of COVID-19. Understanding and resolving tensions between the "ingroup" (i.e., group to which one belongs) and "outgroup" (i.e., group to which one does not belong) in various contexts has been a longstanding theoretical and practical endeavor. Extensive research has investigated how biases against outgroups can be reduced (see Dovidio et al., 2017; Paluck et al., 2021 for reviews). For example, seminal strategies such as intergroup contact have been found to improve attitudes toward outgroups by reducing anxiety about intergroup interactions (Pettigrew and Tropp, 2008). Other studies showed that perspective-taking can lead to stronger self-other overlap, or associative links between the self and an outgroup (Myers et al., 2014; Todd and Galinsky, 2014).

Apart from utilizing these traditional strategies, scholars have identified interactive technology such as virtual reality (VR) as novel, potential avenues for intergroup bias reduction. One distinct feature of VR is embodiment, which is defined as the sensation of "being inside, having, and controlling a [virtual] body" (Kilteni et al., 2012, p. 374). Through the affordances of visuo-motor synchrony and real-time action enabled by VR, embodiment allows a person to feel that they are controlling a virtual body as if it were their own (Tham et al., 2018). The embodied experience of inhabiting an avatar different from oneself can generate behavioral changes that align with that avatar (Yee and Bailenson, 2006), as well as changes in self-perception that suggest overlap between the avatar and self (Banakou et al., 2013, 2016).

Studies have explored how embodying participants in a virtual outgroup avatar can influence biases, especially toward a racial outgroup (Yee and Bailenson, 2006; Groom et al., 2009; Peck et al., 2013; Banakou et al., 2016; Behm-Morawitz et al., 2016b; Hasler et al., 2017; Salmanowitz, 2018; Breves, 2020). However, results have been inconclusive. Some have found that implicit attitudes (i.e., unconscious attitudes measured through response latencies toward valenced ingroup vs. outgroup associations) toward Black people improved through the virtual embodiment of a Black avatar (Peck et al., 2013; Banakou et al., 2016). Similar studies, however, found that embodiment of a Black avatar resulted in greater or no changes to implicit attitudes (Groom et al., 2009; Hasler et al., 2017).

Beyond methodological differences, one possible reason for these inconclusive results is that most studies have not empirically tested the underlying socio-cognitive mechanisms and boundary conditions shaping the effects of embodiment on intergroup bias. One study identified avatar liking as a moderator that enables the positive effects of embodiment in improving attitudes (Behm-Morawitz et al., 2016b). However, psychological variables central to the intergroup relations literature have yet to be investigated in relation to embodiment. Empathy, the process of understanding another's emotions, has been found to be a key mechanism underlying the positive effects of multiple strategies, including intergroup contact (Pettigrew and Tropp, 2008) and perspective-taking (Vescio et al., 2003). At the same time, there may be potential obstacles to bias reduction, such as the cognitive tendency to anchor to an ingroup perspective (Hysenbelli et al., 2013), as well as the variability in latent predispositions to self-identify according to social groups (Brickson and Brewer, 2001).

Addressing multiple components of intergroup bias is also an ideal outcome for bias reduction research. A wealth of studies has shown that the aforementioned strategies can be effective in reducing affective (Tropp and Pettigrew, 2005) and cognitive dimensions (Myers et al., 2014) of intergroup bias. The present study focuses on both closeness (cognitive dimension) and affective attitudes (affective dimension) as primary outcomes. As a direct measure, attitudes refer to the valenced opinions or feelings one holds about a member of an outgroup (Wilcox et al., 1989). Closeness toward an outgroup is often measured as self-other overlap (Aron et al., 1992), which entails a blurring of group boundaries, precluding the propensity for ingroup favoritism and outgroup derogation (Galinsky and Moskowitz, 2000).

The present study tests the effect of VR embodiment on both attitudes and closeness toward an outgroup in a novel co-ethnic immigration context in Asia. To the best of our knowledge, no study has examined the effect of embodiment in a co-ethnic context, where virtual avatars are not differentiated by skin tone or major physiological identity markers. This study seeks to understand how embodiment of a Chinese foreign immigrant (outgroup) vs. a Chinese Singaporean citizen avatar (ingroup) influences Chinese Singaporeans' attitudes toward immigrants. It examines the mechanisms and variables underlying how embodiment influences intergroup attitudes. Specifically, it aims to address how this effect is (1) shaped by ingroup anchoring effects (2) mediated by empathy, and (3) moderated by social identity orientation (SIO).

EMBODIMENT AND INTERGROUP BIAS

The current research predominantly supports the argument that outgroup embodiment can reduce negative intergroup biases (e.g., Yee and Bailenson, 2006; Peck et al., 2013; Banakou et al., 2016). In these studies, light-skinned or White ingroup participants in the manipulation condition are typically made to embody a dark-skinned or Black avatar, while the control group embodies their own ingroup (e.g., Peck et al., 2013; Banakou et al., 2016; Behm-Morawitz et al., 2016b). Peck et al. (2013) tested this manipulation with respect to implicit racial attitudes. In the VR environment, participants were simply instructed to move around, observe their VR avatar's appearance, and test their synchronized movements. White participants embodied in a dark-skinned avatar experienced a greater reduction in implicit negative attitudes toward Black people than those embodied in a light-skinned avatar and those who perceived a non-embodied dark-skinned avatar.

Furthermore, Banakou et al. (2016) found that these positive effects of outgroup embodiment on implicit attitudes can be sustained long after the embodiment scenario. In one experiment, participants were embodied in a Black or White avatar and instructed to follow the movements of a Tai Chi instructor in a VR environment. They found that when compared to ingroup embodiment, embodiment of a Black outgroup avatar can significantly reduce implicit negative bias, even when measured one week after the embodiment manipulation.

However, one risk of outgroup representation in a mediated environment is stereotype activation. Stereotypes are cognitive "shortcuts" or mental representations that comprise automatic associations or assumptions made about a person based on their group identity. Stereotypes can be activated or made salient through situational cues in one's environment, influencing perceptions and behavior (Wheeler and Petty, 2001). Such is the case in the study by Groom et al. (2009), where embodying White participants in a Black avatar resulted in increased implicit bias toward Black people. Unlike other studies, the VR environment used in this study modeled a job interview scenario, where Black people are often stereotyped to perform poorly (Peck et al., 2013), thus potentially activating latent negative stereotypes about Black people being subpar job candidates. Similarly, another study found that the stereotypical representation of a Black avatar can inadvertently increase negative judgments about the outgroup (Behm-Morawitz et al., 2016a).

Hasler et al. (2017) likewise found no significant difference in implicit attitude change between White participants who embodied a White ingroup avatar and those who embodied a Black avatar. Participants were instructed to interact with a programmed virtual partner, who was either Black or White and exhibited standardized behavior in a turn-taking task. Hasler et al. (2017) found through measuring avatar liking that participants varied greatly in their affinity toward this virtual partner. Greater liking of a Black virtual partner was significantly associated with lower implicit bias. As such, in this study, preferences for interaction partners may have confounded the relationship between avatar embodiment and implicit attitudes (Hasler et al., 2017).

Given the inconsistencies found in embodiment studies, the VR environment is designed to minimize the activation of negative stereotypes about the immigrant outgroup through a stereotype-neutral food court scenario. Brief interactions with multiple non-playable characters (NPCs; i.e., food court customers) and objects (i.e., food and drink ingredients) are included as part of the embodiment scenario, making it less likely for the impression of one character to confound overall attitudes. The NPCs are also designed to represent a diverse range of ethnic groups, so affinity toward these characters should not directly correlate with evaluations of the Chinese immigrant outgroup.

> *H1*: Participants exhibit more positive changes in attitudes and perceived closeness toward an immigrant outgroup when embodied in an outgroup avatar than when embodied in an ingroup avatar.

To explain the outcomes of embodiment on intergroup outcomes, studies have frequently drawn parallels between embodiment and perspective-taking, the process of seeing things from another's point of view (see Banakou et al., 2016; Herrera et al., 2018; Herrera, 2020). Perspective-taking has generally been found to strengthen associations between the "self" and "other," promoting more positive intergroup evaluations or attitudes (Galinsky et al., 2005; Boca et al., 2018). However, one distinction is that embodiment is experiential while perspective-taking is imaginal. Perspective-taking manipulations typically require participants to imagine what another person may be going through. With embodiment, participants directly inhabit another's experiences through body-ownership illusions (Banakou et al., 2016). Nonetheless, due to the two concepts' shared theoretical associations with self-other overlap, we draw on research about the cognitive biases and mechanisms underlying perspective-taking to see how they may similarly apply to embodiment processes.

ANCHORING AND ORDER EFFECTS

Research suggests that attempts at perspective-taking may be hindered due to the anchoring heuristic (Keysar et al., 2000; Epley et al., 2004; Barr and Keysar, 2006). People rely on an initial piece of information (the "anchor") to shape their understanding of subsequent stimuli, resulting in inaccurate attempts to deal with situations of ambiguity (Tversky and Kahneman, 1974; Doyle et al., 2020). One's own egocentric or self-centered perspective may serve as the anchor to frame the understanding of another person's viewpoint (Keysar et al., 2000).

People tend to anchor to opinions or judgments made by ingroup members over outgroup members (Hysenbelli et al., 2013; Hedgebeth, 2020). In one study, women were provided with written information about how much an exemplar donated to a charity, and were then asked how much they would be willing to donate themselves. This exemplar was either a member of their national ingroup or outgroup and reportedly donated either a high or low amount. A high anchor amount generated significantly greater donations when the anchor source was an ingroup member versus an outgroup member (Hysenbelli et al., 2013).

To avoid this anchoring bias, one may enact the adjustment process, which involves making sequential and deliberate changes to one's initial perspective to account for new information about another's viewpoint. However, adjustment may be limited due to the lack of a strong motivation for accuracy, the amount of cognitive resources required (Epley et al., 2004; Epley and Gilovich, 2006), as well as the accessibility or salience of anchor-consistent information (Mussweiler and Strack, 1999a,b). When subtle cues related to an ingroup identity were made initially salient, individuals exhibited greater subsequent ingroup loyalty and favoritism (Hertel and Kerr, 2001).

Apart from numerical estimation tasks, the anchoring bias has also been found to influence judgments about the affect and feelings others (Yik et al., 2019), as well as changes in attitudes and beliefs (Hogarth and Einhorn, 1992). In Hogarth and Einhorn's (1992) model of belief adjustment, the process of adjusting one's beliefs from an initial anchor may depend on the order in which a person is exposed to anchor-consistent or inconsistent evidence. For simple judgments (i.e., evaluating the likeability of a person based on a series of adjectives), where evaluation is made after all pieces of evidence are presented, greater adjustment from an anchor is made based on evidence presented earlier (i.e., primacy effect). In contrast, for complex judgments (i.e., evaluating arguments about cause-and-effect based on a series of event descriptions), stimuli presented later may drive adjustment (i.e., recency effect; Hogarth and Einhorn, 1992).

While anchoring-and-adjustment has been applied to perspective-taking, a similar logic may likewise inform embodiment, which can make salient different viewpoints through an immersive role-playing experience. The initial embodiment of a familiar ingroup character may reify an ingroup anchor, hindering the ability to embody a subsequent outgroup character. In line with Hogarth and Einhorn (1992), the order of ingroup vs. outgroup embodiment may affect how much weight people assign to an outgroup avatar's viewpoint, subsequently influencing evaluative judgments about the outgroup.

To our knowledge, no research thus far has explored embodiment order effects when a person undergoes more than one embodiment experience sequentially. This study explores the role of both ingroup *and* outgroup embodiment consecutively. It tests whether the high accessibility of anchor-consistent information can influence the effect of virtual outgroup embodiment, which, compared to the imaginal methods of perspective-taking research, may be a more "robust" method of merging the self with the other (Herrera et al., 2018; Hasson et al., 2019). We counterbalanced the order of both embodiment scenarios to test for order effects. Based on the anchoring literature, we propose the following hypotheses:

> *H2a*: Embodying the outgroup first (i.e., outgroup-only, outgroup-then-ingroup) results in a more positive change in attitudes and closeness toward the outgroup than embodying the ingroup first (i.e., ingroup-only, ingroup-then-outgroup).

> *H2b*: When embodying the ingroup first, there are no significant differences in the change in attitudes and closeness induced by the single embodiment (i.e., ingroup-only) versus double embodiment conditions (i.e., ingroup-then-outgroup).

EMPATHY

Empathy is an affective variable that has been studied in relation to both virtual embodiment and intergroup relations. It is defined as an emotional response to another's feelings and experiences that may develop as a result of trait dispositions and situational cues (Cuff et al., 2016). Embodiment in VR, commonly discussed as an "empathy machine" (Herrera et al., 2018), can stimulate empathy by manipulating the user's multi-sensory experiences (Bertrand et al., 2018) or by vividly conveying another's emotions and experiences to the user (Shin, 2018).

Herrera et al. (2018) found that participants embodied in a homeless person in VR had greater empathy and longer-lasting positive attitudes toward the homeless than the control group. Empathy levels in the VR embodiment group were notably greater than those in the perspective-taking condition, where participants were simply asked to imagine the viewpoint of a homeless person.

Furthermore, studies on empathy outside of VR demonstrate how inducing empathy can improve attitudes toward outgroups (Batson et al., 1997; Shih et al., 2009). Across three experiments, Batson et al. (1997) found that high-empathy participants, who were instructed to imagine a stigmatized group member's feelings, expressed more positive explicit attitudes toward the stigmatized group than did participants exposed to the low-empathy manipulation. Collectively, these findings give credence to a pathway model in which empathy results from embodiment and, in turn, may improve attitudes toward an outgroup.

Parallel to this body of work, empathy has also been identified as a mediator in the relationship between perspective-taking and intergroup attitudes in other research (Vescio et al., 2003; Shih et al., 2009). In one study, where participants were asked to imagine the perspective of the other, Vescio et al. (2003) found empathy to partially mediate the relationship between perspective taking and intergroup attitudes. Similar to, and possibly to a greater extent than perspective-taking, embodiment may nurture empathy by allowing people to viscerally integrate another's viewpoint (Herrera et al., 2018), enhancing the sense that an avatar's experiences are equivalent to one's own. Given these findings, we hypothesize that:

> *H3*: Empathy positively mediates the effect of outgroup embodiment on changes in attitudes and perceived closeness toward the outgroup.

SOCIAL IDENTITY ORIENTATION

The outcomes of intergroup bias reduction can likewise be influenced by dispositional traits that shape how different individuals view the self in relation to others. According to the social categorization theory, individuals have latent predispositions to identify according to personal or social levels of the self (Brickson, 2000; Nario-Redmond et al., 2004). For example, personal identifiers may value their individuality and uniqueness, while social identifiers may focus on the importance of their belonging to particular groups (Nario-Redmond et al., 2004). Given the social nature of intergroup relations how they emerge from group identification, the differential importance people assign to their social selves may play a role in constructing biases and receptiveness to attitude change.

Studies have linked SIO with intergroup bias outcomes, but results have been somewhat conflicting. Research has shown that individuals who orient toward the personal level of the self may be more likely to leverage negative intergroup attitudes to distinguish themselves from others as unique individuals (Augoustinos and Walker, 1998). Conversely, those who gravitate toward the social level of the self may prioritize social equality and harmony, resulting in more favorable attitudes toward an outgroup (Gouveia, 2011). However, the opposite pattern may also be plausible—due to an emphasis on intergroup comparison and hierarchies, social identifiers may be less motivated to individuate or view others as individuals (Brickson and Brewer, 2001), and may instead rely on group-based stereotypes in their attitude formation (Perdue et al., 1990; Duclos and Barasch, 2014).

Additionally, studies have established links between SIO and empathy, our proposed mediator for the effect of embodiment on intergroup bias. People with a stronger awareness of their social group or identity are more likely to exhibit empathy (Preston and De Waal, 2002; Zhao et al., 2013) and are more attuned to the feelings and experiences of others (Cross et al., 2000). In a study by Duan et al. (2008), collectivism—the cultural value placed on the social collective—predicted greater emotional empathy. Likewise, in a neurological ERP study, priming a view of the self as socially interdependent on other people stimulated stronger neural empathic responses to the pain of others (Chen et al., 2020). Taken together, these studies suggest that a SIO may facilitate the prosocial effects of empathy, but this relationship has yet to be examined in the context of embodiment and intergroup bias. As research on the direct influence of SIO on intergroup bias also remains inconclusive, we propose a research question instead of a hypothesis:

> *RQ3*: How does social identity orientation influence the indirect effect *via* empathy of outgroup embodiment in VR on attitudes and closeness toward the outgroup?

THE RESEARCH CONTEXT

This study was conducted in Singapore, an immigration heavy and multi-ethnic society in Southeast Asia. As of end June 2020, the city-state is home to a population of 5.69 million people (Department of Statistics Singapore, 2020) of which Chinese-ethnic Singaporeans comprise the majority (76%) of citizens (gov.sg, 2019).

Migrants (2.16 million) comprise close to 37% of the total population in Singapore (Hirschmann, 2020). Among the migrant groups, approximately 18% are Chinese migrants originating from the People's Republic of China (PRC; United Nations, 2015). However, there is a notable ingroup-outgroup divide between the Singaporean Chinese majority (ingroup) and the PRC Chinese minority (outgroup). A few studies show that Singaporean Chinese hold negative views about PRC Chinese (Liu, 2014; Ortiga, 2015; Ramsay and Pang, 2017; Ahmed et al., 2021). Compared to other immigrant groups, PRC Chinese are stereotyped to be the least warm and most threatening to Singaporeans' cultural values and economic resources (Authors, in Press; Ramsay and Pang, 2017). Such evidence of "co-ethnic prejudice" may stem from Singaporeans' prioritization of national over racial identity in their views toward the PRC Chinese diaspora. Despite shared ethnic and cultural origins, PRC Chinese may be viewed as a novel outgroup based on perceived social and cultural differences, threats to scarce economic resources, and a lack of political loyalty to the Singaporean national identity (Liu, 2014).

This study examines the unique intergroup relations between co-ethnic Singaporean Chinese (ingroup) and PRC Chinese (outgroup). Few studies have examined embodiment in relation to non-racial outgroups, such as the homeless (Herrera et al., 2018), the colorblind (Ahn et al., 2013), and women (Lopez et al., 2019; Schulze et al., 2019). To the best of our knowledge, no study has examined the effect of embodiment in a co-ethnic immigration context in Asia, where virtual avatars are not differentiated by skin tone. As we are focused on ingroup-outgroup differences in an immigration context, the terms "Singaporean Chinese" and "PRC Chinese" will be used throughout the rest of this paper to distinguish between the two groups.

MATERIALS AND METHODS

Participants

One-hundred-seventy-one undergraduate and graduate students from a university in Singapore participated in this experiment. Recruitment emails for participation were sent to a random selection of students from 15 student distribution email lists provided by the university, spanning across different faculties and courses. Participants ($N = 171$) were all Singaporean Chinese, of whom 71 (41%) were men and 100 (58.5%) were women. The age range of participants spanned from 18 to 33 years old ($M = 22.43$, $SD = 2.07$). All students were compensated for participation with either course credit or SGD $10 gift cards.

Experimental Design

The experiment featured four conditions in a 2 (embodiment order: PRC-first vs. Singaporean-first) × 2 (number of embodiment scenarios: single-embodiment vs. double-embodiment) between-subjects design. The single-embodiment conditions, where participants only embodied one avatar, included *PRC-only* embodiment (i.e., PRC Chinese only; $n = 46$) or *SG-only* embodiment (i.e., Singaporean Chinese avatar only; $n = 38$). In the double-embodiment conditions, participants embodied two avatars sequentially in a counterbalanced order: the *PRC-then-SG* embodiment (i.e., PRC Chinese avatar first and Singaporean Chinese avatar second; $n = 41$) and the *SG-then-PRC* embodiment (i.e., Singaporean Chinese avatar first then PRC Chinese avatar second; $n = 45$).

In each embodiment scenario, participants were randomly assigned to embody either a food vendor or a drink vendor in a food court setting. In the PRC-then-SG and SG-then-PRC conditions, participants experienced both food and drink scenarios in a randomized counterbalanced order. In between the two scenarios, a transition scene informed participants which character they would embody next. A difference in character role was important to ensure participants did not undergo the same exact narrative, which could risk inducing maturation effects or boredom. Overall, the food and drink vendor scenarios had the same storyline and dialogue, with only changes in cosmetic details (i.e., the drink vendor prepared coffee, while the food vendor prepared noodles). As such, we did not count vendor role as a between-subjects factor in the design and analysis.

Procedures

Upon arrival to the research laboratory, participants filled out an online consent form and pre-test questionnaire that measured their baseline perception and attitudes toward PRC Chinese immigrants in Singapore. They then were introduced to the HTC Vive headset and controls before entering a randomly assigned VR scenario. After the VR playthrough, they completed a post-test questionnaire, which included manipulation check questions and re-measured the dependent variables.

Through a pilot test with eight undergraduate participants, all stimuli used in the VR environment were developed and refined based on qualitative feedback. Within the VR environment, a voice narrator guided participants to complete tasks across four scenes (refer to **Figure 1** for visuals). The participants' character dialogue was voiced with a PRC Chinese accent and a Singaporean Chinese accent in the PRC embodiment and Singaporean embodiment scenarios, respectively. PRC Chinese and Singaporean Chinese student assistants were recruited to record voiceovers.

Scene 1: Participants were presented with a short introductory text pop-up explaining their embodied character's role and background. Starting out in an ingredient storeroom, participants were made to observe their character's appearance in a mirror and were prompted to test out their synchronized movements. They also interacted with their character's personal belongings that emphasized their character's identity. The character either had a Singaporean citizen's identity card (pink in color) in the Singaporean Chinese scenario or a foreigner's identity card (green in color) in the PRC Chinese scenario. Differentiating citizenship status by the color of official identity cards is a widely understood practice in Singapore (see Wan, 2015).

Scene 2: Outside of the storeroom, participants were first tasked with setting up the tables and chairs outside their respective stall. As the food vendor, they then had to replenish the supply of chili and spring onions in designated ingredient bowls. As the drink vendor, participants opened a can of evaporated milk and filled a kettle with hot water.

Scene 3: Participants started taking orders from virtual customers. In all conditions, participants then experienced a brief conflict with one Singaporean customer who expressed frustration as the participant could not understand the customer's order. The customer is portrayed to be displeased in all conditions. In the PRC Chinese embodiment scenarios, the customer has an additional critique about the participant's English proficiency. This addition was included to subtly highlight a realistic experience of discrimination faced by the PRC Chinese worker. The negative affect and narrative of this scene remained consistent for both PRC and Singaporean embodiment scenarios.

Scene 4: As participants are cleaning tables after customers have left, they received a phone call from their character's child, who requested a considerable amount of money to be used as allowance for a school trip. At the conclusion of the scene, the narrator commented on how the character would need to find a way to provide for their child.

Measures

The means, standard deviations, and Pearson's correlations (r) of all measures are reported in **Table 1**. Only self-other overlap (i.e., closeness) and feeling thermometer scores (i.e., attitudes) were measured both pre-test and post-test. Difference scores were obtained by subtracting the mean pre-test rating from the mean post-test ratings for each of the two dependent variables. All other variables were measured only in the post-experiment questionnaire.

Self-Other Overlap (Closeness)

To measure perceived closeness, participants answered a single item modified and adapted from (Aron et al., 1992) questioning which of seven images best describes their relationship with PRC Chinese (1 = no overlap at all, 7 = high overlap). The prompt read: "Please select the picture below which best describes your relationship with a PRC Chinese." Each picture featured two circles, each representing the "self" and "other." From the first image to the last, the two circles progressively overlap with one another to represent greater degrees of self-other overlap. A higher score indicated greater perceived closeness between participants and PRC Chinese (pre-test: $M = 3.00$, $SD = 1.41$; post-test: $M = 3.42$, $SD = 1.47$).

Feeling Thermometer (Attitudes)

Attitudes toward outgroup members are measured by three items adapted from Alwin (1997). The prompt read: "Please indicate your attitudes toward PRC Chinese." Items included "Cold (1) … Warm (100)," "Unfavourable (1) … Favourable (100)," and "Negative (1) … Positive (100)." A higher score indicated more positive attitudes (pre-test: $M = 57.41$, $SD = 19.73$, Cronbach's $\alpha = 0.92$; post-test: $M = 63.69$, $SD = 18.84$, Cronbach's $\alpha = 0.95$).

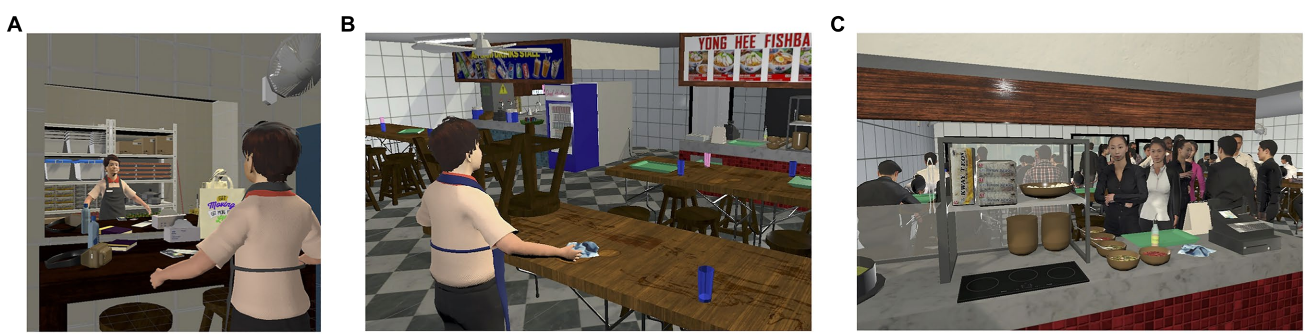

FIGURE 1 | (A) In Scene 1, the participant begins by testing out their visuo-motor synchrony through a mirror in the storeroom. **(B)** In Scene 2, the participant interacts with the environment by setting up and cleaning the tables outside their stall. **(C)** In Scenes 3 and 4, the participant starts serving customers who enter the food court.

TABLE 1 | Descriptive statistics and correlations between the feeling thermometer change scores, self-other overlap change scores, social identity orientation (SIO), and empathy.

S. No.		*M*	*SD*	1.	2.	3.	4.
1.	Δ Feeling thermometer	6.28	12.81	1			
2.	Δ Self-other overlap	0.42	0.96	0.297**	1		
3.	Social identity orientation	4.41	1.12	0.158*	0.183*	1	
4.	Empathy	5.01	1.45	0.306**	0.267**	0.228**	1

*$p<0.05$; **$p<0.01$.
M, mean; SD, standard deviation; Δ, change score.

Empathy

In the post-test questionnaire, participants were asked the extent to which they agreed or disagreed (1 = strongly disagree, 7 = strongly agree) with seven items, adapted from the Interpersonal Reactivity Index by Davis (1980), measuring their empathy levels toward PRC Chinese after the embodiment scenario. Items included "I felt as if I were in the shoes of the Chinese PRC" and "I felt compassion for the Chinese PRC." A higher score indicated greater empathy toward PRC Chinese ($M =$ 5.01, $SD =$ 1.45, Cronbach's $\alpha = 0.95$).

Social Identity Orientation

In the post-test questionnaire, participants completed 8 items adapted from Nario-Redmond et al. (2004) measuring the level of importance (1 = not important at all, 7 = extremely important) they ascribed to their social identity, with examples including "The memberships I have in various groups" and "My sense of belonging to my own racial group." Note that the scale items are not designed to refer to a particular social identity, such as one's Singaporean identity, but rather aim to get a general sense of participants' propensity to identify at the social level more broadly. A higher score on this scale indicated a stronger SIO ($M = 4.41$, $SD = 1.12$, Cronbach's $\alpha = 0.84$).

Manipulation Check

Participants were asked which character they represented in the VR context in the post-test questionnaire. Only participants in the double-embodiment conditions were made to indicate the correct order of embodiment. Participants in the PRC-only condition were significantly more likely than those in the SG-only condition to correctly report having represented a PRC Chinese character, $X^2(1, N = 84) = 80.05$, $p = 0.000$. Only one participant reported the incorrect character; as such, we did not exclude any data prior to analysis. All participants in the double-embodiment conditions reported the correct order of embodiment.

RESULTS

Total Effect of Embodiment

To address the effects of embodiment on changes in feeling thermometer scores and self-other overlap, we first conducted a 2 (embodiment order) × 2 (number of embodiment scenarios) between-subjects ANOVA with a Bonferroni adjustment for each dependent variable. Both tests ruled out the main effects of the number of embodiment scenarios and identified main effects of embodiment order, providing support for H2a.

Predicting changes in feeling thermometer attitudes, embodiment order had a significant main effect [$F(1, 167) = 6.54$, $p = 0.011$, $\eta_p^2 = 0.04$], such that embodying a PRC Chinese avatar first resulted in significantly more positive attitude change than embodying a Singaporean Chinese avatar first ($M_{\text{diff}} = 4.91$, $SE = 1.92$, $p = 0.011$). The main effect of the number of embodiment scenarios was not significant [$F(1, 167) = 1.60$, $p = 0.207$, $\eta_p^2 = 0.01$], nor was the interaction between embodiment order and the number of embodiment conditions [$F(1, 167) = 3.19$, $p = 0.076$, $\eta_p^2 = 0.02$].

A significant main effect of embodiment order likewise predicted changes in self-other overlap [$F(1, 167) = 4.52$, $p = 0.035$, $\eta_p^2 = 0.03$], such that embodying a PRC Chinese avatar first led to significantly greater self-other overlap than embodying a Singaporean Chinese avatar first ($M_{\text{diff}} = 0.31$, $SE = 0.15$, $p = 0.035$). Neither the main effect of the number of embodiment scenarios [$F(1, 167) = 0.01$, $p = 0.924$, $\eta_p^2 = 0.00$], nor its interaction with embodiment order [$F(1, 167) = 3.73$, $p = 0.055$, $\eta_p^2 = 0.02$] was significant.

Having discounted the two-way interaction and a confounding effect of the number of embodiment conditions, we then conducted two separate one-way ANOVAs to assess multiple contrasts between the four embodiment conditions, with the SG-only condition set as a control. For feeling thermometer difference scores, the ANOVA model was significant, [$F(3, 170) = 3.54$, $p = 0.016$, $\eta_p^2 = 0.06$]. *Post hoc* tests with a Tukey HSD adjustment indicate that significant differences only exist between the PRC-only and SG-only groups, and between the PRC-then-SG and SG only groups. Participants in the SG-only condition experienced significantly less change in attitudes toward the PRC Chinese than those in the PRC-only condition ($M_{\text{diff}} = -8.34$, $SE = 2.75$, $p = 0.015$) and the PRC-then-SG only condition ($M_{\text{diff}} = -7.35$, $SE = 2.81$, $p = 0.047$). These results provide support for H1. Contrary to H2a, despite a main effect found for the PRC-first embodiment factor, no significant differences were found between the SG-then-PRC and PRC conditions, nor between the SG-then-PRC and PRC-then-SG conditions (ps > 0.05; see **Figure 2** for mean differences). However, supporting H2b, there was no significant difference between the SG-then-PRC and SG-only conditions.

A significant effect of embodiment was also found on difference scores in self-other overlap, [$F(3, 170) = 2.70$, $p = 0.048$, $\eta_p^2 = 0.05$]. As the assumption of homogeneity of variances was violated in this analysis, a Games–Howell *post hoc* adjustment was utilized to deduce group differences. Participants in the SG-only embodiment condition displayed significantly less change in overlap with PRC Chinese than those who underwent PRC-only embodiment ($M_{diff} = -0.59$, $SE = 0.18$, $p = 0.010$), partially supporting H1. Difference scores in the SG-then-PRC group did not significantly contrast with scores in the PRC-then-SG, PRC-only and SG-only conditions ($ps > 0.05$), likewise supporting H2b but contradicting H2a (see **Figure 3** for mean differences).

Indirect Effect of Embodiment *via* Empathy

To explore mediation effects, we utilized the method recommended by Hayes and Preacher (2013) for mediation with a multi-categorical antecedent. This approach involves conducting multiple ordinary least squared (OLS) regression models that deduce the relative indirect effects of each condition *via* empathy against the control, while the effects of the other manipulation groups are held constant (Hayes and Preacher, 2013). To assess the relative indirect effects of the PRC-only, PRC-then-SG, and SG-then-PRC conditions against the SG-only group, we ran Model 4 with 10,000 bootstraps in the PROCESS macro developed by Hayes (2012) for SPSS v24. Z-scores were computed for all continuous variables to generate standardized path estimates.

Feeling Thermometer

The model predicting standardized feeling thermometer difference scores was significant with the dummy-coded PRC-only, PRC-then-SG, and SG-then-PRC conditions, as well as empathy, set as predictors [$F(4, 166) = 4.61$, $R^2 = 0.10$, $MSE = 0.92$, $p = 0.002$]. An omnibus test revealed a significant total direct effect of embodiment condition on feeling thermometer differences [$F(3, 167) = 3.54$, $R^2 = 0.06$, $p = 0.016$]. Separately, the relative total effects of the PRC-only [$\beta = 0.65$, $t(82) = 3.04$, $p = 0.003$ (0.23, 1.07)], SG-then-PRC [$\beta = 0.46$, $t(81) = 2.12$, $p = 0.035$ (0.03, 0.88)], and PRC-then-SG conditions [$\beta = 0.57$, $t(78) = 2.62$, $p = 0.010$ (0.14, 1.01)] were significant. Notably, none of the relative direct effects of embodiment were significant [$F(3, 166) = 0.41$, $R^2 = 0.01$, $p = 0.75$]. The relative indirect effects, however, were all significant, as the omnibus indirect effect confidence interval did not include zero [$\beta = 0.09$, $SE = 0.04$ (0.03, 0.18)]. The effects of the PRC-only [$\beta = 0.39$, $SE = 0.15$ (0.14, 0.73)], SG-then-PRC [$\beta = 0.34$, $SE = 0.13$ (0.13, 0.65)], and PRC-then-SG conditions [$\beta = 0.39$, $SE = 0.15$ (0.14, 0.72)] were positively mediated by empathy. The presence of indirect effects and the absence of direct effects support H3 (see **Figure 4**).

Self-Other Overlap

With the dummy-coded PRC-only, PRC-then-SG, and SG-then-PRC conditions and empathy set as predictors for standardized differences in self-other overlap, the overall model was significant [$F(4, 166) = 3.83$, $R^2 = 0.08$, $MSE = 0.94$, $p = 0.005$].

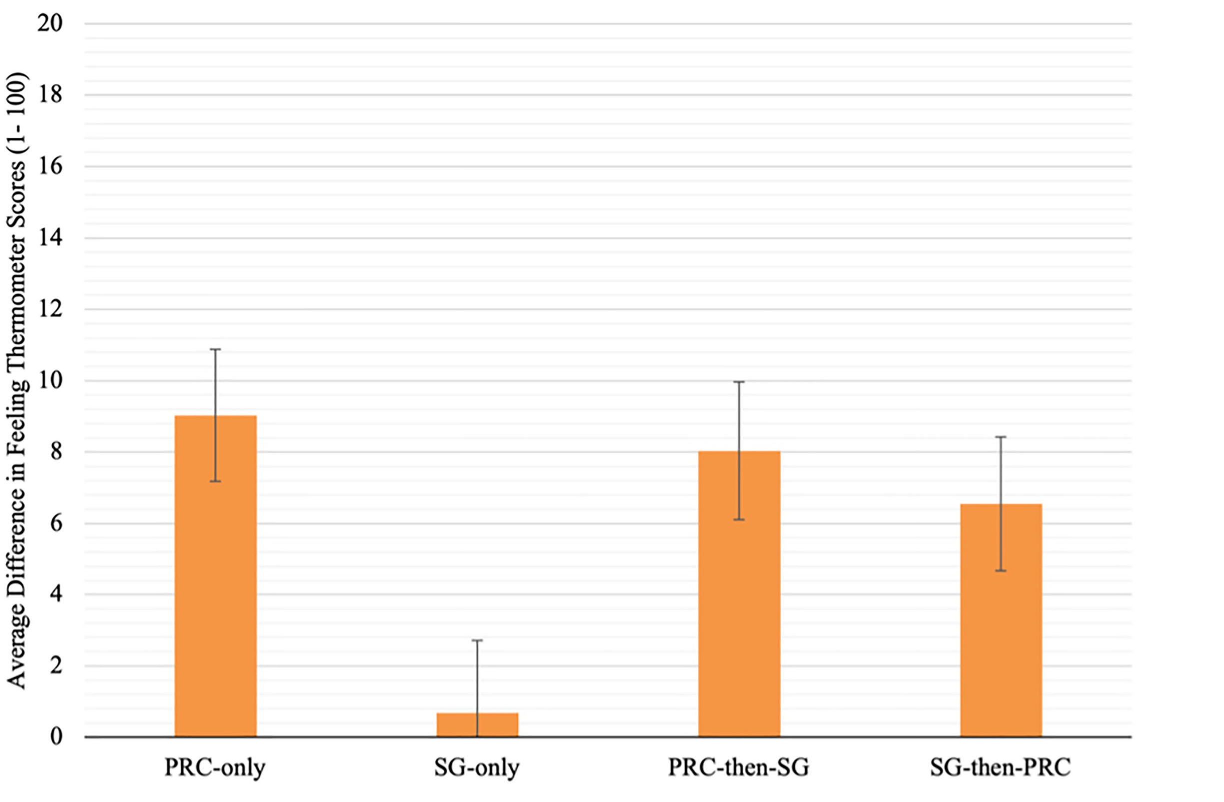

FIGURE 2 | Mean pre-to-post-change in feeling thermometer scores (1–100) for each embodiment condition. Error bars represent standard errors of the mean.

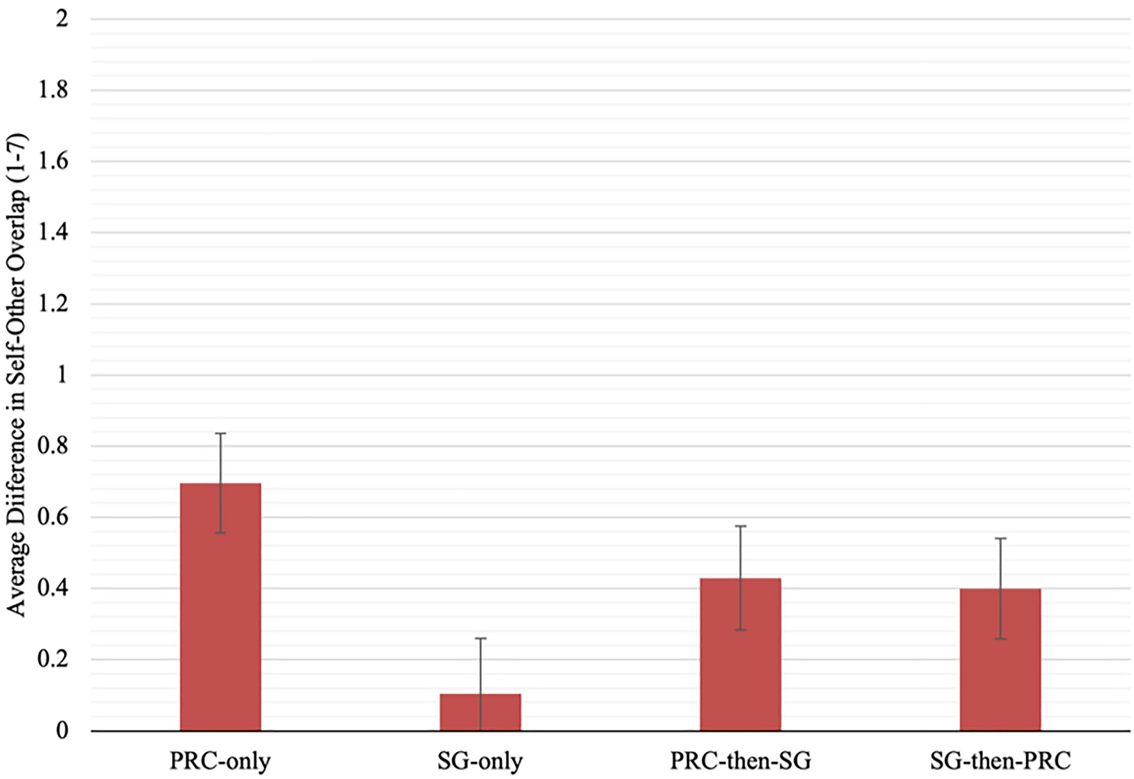

FIGURE 3 | Mean pre-to-post-change in self-other overlap (1–7) for each embodiment condition. Error bars represent standard errors of the mean.

The overall total effect of embodiment condition on difference scores was significant [$F(3, 167) = 2.69$, $R^2 = 0.05$, $p = 0.048$]. The PRC-only condition was the only one that had a significant, relative total effect on self-overlap differences compared to the SG-only group [$\beta = 0.61$, $t(82) = 2.84$, $p = 0.005$ (0.19, 1.04)]. Nonetheless, indirect effects can still exist in the apparent absence of a total effect, as the statistical power to detect an indirect effect may exceed the power used to determine a total effect. These indirect effects are thus still worth investigating (Rucker et al., 2011; Hayes, 2017). True enough, the relative indirect effect of embodiment condition *via* empathy was found to be significant, as the confidence interval for the omnibus effect did not include zero [$\beta = 0.09$, $SE = 0.03$ (0.03, 0.17)]. Analyzed separately, the PRC-only [$\beta = 0.38$, $SE = 0.14$ (0.14, 0.69)], SG-then-PRC [$\beta = 0.33$, $SE = 0.13$ (0.12, 0.63)], and the PRC-then-SG [$\beta = 0.38$, $SE = 0.14$ (0.13, 0.70)] all had significant positive indirect effects on self-other overlap differences through empathy. None of the relative direct effects were significant, providing support for H3 (see **Figure 5**).

Moderated Mediation With Social Identity Orientation

Higher aggregate scores for SIO positively predicted greater improvements in feeling thermometer scores [$b = 1.81$, $\beta = 0.158$, $t(170) = 2.08$, $p = 0.04$] and self-other overlap [$b = 0.157$, $\beta = 0.183$, $t(170) = 2.42$, $p = 0.02$]. In line with the past research, there was also a significant positive relationship between SIO and empathy [$b = 0.29$, $\beta = 0.23$, $t(170) = 3.04$, $p = 0.003$]. Given the significant relationship between SIO and outcome variables, we tested the possibility of SIO moderating the both the direct and indirect of embodiment condition *via* empathy on changes in both self-other overlap and feeling thermometer scores. We utilized Model 15 in the PROCESS Macro with 10,000 bootstraps and standardized all continuous variables.

Feeling Thermometer

The overall model predicting feeling thermometer differences was significant [$F(9, 161) = 2.56$, $R^2 = 0.13$, $p = 0.009$]. However, the indices of moderated mediation with PRC-only [$\beta = 0.07$, $SE = 0.12$ (−0.14, 0.35)], PRC-then-SG [$\beta = 0.06$, $SE = 0.11$ (−0.13, 0.31)], and SG-then-PRC [$\beta = 0.07$, $SE = 0.12$ (−0.15, 0.35)] as focal predictors were not significant, as the bootstrapped confidence intervals all included zero. As such, there was no evidence to suggest that SIO moderated the effect of embodiment condition on attitude change *via* empathy.

Self-Other Overlap

The overall model predicting self-other overlap difference scores was significant [$F(9, 161) = 3.28$, $R^2 = 0.15$, $MSE = 0.83$, $p = 0.001$]. Furthermore, the indices of moderated mediation with PRC-only [$\beta = 0.25$, $SE = 0.12$ (0.01, 0.50)], PRC-then-SG [$\beta = 0.22$, $SE = 0.11$ (0.01, 0.45)] and SG-then-PRC [$\beta = 0.25$, $SE = 0.13$ (0.02, 0.52)] as focal predictors were all significant, as the bootstrapped confidence intervals did not include zero. Empathy positively

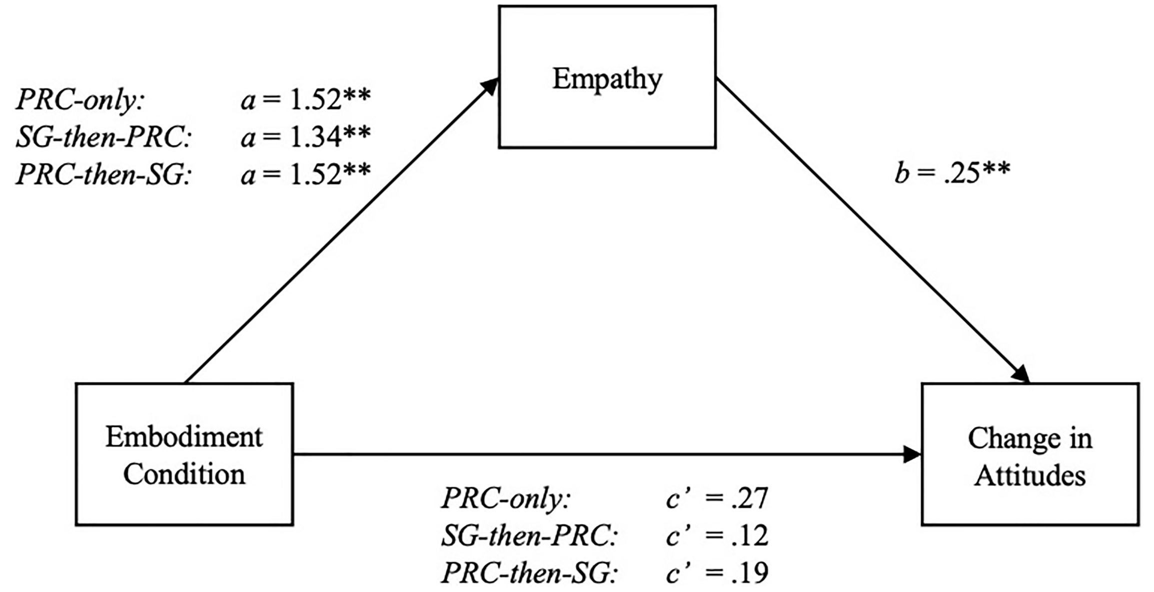

FIGURE 4 | Statistical model of empathy mediating the relative effects of embodiment condition on differences in feeling thermometer scores (attitudes). Coefficients are based on z-scored standardized values for empathy and feeling thermometer change scores. $^{*}p<0.05$; $^{**}p<0.01$.

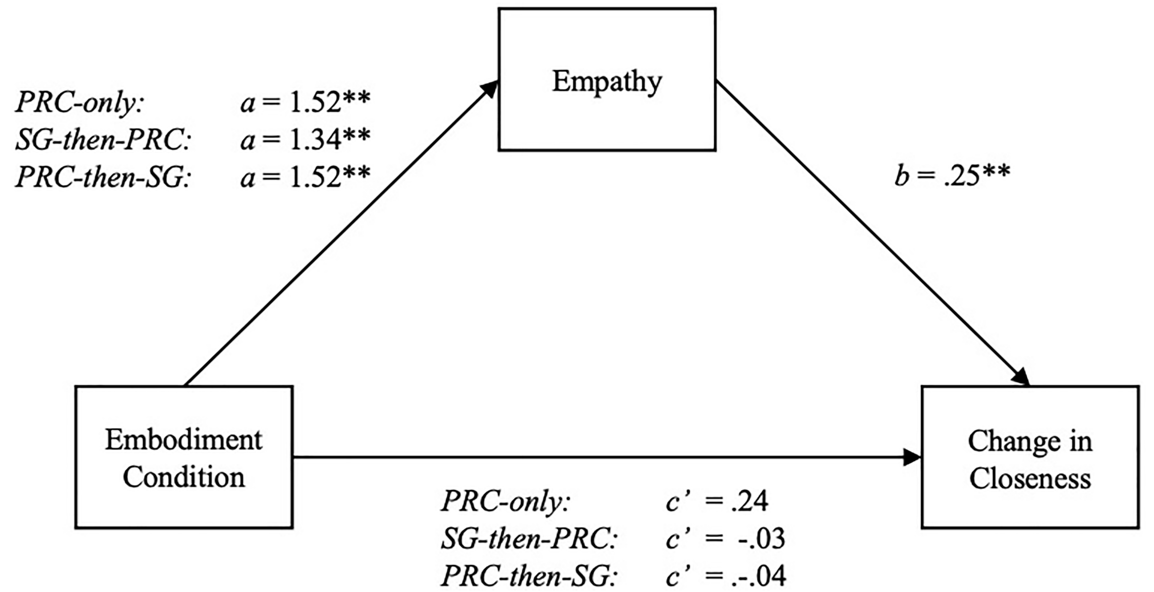

FIGURE 5 | Statistical model of empathy mediating the relative effects of embodiment condition on differences in self-other overlap (closeness). Coefficients are based on z-scored standardized values for empathy and self-other overlap change scores. $^{*}p<0.05$; $^{**}p<0.01$.

predicted changes in self-other overlap when SIO was high [+1 SD; $\beta=0.38$, $SE=0.13$, $p=0.004$ (0.13, 0.63)], but not low [−1 SD; $\beta=0.05$, $SE=0.13$, $p=0.69$ (−0.20, 0.31)]. Further probing into these conditional effects, we found that only the relative indirect effects of each PRC embodiment condition varied by SIO. When SIO was high (+1 SD), the three conditions significantly improved self-other overlap (compared against the SG-only control) indirectly *via* empathy but not directly. In contrast, when SIO was low (−1 SD), the effect of PRC-embodiment was not significant, whether direct or indirect (see **Figure 6**). Conditional effects of each condition are presented in **Table 2**.

There was a marginally significant interaction between empathy and SIO, [$\beta=0.11$, $t(170)=0.1.87$, $p=0.064$ (−0.01, 0.33)]. In contrast, the highest-order interaction between embodiment condition and SIO was not significant [$\beta=0.18$,

$t(82) = 0.73$, $p = 0.47$ (−0.32, 0.70)]. Though significant interaction coefficients are neither required nor sufficient to determine an overall moderated mediation effect (Hayes, 2015), the clear lack of a significant embodiment by SIO interaction does align with the absence of conditional direct effects.

Accounting for the possibility of a first-stage moderated mediation in the model, we tested whether embodiment condition interacted with SIO to predict empathy. The interactions were not significant with PRC-only [$\beta = -0.01$, $t(82) = -0.03$, $p = 0.97$ (−0.36, 0.35)], PRC-then-SG [$\beta = -0.11$, $t(82) = -0.63$, $p = 0.53$ (−0.44, 0.23)], and SG-then-PRC groups [$\beta = 0.08$, $t(82) = 0.53$, $p = 0.59$ (−0.23, 0.40)] as focal predictors. As such, there was no evidence to suggest conditional effects of embodiment on empathy.

The absence of conditional direct effects suggests that in response to RQ3, SIO moderates only the indirect effects of embodiment *via* empathy, not the direct effects (see **Figure 7**).

Findings from all analyses are summarized in **Table 3**.

DISCUSSION

The Effect of Outgroup Embodiment

Findings from this study support past research on how outgroup embodiment can result in more positive attitudes toward a salient outgroup (Peck et al., 2013; Banakou et al., 2016; Hasler et al., 2017). Mirroring research on perspective-taking (Galinsky et al., 2005), participants exposed to the outgroup-only embodiment scenario also reported significantly greater gains in self-other overlap with the outgroup than participants in the ingroup-only control. Whereas past embodiment research focused on assessing attitudes (e.g., Groom et al., 2009; Peck et al., 2013) and prosocial intentions (Herrera et al., 2018), our study additionally demonstrates that effects can be induced for cognitive perceptions of self-outgroup merging as well.

Two of three outgroup embodiment conditions were successful in improving attitudes relative to the ingroup condition. However, while both the outgroup-only and outgroup-then-ingroup conditions were found to have significant total effects on attitude change, only the outgroup-only condition produced a significant total effect on self-other overlap. Conceptually, while the feeling thermometer scale is utilized as a direct measure of attitudes self-other overlap measures perceptions of the self in relation to the other (Aron et al., 1992; Galinsky et al., 2005). The outgroup-then-ingroup manipulation involved both self- *and* other-embodiment, potentially distracting participants from concentrating fully on the "other" perspective. Moreover, by embodying both identities, participants' attention

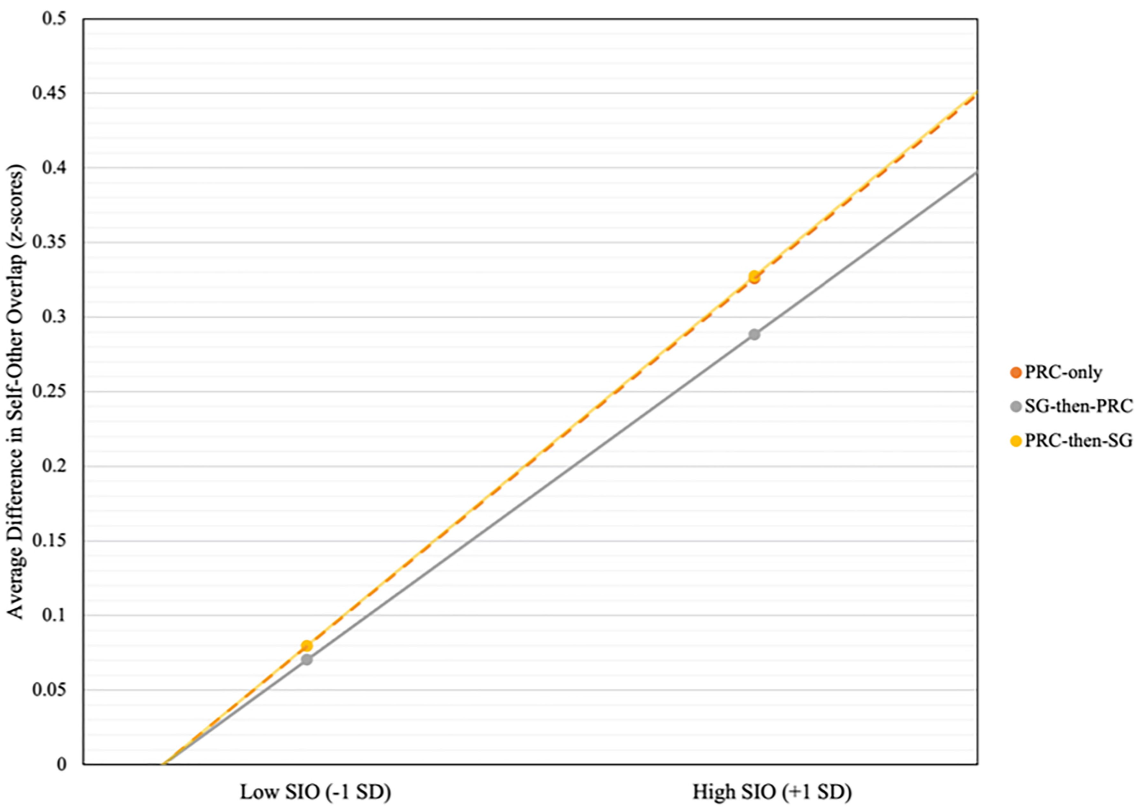

FIGURE 6 | Comparison of indirect effects of the PRC-only, SG-then-PRC, and PRC-then-SG conditions on differences in self-other overlap (closeness) moderated by social identity orientation (SIO). Slopes represent conditional indirect effects of each embodiment condition *via* empathy, based on values when SIO is −1 SD and + 1 SD from the mean. For high SIO (+1 SD) participants, all three conditions produced significant indirect effects.

TABLE 2 | Direct and indirect effects *via* empathy of PRC embodiment on change in self-other overlap, conditional on social identity orientation (SIO). Values are based on z-scored empathy, SIO, and change in self-other overlap.

		Direct effect			Indirect effect		
Condition	**SIO values**	**β**	**SE**	**CI**	**β**	**SE**	**CI**
PRC-only	+1 SD	0.50	0.37	−0.22, 1.23	0.57*	0.21	0.18, 1.00
	−1 SD	0.13	0.36	−0.58, 0.83	0.08	0.15	−0.24, 0.38
PRC-then-SG	+1 SD	−0.04	0.34	−0.70, 0.63	0.51*	0.19	0.15, 0.90
	−1 SD	0.05	0.36	−0.66, 0.76	0.07	0.14	−0.21, 0.35
SG-then-PRC	+1 SD	−0.31	0.36	−1.02, 0.40	0.58*	0.21	0.17, 1.02
	−1 SD	0.28	0.33	−0.38, 0.94	0.08	0.16	−0.24, 0.38

*CI does not include zero.

β, standardized effect; SE, standard error; CI, confidence interval.

TABLE 3 | Summary of main analyses and significant effects. Cells indicate embodiment conditions that resulted in significant effects (contrasted with the SG-only condition) for each analysis.

Effect \ DV	Feeling thermometer scores (attitudes)	Self-other overlap (closeness)
Total effect of embodiment (one-way ANOVA)	PRC-only PRC-then-SG	PRC-only
Indirect effect *via* empathy (mediation)	PRC-only PRC-then-SG SG-then-PRC*	PRC-only PRC-then-SG* SG-then-PRC*
Moderation of indirect effect *via* empathy by social identity orientation (moderated mediation)		PRC-only PRC-then-SG* SG-then-PRC*

*Significant indirect effects were found (i.e., confidence interval does not include zero) despite the absence of significant total effects in the one-way ANOVAs.

may have inadvertently been drawn to differences in ingroup and outgroup experiences instead of the similarities or overlap between groups.

In contrast to the majority of studies testing the effect of outgroup embodiment in a racial context, our study demonstrates improved intergroup attitudes in a co-ethnic context, where there are no visually salient distinctions by skin tone. Outgroups perceived as too similar to an ingroup may threaten the uniqueness or novelty of the ingroup's social identity, thus resulting in negative attitudes as a defensive mechanism (Binggeli et al., 2014). Thus, while individuals may identify with groups to bolster their self-concept, maintaining some level of distinctiveness is still crucial (Hornsey and Hogg, 2000). Our Singaporean Chinese participants may be especially reluctant to associate themselves with the broad "Chinese" label they share with PRC Chinese, as doing so may risk sacrificing their distinct sub-group cultural identity. Our study contributes to the very scarce body of research on mitigating intraethnic divides (Clark, 2004), where the desire for positive distinctiveness may be especially heightened due to superficial group similarities.

Anchoring and Order Effects

The order of perspective-taking *via* embodiment matters, albeit to a limited extent. Supporting H2b, no differences were found between the ingroup-then-outgroup and the ingroup-only conditions, despite the former including an outgroup embodiment scenario. In the ingroup-then-outgroup condition, undergoing the ingroup scenario condition first may have enhanced the salience and accessibility of the ingroup perspective as an anchor (Mussweiler and Strack, 1999a), thus increasing the amount of cognitive resources required for participants to adjust to the subsequent outgroup perspective (Epley et al., 2004). These findings thus support the literature on how the adjustment required in perspective-taking can be limited in effectiveness due to the stability of an egocentric anchor (Mussweiler and Strack, 1999a,b).

H2a was partially supported. We found a main effect of order on attitudes and closeness, such that outgroup-first conditions generated more positive shifts in bias than ingroup-first conditions. These findings provide support for a primacy effect when evaluating contrasting pieces of evidence in simple judgment tasks (Hogarth and Einhorn, 1992). Through a subsequent contrast analysis, we also found that the outgroup-then-ingroup condition significantly influenced changes in attitudes relative to the ingroup-only control group, while the ingroup-then-outgroup condition did not.

However, contrary to predictions, there were no significant differences between the ingroup-then-outgroup and the outgroup-only/outgroup-then-ingroup conditions, where outgroup embodiment was induced first or alone. In a preliminary analysis, we found that within the ingroup-then-outgroup condition, both attitudes and perceived closeness significantly improved from pre-test to post-test, whereas no improvements were found in the ingroup-only group (refer to **Supplementary Material**). It is possible that that anchoring effects worked in opposition to latent effects of embodiment in the ingroup-then-outgroup condition, both sides "cancelling" each other out to an extent. Due to competing influences, the attitudinal change generated by this manipulation may have not been different enough from other conditions to generate statistical significance. While anchor-consistent information can strengthen an anchor, anchor-inconsistent information can destabilize the anchor (Mussweiler et al., 2000; Strack et al., 2016).

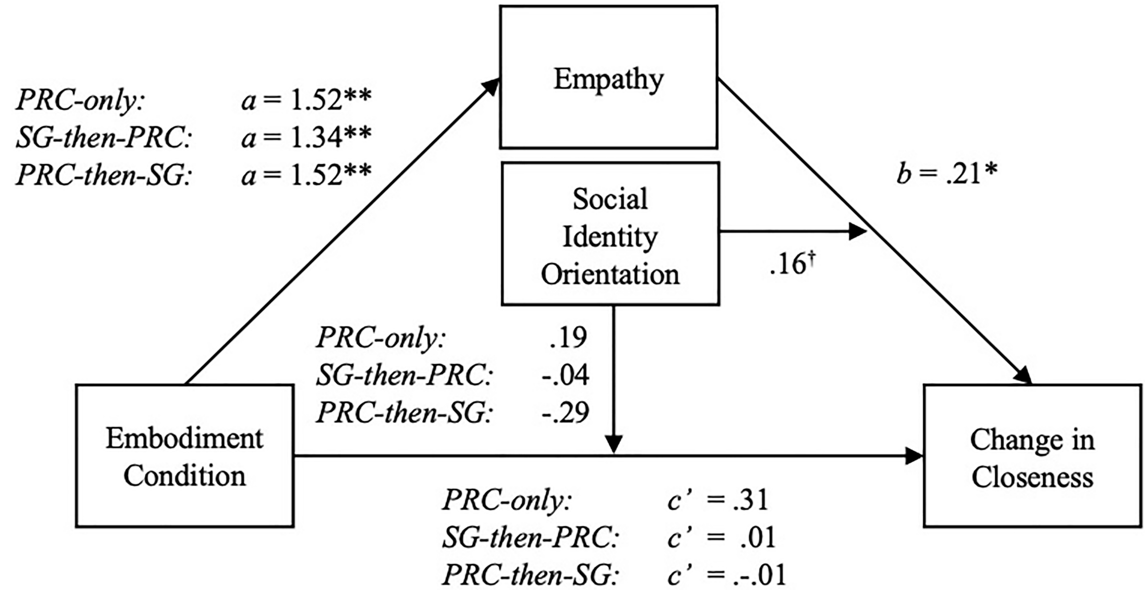

FIGURE 7 | Statistical moderated mediation model with SIO moderating the second-stage indirect effects of embodiment *via* empathy on changes in self-other overlap. Coefficients are based on z-scored standardized values for empathy, SIO, and self-other overlap change scores. $^{*}p<0.05$; $^{**}p<0.01$; $^{\dagger}p<0.07$.

In the ingroup-then-outgroup condition, perhaps the immersive outgroup embodiment scenario helped to destabilize the anchor induced by the ingroup embodiment scenario, although not completely.

Additive explanations to anchoring, such as mental fatigue, are plausible. Extended exposure and repeating similar tasks during VR may hinder participants' performance due to an onset of visual and cognitive fatigue (Malińska et al., 2015). We designed two different scenarios (food and drink vendors) to prevent repetitiveness, but the narrative and dialogue remained mostly the same. As such, participants in the double-embodiment conditions had to undergo similar scenes twice, potentially contributing to fatigue. This fatigue may have added on to the cognitive load induced by anchoring effects in the ingroup-then-outgroup condition, hindering perspective-taking efforts. When tired, people tend to form quick and easy judgments without excessive thought to conclude an activity (Webster et al., 1996).

Empathy as a Mediator

A notable finding from the present study is the role of empathy as a complete mediator of the effect of embodiment on attitudes and self-other overlap of an outgroup. These results support the few studies that identified empathy as a partial mediator between perspective-taking and intergroup attitudes (Vescio et al., 2003; Shih et al., 2009). Embodiment may be a robust mechanism for inducing empathy toward an outgroup. In fact, significant indirect effects of empathy on attitude change were present for all three outgroup manipulation conditions, despite the absence of total effects. This outcome can be explained by how the relationship between outgroup embodiment and empathy was stronger than the overall effect of outgroup embodiment on the dependent variables (Rucker et al., 2011).

Nonetheless, Rucker et al. (2011) caution against describing a statistical mediator as "full" or "complete," given that any regression model does not account for all possible mediators and moderators at the same time. One possibility for the absence of total effects may lie in suppression effects (MacKinnon et al., 2000), where our model may have not accounted for other variables that mediated the effect of outgroup embodiment in the opposite direction (Rucker et al., 2011). We qualify that empathy may only act as a "full" mediator of the observed effect of embodiment given the scope of our study and variables of interest. Further research should directly compare the indirect effect sizes of empathy (as a mediator) in VR embodiment versus imaginal perspective-taking manipulations and account for other mediators that could explain variance in this effect. The present study is the first, to our knowledge, to situate VR embodiment, empathy, and intergroup attitudes in a path analysis.

Social Identity Orientation as a Moderator

The effect on self-other overlap was moderated by participants' level of importance ascribed to social identity. These findings contribute to the divisive literature on how identity dispositions influence negative intergroup attitudes and are the first to test this construct in relation to embodiment. The stronger one's SIO is, the more effective embodiment is in improving self-other overlap with the outgroup. These findings provide additional evidence for the attentional hypothesis proposed by Wu and Keysar (2007). People with a SIO define the self in relational terms and thus perceive the role of others' behavior and thoughts to be more significant (Markus and Kitayama, 1991). They may be less prone to egocentrism and are more receptive to identifying commonalities with others (Wu and Keysar, 2007).

Through a moderated mediation analysis, we also found that this moderation solely impacts the indirect effect of outgroup embodiment *via* empathy. Findings thus extend past literature on how related constructs such as collectivism (Duan et al., 2008), interdependence (Cross et al., 2000; Chen et al., 2020), and social group awareness (Zhao et al., 2013) are conducive to empathic expression. Attaching importance to social identity may heighten one's propensity toward forging bonds and solidarity with others, thus enabling the prosocial benefits of empathy to manifest.

SIO notably did not moderate the first-stage relationship between embodiment and empathy. It is possible that the *type*, rather than the existence of empathy, depends on SIO. Research has found that collectivists, who value the social collective, are more likely to develop emotional empathy (i.e., the vicarious experience of others' emotions), while individualists, who value personal distinctiveness, are drawn to cognitive empathy (i.e., the mental understanding of another's perspective; Duan et al., 2008). A stronger SIO may then relate to emotional empathy development, where participants feel the pain and struggles of the PRC Chinese first-hand. Being this emotionally involved may encourage feelings of intimacy and closeness with the other (Roberts et al., 2014), possibly to a greater extent than cognitive empathy, which is less personally involving and taxing (Duan, 2000). More research should be done to unpack how dimensions of empathy differentially influence prosocial outcomes, preferably with a more robust sample size for this analysis.

However, SIO did not significantly moderate the effect of embodiment on attitudinal change, despite trending in the expected direction. The difference may lie in the stronger conceptual connections between identity orientations and self-other overlap, which both focus on the cognitive self-concept. Those with a SIO are more attuned to self-identity *in relation* to others (Nario-Redmond et al., 2004)—in turn, this disposition may make one more receptive to merging the 'self' with the 'other.'

Limitations

The study is not without its limitations. In our test of order effects, the double-embodiment manipulation conditions inevitably required twice as much time than the single-embodiment conditions to complete. Though this concern was mitigated by a nonsignificant main effect of the number of embodiment conditions, it is unclear whether time or effort may have influenced results in unidentified ways. Furthermore, SIO was also analyzed as a quasi-independent variable and not manipulated, so although moderation findings are predictive, direct causality cannot be inferred. Due to time and resource constraints, we also did not gauge implicit attitudes as a measure of intergroup attitudes (e.g., Groom et al., 2009; Peck et al., 2013; Lopez et al., 2019). It is possible that our dependent measures were limited in fully capturing non-conscious thoughts and avoiding demand characteristics.

As we strove to achieve ecological validity and realism in the embodiment scenario, we included an additional customer critique about English proficiency toward the PRC Chinese migrant avatar in the PRC embodiment scenario. Outside of this addition, the ingroup and outgroup embodiment scenarios were kept identical in terms of dialogue and storyboard. However, we acknowledge that the slightly more explicit negative feedback conveyed to the outgroup avatar may have inflated the apparent effects of embodiment on empathy for the outgroup. Future research should empirically test how different levels of positive versus negative experiences in outgroup (versus ingroup) embodiment can influence intergroup outcomes.

CONCLUSION

The present study addresses the research gap regarding the psychological processes underlying VR avatar embodiment. It extends scarce research on the role of trait variables, affective responses, and cognitive heuristics that may serve as underlying mechanisms or boundary conditions for embodiment to work effectively. Findings showed that virtual embodiment of an outgroup avatar significantly improved attitudes and self-other overlap with the outgroup. Furthermore, the study demonstrated this effect in a novel co-ethnic immigration context. Extending embodiment research, we find that the effects of embodiment on intergroup bias are strongly mediated by empathy. However, the prosocial benefits of this manipulation may also be contingent on the strength of one's SIO. The order of embodiment also matters to a certain extent due to potential anchoring effects. This study has important implications for the application of VR avatar embodiment to intergroup tensions. Moving forward, future research should further delve into these mechanisms to optimize virtual embodiment strategies for various contexts.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because the data is under restriction of the Data Management Plan (DMP) approved by Nanayang Technological University and Ministry of Education Singapore (funder). Requests to access the datasets should be directed to VC, the corresponding author, at chenhh@ntu.edu.sg.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Institutional Review Board, Nanyang Technological University, Singapore. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

VC contributed to the overall conceptualization of the study, study design, operationalization of variables, the virtual reality environment design, writing of the paper, as well as supervised the data collection and data analysis. GI contributed to the literature search, literature review, formation of arguments, and writing of all sections of the manuscript and conducted data analysis. VL and JL contributed to the literature search, a preliminary summary of the literature, operationalization of the variables, and VR design ideas and conducted experiment sessions. All authors contributed to the article and approved the submitted version.

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REFERENCES

Ahmed, S., Hsueh-Hua, V. C., and Chib, A. I. (2021). Xenophobia in the time of a pandemic: social media use, stereotypes, and prejudice against immigrants during the COVID-19 crisis. *Inter. J. Public Opinion Res.*:edab014. doi: 10.1093/ijpor/edab014

Ahn, S. J., Le, A. M. T., and Bailenson, J. (2013). The effect of embodied experiences on self-other merging, attitude, and helping behavior. *Media Psychol.* 16, 7–38. doi: 10.1080/15213269.2012.755877

Alwin, D. F. (1997). Feeling thermometers versus 7-point scales: which are better? *Sociol. Methods Res.* 25, 318–340. doi: 10.1177/0049124197025003003

Aron, A., Aron, E. N., and Smollan, D. (1992). Inclusion of other in the self scale and the structure of interpersonal closeness. *J. Pers. Soc. Psychol.* 63, 596–612. doi: 10.1037/0022-3514.63.4.596

Augoustinos, M., and Walker, I. (1998). The construction of stereotypes within social psychology: from social cognition to ideology. *Theory Psychol.* 8, 629–652. doi: 10.1177/0959354398085003

Banakou, D., Groten, R., and Slater, M. (2013). Illusory ownership of a virtual child body causes overestimation of object sizes and implicit attitude changes. *Proc. Natl. Acad. Sci. U. S. A.* 110, 12846–12851. doi: 10.1073/pnas.1306779110

Banakou, D., Hanumanthu, P. D., and Slater, M. (2016). Virtual embodiment of white people in a black virtual body leads to a sustained reduction in their implicit racial bias. *Front. Hum. Neurosci.* 10:601. doi: 10.3389/fnhum.2016.00601

Barr, D. J., and Keysar, B. (2006). "Perspective taking and the coordination of meaning in language use," in *Handbook of Psycholinguistics*. eds. M. J. Traxler and M. A. Gernshacher (USA: Elsevier), 901–938.

Batson, C. D., Polycarpou, M. P., Harmon-Jones, E., Imhoff, H. J., Mitchener, E. C., Bednar, L. L., et al. (1997). Empathy and attitudes: can feeling for a member of a stigmatized group improve feelings toward the group? *J. Pers. Soc. Psychol.* 72, 105–118. doi: 10.1037/0022-3514.72.1.105

Behm-Morawitz, E., Hoffswell, J., and Chen, S.-W. (2016a). The virtual threat effect: a test of competing explanations for the effects of racial stereotyping in video games on players' cognitions. *Cyberpsychol. Behav. Soc. Netw.* 19, 308–313. doi: 10.1089/cyber.2015.0461

Behm-Morawitz, E., Pennell, H., and Speno, A. G. (2016b). The effects of virtual racial embodiment in a gaming app on reducing prejudice. *Commun. Monogr.* 83, 396–418. doi: 10.1080/03637751.2015.1128556

Bertrand, P., Guegan, J., Robieux, L., McCall, C. A., and Zenasni, F. (2018). Learning empathy through virtual reality: multiple strategies for training empathy-related abilities using body ownership illusions in embodied virtual reality. *Front.Robotics AI* 5:26. doi: 10.3389/frobt.2018.00026

Binggeli, S., Krings, F., and Sczesny, S. (2014). Perceived competition explains regional differences in the stereotype content of immigrant groups. *Soc. Psychol.* 45, 62–70. doi: 10.1027/1864-9335/a000160

Boca, S., Garro, M., Giammusso, I., and Abbate, C. S. (2018). The effect of perspective taking on the mediation process. *Psychol. Res. Behav. Manag.* 11, 411–416. doi: 10.2147/PRBM.S168956

Breves, P. (2020). Reducing outgroup bias through intergroup contact with non-playable video game characters in VR. *PRESENCE: Virtual Augmented Reality* 27, 257–273. doi: 10.1162/pres_a_00330

Brickson, S. (2000). The impact of identity orientation on individual and organizational outcomes in demographically diverse settings. *Acad. Manag. Rev.* 25, 82–101. doi: 10.5465/amr.2000.2791604

Brickson, S., and Brewer, M. B. (2001). "Identity orientation and intergroup relations in organizations," in *Social Identity Processes in Organizational Contexts*. eds. M. A. Hogg and D. J. Terry (Philadelphia, PA: Taylor and Francis), 49–66.

Chen, J., Chang, B., Li, W., Shi, Y., Shen, H., Wang, R., et al. (2020). Dispositional self-construal modulates the empathy for others' pain: an ERP study. *Front. Psychol.* 11:508141. doi: 10.3389/fpsyg.2020.508141

Clark, R. (2004). Interethnic group and intraethnic group racism: perceptions and coping in black university students. *J. Black Psychol.* 30, 506–526. doi: 10.1177/0095798404268286

Cross, S. E., Bacon, P. L., and Morris, M. L. (2000). The relational-interdependent self-construal and relationships. *J. Pers. Soc. Psychol.* 78, 791–808. doi: 10.1037/0022-3514.78.4.791

Cuff, B. M., Brown, S. J., Taylor, L., and Howat, D. J. (2016). Empathy: a review of the concept. *Emot. Rev.* 8, 144–153. doi: 10.1177/1754073914558466

Davis, M. H. (1980). A multidimensional approach to individual differences in empathy. *J. Pers. Soc. Psychol.* 10:85

Department of Statistics Singapore (2020). Population and population structure. *Department of Statistics Singapore*. Available at: https://www.singstat.gov.sg/find-data/search-by-theme/population/population-and-population-structure/latest-data (Accessed February 2021).

Dovidio, J. F., Love, A., Schellhaas, F. M., and Hewstone, M. (2017). Reducing intergroup bias through intergroup contact: twenty years of progress and future directions. *Group Process. Intergroup Relat.* 20, 606–620. doi: 10.1177/1368430217712052

Doyle, J., Ojiako, U., Marshall, A., Dawson, I., and Brito, M. (2020). The anchoring heuristic and overconfidence bias among frontline employees in supply chain organizations. *Prod. Plann. Control* 32, 1–18. doi: 10.1080/09537287.2020.1744042

Duan, C. (2000). Being empathic: The role of motivation to empathize and the nature of target emotions. *Motiv. Emot.* 24, 29–49. doi: 10.1023/A:1005587525609

Duan, C., Wei, M., and Wang, L. (2008). The role of individualism-collectivism in empathy: an exploratory study. *Asian J. Counselling* 15, 57–81.

Duclos, R., and Barasch, A. (2014). Prosocial behavior in intergroup relations: how donor self-construal and recipient group-membership shape generosity. *J. Consum. Res.* 41, 93–108. doi: 10.1086/674976

Epley, N., and Gilovich, T. (2006). The anchoring-and-adjustment heuristic: why the adjustments are insufficient. *Psychol. Sci.* 17, 311–318. doi: 10.1111/j.1467-9280.2006.01704.x

Epley, N., Keysar, B., Van Boven, L., and Gilovich, T. (2004). Perspective taking as egocentric anchoring and adjustment. *J. Pers. Soc. Psychol.* 87, 327–339. doi: 10.1037/0022-3514.87.3.327

Galinsky, A. D., Ku, G., and Wang, C. S. (2005). Perspective-taking and self-other overlap: fostering social bonds and facilitating social coordination. *Group Process. Intergroup Relat.* 8, 109–124. doi: 10.1177/1368430205051060

Galinsky, A. D., and Moskowitz, G. B. (2000). Perspective-taking: decreasing stereotype expression, stereotype accessibility, and in-group favoritism. *J. Pers. Soc. Psychol.* 78, 708–724. doi: 10.1037/0022-3514.78.4.708

Gouveia, V. V. (2011). Individualism-collectivism as predictors of prejudice toward gypsies in Spain. *Int. J. Psychol.* 45, 223–234. doi: 10.30849/rip/ijp.v45i2.152

gov.sg (2019). What are the racial proportions among Singapore citizens? Available at: https://www.gov.sg/article/what-are-the-racial-proportions-among-singapore-citizens (Accessed 2021).

Groom, V., Bailenson, J., and Nass, C. (2009). The influence of racial embodiment on racial bias in immersive virtual environments. *Soc. Influ.* 4, 231–248. doi: 10.1080/15534510802643750

Hasler, B. S., Spanlang, B., and Slater, M. (2017). Virtual race transformation reverses racial in-group bias. *PLoS One* 12:e0174965. doi: 10.1371/journal.pone.0174965

Hasson, Y., Schori-Eyal, N., Landau, D., Hasler, B. S., Levy, J., Friedman, D., et al. (2019). The enemy's gaze: immersive virtual environments enhance peace promoting attitudes and emotions in violent intergroup conflicts. *PLoS One* 14:e0222342. doi: 10.1371/journal.pone.0222342

Hayes, A. F. (2012). PROCESS: a versatile computational tool for observed variable mediation, moderation, and conditional process modeling. Available at: http://www.personal.psu.edu/jxb14/M554/articles/process2012.pdf (Accessed March 2021).

Hayes, A. F. (2015). An index and test of linear moderated mediation. *Multivar. Behav. Res.* 50, 1–22. doi: 10.1080/00273171.2014.962683

Hayes, A. F. (2017). *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach*. New York, NY: Guilford Publications.

Hayes, A. F., and Preacher, K. J. (2013). Statistical mediation analysis with a multicategorical independent variable. *Br. J. Math. Stat. Psychol.* 67, 451–470. doi: 10.1111/bmsp.12028

Hedgebeth, M.V. (2020). The effects of ingroup threat on the anchoring and adjustment heuristic. VCU theses and dissertations. Virginia Commonwealth University.

Herrera, F. (2020). "Virtual embodiment and embodied cognition: effect of virtual reality perspective taking tasks on empathy and prejudice," in *A Multidisciplinary Approach to Embodiment: Understanding Human Being*. ed. N. K. Dess (New York, NY: Routledge), 127–132.

Herrera, F., Bailenson, J., Weisz, E., Ogle, E., and Zaki, J. (2018). Building long-term empathy: a large-scale comparison of traditional and virtual reality perspective-taking. *PLoS One* 13:e0204494. doi: 10.1371/journal.pone.0204494

Hertel, G., and Kerr, N. L. (2001). Priming in-group favoritism: the impact of normative scripts in the minimal group paradigm. *J. Exp. Soc. Psychol.* 37, 316–324. doi: 10.1006/jesp.2000.1447

Hirschmann, R. (2020). Population of Singapore in 2019, by citizenship status. Available at: https://www.statista.com/statistics/1087802/singapore-resident-population-by-citizenship-status/ (Accessed February 2021).

Hogarth, R. M., and Einhorn, H. J. (1992). Order effects in belief updating: the belief-adjustment model. *Cogn. Psychol.* 24, 1–55. doi: 10.1016/0010-0285(92)90002-J

Hornsey, M. J., and Hogg, M. A. (2000). Subgroup relations: a comparison of mutual intergroup differentiation and common ingroup identity models of prejudice reduction. *Personal. Soc. Psychol. Bull.* 26, 242–256. doi: 10.1177/0146167200264010

Hysenbelli, D., Rubaltelli, E., and Rumiati, R. (2013). Others' opinions count, but not all of them: anchoring to ingroup versus outgroup members' behavior in charitable giving. *Judgment Decis. Making* 8, 678–690.

Keysar, B., Barr, D. J., Balin, J. A., and Brauner, J. S. (2000). Taking perspective in conversation: the role of mutual knowledge in comprehension. *Psychol. Sci.* 11, 32–38. doi: 10.1111/1467-9280.00211

Kilteni, K., Groten, R., and Slater, M. (2012). The sense of embodiment in virtual reality. *Presence Teleop. Virt.* 21, 373–387. doi: 10.1162/PRES_a_00124

Liu, H. (2014). Beyond co-ethnicity: the politics of differentiating and integrating new immigrants in Singapore. *Ethn. Racial Stud.* 37, 1225–1238. doi: 10.1080/01419870.2014.892630

Lopez, S., Yang, Y., Beltran, K., Kim, S.J., Cruz Hernandez, J., Simran, C., et al. (2019). "Investigating implicit gender bias and embodiment of White males in virtual reality with full body visuomotor synchrony." in *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*; May 4–9, 2019; 1–12.

MacKinnon, D. P., Krull, J. L., and Lockwood, C. M. (2000). Equivalence of the mediation, confounding and suppression effect. *Prev. Sci.* 1, 173–181. doi: 10.1023/A:1026595011371

Malińska, M., Zużewicz, K., Bugajska, J., and Grabowski, A. (2015). Heart rate variability (HRV) during virtual reality immersion. *Int. J. Occup. Saf. Ergon.* 21, 47–54. doi: 10.1080/10803548.2015.1017964

Markus, H. R., and Kitayama, S. (1991). Culture and the self: implications for cognition, emotion, and motivation. *Psychol. Rev.* 98, 224–253. doi: 10.1037/0033-295X.98.2.224

Mussweiler, T., and Strack, F. (1999a). Comparing is believing: a selective accessibility model of judgmental anchoring. *Eur. Rev. Soc. Psychol.* 10, 135–167. doi: 10.1080/14792779943000044

Mussweiler, T., and Strack, F. (1999b). Hypothesis-consistent testing and semantic priming in the anchoring paradigm: a selective accessibility model. *J. Exp. Soc. Psychol.* 35, 136–164. doi: 10.1006/jesp.1998.1364

Mussweiler, T., Strack, F., and Pfeiffer, T. (2000). Overcoming the inevitable anchoring effect: considering the opposite compensates for selective accessibility. *Personal. Soc. Psychol. Bull.* 26, 1142–1150. doi: 10.1177/01461672002611010

Myers, M. W., Laurent, S. M., and Hodges, S. D. (2014). Perspective taking instructions and self-other overlap: different motives for helping. *Motiv. Emot.* 38, 224–234. doi: 10.1007/s11031-013-9377-y

Nario-Redmond, M. R., Biernat, M., Eidelman, S., and Palenske, D. J. (2004). The social and personal identities scale: a measure of the differential importance ascribed to social and personal self-categorizations. *Self Identity* 3, 143–175. doi: 10.1080/13576500342000103

Ortiga, Y. Y. (2015). Multiculturalism on its head: unexpected boundaries and new migration in Singapore. *J. Int. Migr. Integr.* 16, 947–963. doi: 10.1007/s12134-014-0378-9

Paluck, E. L., Porat, R., Clark, C. S., and Green, D. P. (2021). Prejudice reduction: progress and challenges. *Annu. Rev. Psychol.* 72, 533–560. doi: 10.1146/annurev-psych-071620-030619

Peck, T. C., Seinfeld, S., Aglioti, S. M., and Slater, M. (2013). Putting yourself in the skin of a black avatar reduces implicit racial bias. *Conscious. Cogn.* 22, 779–787. doi: 10.1016/j.concog.2013.04.016

Perdue, C. W., Dovidio, J. F., Gurtman, M. B., and Tyler, R. B. (1990). Us and them: social categorization and the process of intergroup bias. *J. Pers. Soc. Psychol.* 59, 475–486. doi: 10.1037/0022-3514.59.3.475

Pettigrew, T. F., and Tropp, L. R. (2008). How does intergroup contact reduce prejudice? Meta-analytic tests of three mediators. *Eur. J. Soc. Psychol.* 38, 922–934. doi: 10.1002/ejsp.504

Preston, S. D., and De Waal, F. B. (2002). Empathy: its ultimate and proximate bases. *Behav. Brain Sci.* 25, 1–20. doi: 10.1017/S0140525X02000018

Ramsay, J. E., and Pang, J. S. (2017). Anti-immigrant prejudice in rising East Asia: a stereotype content and integrated threat analysis. *Polit. Psychol.* 38, 227–244. doi: 10.1111/pops.12312

Roberts, W., Strayer, J., and Denham, S. (2014). Empathy, anger, guilt: emotions and prosocial behaviour. *Can. J. Behav. Sci.* 46:465. doi: 10.1037/a0035057

Rucker, D. D., Preacher, K. J., Tormala, Z. L., and Petty, R. E. (2011). Mediation analysis in social psychology: current practices and new recommendations. *Soc. Personal. Psychol. Compass* 5, 359–371. doi: 10.1111/j.1751-9004.2011.00355.x

Salmanowitz, N. (2018). The impact of virtual reality on implicit racial bias and mock legal decisions. *J. Law Biosci.* 5, 174–203. doi: 10.1093/jlb/lsy005

Schulze, S., Pence, T., Irvine, N., and Guinn, C. (2019). "The effects of embodiment in virtual reality on implicit gender bias." in *International Conference on Human-Computer Interaction*; July 26–31, 2019; (Springer), 361–374.

Shih, M., Wang, E., Trahan Bucher, A., and Stotzer, R. (2009). Perspective taking: reducing prejudice towards general outgroups and specific individuals. *Group Process. Intergroup Relat.* 12, 565–577. doi: 10.1177/1368430209337463

Shin, D. (2018). Empathy and embodied experience in virtual environment: to what extent can virtual reality stimulate empathy and embodied experience? *Comput. Hum. Behav.* 78, 64–73. doi: 10.1016/j.chb.2017.09.012

Strack, F., Bahník, Š., and Mussweiler, T. (2016). Anchoring: accessibility as a cause of judgmental assimilation. *Curr. Opin. Psychol.* 12, 67–70. doi: 10.1016/j.copsyc.2016.06.005

Tham, J., Duin, A. H., Gee, L., Ernst, N., Abdelqader, B., and McGrath, M. (2018). Understanding virtual reality: presence, embodiment, and professional practice. *IEEE Trans. Prof. Commun.* 61, 178–195. doi: 10.1109/TPC.2018.2804238

Todd, A. R., and Galinsky, A. D. (2014). Perspective-taking as a strategy for improving intergroup relations: evidence, mechanisms, and qualifications. *Soc. Personal. Psychol. Compass* 8, 374–387. doi: 10.1111/spc3.12116

Tropp, L. R., and Pettigrew, T. F. (2005). Differential relationships between intergroup contact and affective and cognitive dimensions of prejudice. *Personal. Soc. Psychol. Bull.* 31, 1145–1158. doi: 10.1177/0146167205274854

Tversky, A., and Kahneman, D. (1974). Judgment under uncertainty: heuristics and biases. *Science* 185, 1124–1131. doi: 10.1126/science.185.4157.1124

United Nations (2015). Number of international migrants by major area of destination and major area of origin. Available at: https://www.un.org/en/development/desa/population/migration/data/estimates2/estimates15.asp (Accessed February 2021).

Vescio, T. K., Sechrist, G. B., and Paolucci, M. P. (2003). Perspective taking and prejudice reduction: the mediational role of empathy arousal and situational attributions. *Eur. J. Soc. Psychol.* 33, 455–472. doi: 10.1002/ejsp.163

Wan, W. (2015). Pink IC and red passport not enough to make you Singaporean. *The Straits Times*, January 2. https://www.straitstimes.com/opinion/pink-ic-and-red-passport-not-enough-to-make-you-singaporean (Accessed August 2021).

Webster, D. M., Richter, L., and Kruglanski, A. W. (1996). On leaping to conclusions when feeling tired: mental fatigue effects on impressional primacy. *J. Exp. Soc. Psychol.* 32, 181–195. doi: 10.1006/jesp.1996.0009

Wheeler, S. C., and Petty, R. E. (2001). The effects of stereotype activation on behavior: a review of possible mechanisms. *Psychol. Bull.* 127, 797–826. doi: 10.1037/0033-2909.127.6.797

Wilcox, C., Sigelman, L., and Cook, E. (1989). Some like it hot: individual differences in responses to group feeling thermometers. *Public Opin. Q.* 53, 246–257. doi: 10.1086/269505

Wu, S., and Keysar, B. (2007). The effect of culture on perspective taking. *Psychol. Sci.* 18, 600–606. doi: 10.1111/j.1467-9280.2007.01946.x

Yee, N., and Bailenson, J.N. (2006). "Walk a mile in digital shoes: the impact of embodied perspective-taking on the reduction of negative stereotyping in immersive virtual environments." in *Proceedings of PRESENCE: The 9th Annual International Workshop on Presence*; August 24–26, 2006; 24, 26.

Yik, M., Wong, K. F. E., and Zeng, K. J. (2019). Anchoring-and-adjustment during affect inferences. *Front. Psychol.* 9:2567. doi: 10.3389/fpsyg.2018.02567

Zhao, J., Abrahamson, K., Anderson, J. G., Ha, S., and Widdows, R. (2013). Trust, empathy, social identity, and contribution of knowledge within patient online communities. *Behav. Inform. Technol.* 32, 1041–1048. doi: 10.1080/0144929X.2013.819529

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Exercising With Embodied Young Avatars: How Young vs. Older Avatars in Virtual Reality Affect Perceived Exertion and Physical Activity Among Male and Female Elderly Individuals

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This study demonstrated that implementation of the Proteus effect via manipulation of avatar age in VR is effective among elderly individuals in the context of exercise. One hundred and four elderly adults aged 60 years and older who did not engage in vigorous physical activities participated in this experiment with a 2 (avatar age: young vs. older) × 2 (sex: male vs. female) design. The results showed that the embodiment of younger avatars (age approximately 20 years) in VR leads to greater perceived exercise exertion regardless of sex after controlling for age and emotion. Older adults with young avatars perceived a greater contribution of efforts to exercise. This study also found that among those who did not engage in vigorous exercise, female older adults who embodied young avatars reported greater self-efficacy for future exercise and greater physical activity during the exercise phase than those who embodied older avatars. This study suggests that females are more likely to be motivated to continue exercising through young avatar embodiment. In contrast, female elderly who embodied old avatars reported significant fewer physical activity than male elderly who embodied old avatars. This indicated that the Proteus effect had stronger effects among females than among older males. Although we found the Proteus effect through VR avatar manipulation, the effect was temporary and limited to the experimental phase. This study is the first to examine the Proteus effect among elderly individuals in the context of exercise. It also contributes to the literature by indicating that avatar age manipulation is an effective means of promoting exercise among elderly individuals and helping them achieve exercise outcomes. This study further demonstrates that female elderly individuals respond to young avatars differently than male elderly individuals, with female elderly individuals showing more positive effects of young avatar embodiment than males. Implications and theoretical contributions are discussed.

Keywords: Proteus effect, elder exercise, avatar, embodiment, perceived exertion, physical activity, virtual reality exercise, sex difference

INTRODUCTION

Using communication technology to encourage older adults to engage in safe and moderate exercise is an important goal of scholars and society (Kim et al., 2013). According to the World Health Organization (World Health Organization [WHO], 2020), older adults aged 65 years old and above should engage in at least 150 min of moderate-intensity aerobic physical activity per week. Existing video game-based interventions for elderly individuals have indicated positive results and responses among elderly participants (Cyarto et al., 2016). Specifically, compared to video-streamed channels, avatar manipulations and representation in exergames (e.g., video games promoting exercise) have shown promising outcomes for elderly individuals and offer greater privacy (Cyarto et al., 2016). With the commercialization of virtual reality (VR) systems and stand-alone VR machines, VR has garnered considerable attention from both the exergame industry and scholars for promoting exercise. Several VR training programs have shown positive results, such as in improving elderly individuals' balance, posture and muscle strength through VR exercise intervention (Kim et al., 2013; Lee et al., 2017; Monteiro-Junior et al., 2017). However, the potential effects and underlying mechanism of avatar embodiment manipulation in VR exercise among elderly individuals remain unknown and require investigation.

Embodiment manipulation in VR has received increasing attention in the past decade (Ratan et al., 2019), with scholars exploring how changing one's embodied avatar with various traits can influence an individual's attitude and behavior (Yee and Bailenson, 2007; Yee et al., 2009). Yee and Bailenson (2007) theorized the Proteus effect as a top-down effect in which the appearance and traits of an embodied avatar in VR influence one's self-perception and behavior. For example, participants embodying avatars with attractive faces engaged in more self-disclosure and maintained a shorter physical distance from others while talking to others in VR, and participants embodying taller avatars were more likely to turn down unfair money split offers than those embodying shorter avatars (Yee and Bailenson, 2007). Compared to elderly individuals who embodied adult avatars, elderly individuals who embodied avatars who appeared to be 4 years old perceived themselves to be younger and were more likely to overestimate object sizes (Tajadura-Jiménez et al., 2017). Evidence has shown that people's perceptions of their body are malleable and depend on sensory cues in VR (Tajadura-Jiménez et al., 2017; Tacikowski et al., 2020).

One specific stream of avatar embodiment research has focused on exercise. However, most studies have employed video game-based avatars shown on a screen where the participants can see their own actual bodies while exercising (Li et al., 2014; Waddell et al., 2015; Peña et al., 2016; Joo and Kim, 2017). Very few studies (Fox and Bailenson, 2009; Reinhard et al., 2020) have explored embodiment illusion in VR. In addition, to the best of our knowledge, avatar manipulation in VR has not been applied to elderly individuals in the context of exercise. In this study, we manipulated the age of the embodied avatars so that elderly individuals embodied either older avatars or younger avatars (i.e., 20 years old), and we examined their self-efficacy and physical activity in VR. We also investigated the underlying theoretical mechanism of avatar manipulation in VR. Last, we explored potential sex differences in the persuasion effects of embodiment manipulation on exercise since females are more likely to internalize idealized thin body representations in the media (e.g., Hargreaves and Tiggemann, 2003; Levine and Murnen, 2009). In this paper, we first discuss the main outcomes expected from this study, then review the previous literature on the avatar manipulation approach, and then end with a discussion of the theoretical mechanisms of the Proteus effect and self-concept.

Exercise-Related Outcomes

Regular weekly aerobic exercise is recommended for older adults for healthier physical and mental well-being and to reduce potential health risks (World Health Organization [WHO], 2020). Among several interventions designed to encourage elderly individuals' physical activity, self-efficacy for future exercise is a central goal and is the most important variable among the psychological factors related to physical activity (Anderson et al., 2006). As a core construct in social cognitive theory (Bandura, 1977), self-efficacy is defined as "the belief in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1977, p. 3). Self-efficacy for exercise thus describes one's belief that he or she is capable of engaging in future exercise or physical activity. Research has indicated a positive association between self-efficacy and regular exercise among elderly individuals (Hwang and Chung, 2008). Self-efficacy for exercise among elderly individuals was even found to be more predictive of long-term exercise (7–12 months) than exercise-related social support in intervention-based programs (Brassington et al., 2002).

Another common goal is exercise as a behavioral outcome among elderly people, i.e., their actual physical activity. Defined as a "bodily movement produced by skeletal muscles that requires energy expenditure," physical activity "refers to all movement, including during leisure time, for transport to and from places or as part of a person's work" (World Health Organization [WHO], 2020). The WHO recommends various levels of moderate- and vigorous-intensity physical activity for improving health. In sum, physical activity refers to all physical movements made through various types of exercise such as walking, running, or swimming. Greater physical activity refers to higher degrees of physical movement. Among sensor-based physical activity monitoring systems, accelerometers have been reported to be effective and reliable in measuring physical activity among elderly individuals (van Schooten et al., 2015). Accelerometer sensors assess physical activity based on the vector magnitude (created by movements on the three axes) and step counts, which predict energy expenditure. That is, accelerometer sensors record the movements a participant makes in horizontal (x-axis), vertical (y-axis), forward, and backward (z-axis) directions, which created the vector magnitude representing physical movements during exercise. Accelerometer sensors also count the number of steps a participant takes during the assessment period. Exergame research (Peng et al., 2015) assesses accelerometer data upon engagement in physical activity, with higher values of vector data representing greater engagement in activities and physical movement.

Furthermore, not only physical activity intention and behavior but also one's effort devoted to exercise is important because some programs require precise movements for rehabilitation or further efforts for the advanced training of specific muscles. Borg's rating of perceived exertion (RPE) refers to the level of perceived effort in an exercise based on the estimation of "effort and exertion, breathlessness, and fatigue during physical work" (Borg, 1998, p. v). A higher RPE indicates more intensive exercise requiring higher effort. RPE measures subjective perception of self-effort during the exercise. Higher effort devoted to exercise can indicate greater engagement or higher requirement of the physical task.

Avatar-Based Exercise Interventions

Academics have examined the effects of the traits of digital avatars in exergame programs on players' exercise outcomes and attitudes (Li et al., 2014; Joo and Kim, 2017). Most exergames are video game-based programs using Nintendo Wii and Xbox motion-sensing systems, which allow participants to see their avatars on TV screens and simultaneously see their actual bodies while engaging in exercise. The results of these studies showed that the provision of reinforcement through this self-modeling approach encouraged participants to exercise harder. For example, participants with normal-weight avatars had better exercise outcomes, such as exercise attitude, motivation and game performance, than those with overweight avatars (Li et al., 2014). In addition, compared to participants with overweight avatars, for those with normal-weight avatars, there was a greater association between the avatar's healthy behavior and the participant's step counts (Joo and Kim, 2017). Even without any avatar manipulation, simply using an avatar in Wii boxing significantly reduced social physique anxiety and increased enjoyment among participants with high body dissatisfaction compared with participants with low body dissatisfaction (Song et al., 2014).

Social dynamics have also been explored (Peña et al., 2016) in the context of video game-based exercise examination using avatar manipulation. In addition to the main effect of the use of normal-weight avatars leading to greater physical activity among male participants than the use of normal-weight avatars, the body sizes of participant and opponent avatars also influenced participants' exercise behavior. Participants engaged in less physical activity when they perceived the opponent avatars to be more obese than their own avatars. Participants also engaged in less physical activity when they perceived their own avatars to be more obese than the opponent avatars.

Scholars have explored avatar manipulation in VR. In the context of exercise, Fox and Bailenson (2009) asked the participants to view their virtual bodies from a third-person perspective, and the results indicated that viewing a virtual body with reinforcement (i.e., gained or lost weight) affected their own exercise behavior—the reinforcement group engaged in more voluntary exercise. In the second study, they found that viewing virtual bodies with models of their own heads made the participants exercise more than viewing virtual bodies with other people's heads. In the third study, the participants engaged in more exercise in the following 24 h when they viewed a self-avatar running on a treadmill in VR than when they viewed other avatars running or a self-avatar loitering. These results indicated that self-referencing in VR using avatar manipulation has both temporary and prolonged effects on exercise behavior.

Another form of avatar manipulation in VR is embodiment, in which participants directly embody the virtual body as opposed to seeing an avatar on the screen. When embodying a virtual body, a participant can look down and see his or her body as the virtual body and look at his or her virtual body in the mirror as in reality. Seeing is different from being (Yee and Bailenson, 2009), which supports the concept of the Proteus effect (Yee and Bailenson, 2007), in which the traits and appearance of embodied avatars change participants' actual behavior. One study (Reinhard et al., 2020) tested the age difference (i.e., younger vs. older) in walking speed among undergraduate students. The results showed that participants who had embodied an older avatar in a previous test walked significantly slower than those who had previously embodied younger avatars. They also indicated fast decay effects of the Proteus effect on participants. Furthermore, only two-thirds of participants who had high spatial presence showed such effects. Reinhard et al. (2020) indicated that perceiving themselves as old decreased young participants' walking speed, and only high levels of spatial presence led to this effect.

Regarding VR-based exercise programs targeting elderly individuals, the existing research has focused on designing programs tailored to elderly individuals with various symptoms or rehabilitation needs. For example, in a 6-week VR exercise program for elderly individuals over 65 years old (Lee et al., 2017), those who participated in the intervention demonstrated significantly improved static and dynamic balance from baseline to posttest, while the control group did not. To the best of our knowledge, no research has tested the effects of avatar manipulation among elderly individuals, and the effects and underlying mechanisms remain unexplored.

Underlying Mechanism: Proteus Effect and Self-Concept

Most research has attributed the effects of avatar manipulation on participants' behavior to the Proteus effect (Yee and Bailenson, 2006). A meta-analysis of 46 quantitative experimental studies (Ratan et al., 2019) showed small-to-medium effect sizes, with the participants conforming their behavior to the characteristics of avatars assigned to them. For example, Yee et al. (2009) found that avatar height and attractiveness both affected players' performance in an online game. In the online game World of Warcraft, taller avatars, and more attractive avatars showed better game performance than shorter and unattractive avatars. In a subsequent study (Yee et al., 2009), the authors found that the Proteus effect induced in the virtual world transferred to later face-to-face interactions. Participants who embodied taller avatars in a virtual environment later negotiated more aggressively in a face-to-face context than those who embodied shorter avatars.

Yee and Bailenson (2006) explained that embodiment changes participants' self-perception in VR because people rely on external cues, such as the traits of avatars, to form their selves. Therefore, the traits and characteristics of the embodied avatars change participants' attitudes and behavioral conformity. Peña et al. (2009) theorized that this phenomenon is based a priming mechanism by which limited cues in virtual environments prime participants' attitudes toward and expectations of such behavioral cues. Ratan and Dawson (2016) theorized this phenomenon to occur through schema activation; they suggested that when embodying an avatar, participants activate schemas related to self that are closely connected to traits of the avatar. In a virtual environment, when participants engage in a certain activity with assigned avatars, they then develop self-perceptions to plan how they should act.

The above theoretical arguments implicitly suggest the association between the self and the avatar as the character that one identifies with in digital games (Klimmt et al., 2009). Klimmt et al. (2009) theorized character identification to be a temporarily altered self-concept, as one temporarily adopts the character's traits when using the avatar to play a game. Tajadura-Jiménez et al. (2017) examined the self-concept as the underlying mechanism for avatar manipulation in VR. For example, older women who embodied a 4-year-old girl avatar perceived their own self-concept to be younger than did those who embodied a 60-year-old woman avatar. This study adopted the altered self-concept as the potential mechanism. In the exercise context, older adults who embody a young avatar should have a younger self-concept and better exercise outcomes than those who embody an older avatar. When such individuals perceive themselves as young, they may be willing to devote more energy to exercise, resulting in more movement. In the context of aerobics, being in poor physical condition may result in making fewer physical movements and primarily smaller, shorter-range movements. In contrast, being in better physical condition allows participants to fully execute aerobic movements. Therefore, perceiving oneself as young equates to better physical fitness, which further leads to more physical activity. In addition, those with this perception should exhibit greater self-efficacy to engage such exercise in the future. We therefore define better exercise outcomes as higher levels of physical activity and higher degrees of self-efficacy to engage in future exercise.

H1: Elderly individuals embodying young avatars will demonstrate (a) greater self-efficacy for future exercise and (b) greater physical activity than elderly individuals embodying older avatars.

H2: Elderly individuals embodying young avatars will perceive themselves to be younger than those embodying older avatars.

Regarding perceived exertion, existing research on the Proteus effect (Kocur et al., 2020) has found that those who embodied a muscular avatar reported lower perceived exertion when lifting weights than those who embodied a normal body avatar. In addition, even when holding the same weight, those who embodied the normal body avatar perceived the task as more demanding than those who embodied the muscular avatar. For the elderly, embodying a younger body may alter their self-concept of being young, and they may perceive the exercise as effortless and report lower perceived exertion. However, it is also possible that elders embodying a young avatar are more motivated to distribute more efforts to the task. In the context of aerobics, better exercise outcomes should include devoting more energy to engaging in movement, and thus greater perceived exertion is an ideal outcome. Perceiving themselves as young leads participants to devote energy more to the assigned movements, leading to higher levels of perceived exertion. Perceived exertion is closely tied to age, as age represents one's physical condition. Older adults perceive the same task as more demanding and thus requiring greater exertion (Allman and Rice, 2003). In addition, VR technology may introduce novel effects in which exercise in a virtual environment results in greater exertion, energy, and enjoyment than in real-world exercise (Chuang et al., 2003; Plante et al., 2003; Fox and Bailenson, 2009). Therefore, regarding perceived exertion, we included age and emotion (i.e., affect and arousal) as control variables. Furthermore, self-concept is theorized as the underlying mechanism in this study by which avatar age leads to altered self-concept, resulting in greater exercise outcomes. Therefore, we propose the following research question and mediation hypothesis.

RQ1: How do elderly individuals embodying young avatars report their perceived exertion compared to those embodying older avatars after controlling for age and emotion?

H3: Self-concept will mediate the effects of avatar age on exercise outcomes: (a) greater self-efficacy for future exercise and (b) greater physical activity.

RQ2: How does self-concept mediate the effects of avatar age on perceived exertion, controlling for age and emotion?

Sex differences have rarely been explored in avatar manipulation and almost never in the context of exercise among elderly individuals. The existing literature on exercise has either focused on individuals of a single sex (Peña and Kim, 2014; Peña et al., 2016) or included individuals of both sexes but rarely explored sex differences. The literature on regular exercise interventions without technological components showed sex differences in aerobic exercise efficacy (Barha et al., 2017). Female participants who participated in the intervention showed improved aerobic exercise efficacy and cognition compared to that of participants who received usual care plus education, and this effect was retained at follow-up. However, such an effect was not observed among male participants. Since females are more likely to experience body-related schema activation from viewing thin-ideal images than male participants (Hargreaves and Tiggemann, 2003), it is likely that female participants would have better exercise outcomes when embodying younger avatars. However, the potential moderating effect of sex on the association of avatar manipulation with exercise outcomes in VR exercise has not been explored. We thus posed the following research question:

RQ3: Does sex moderate the association of avatar age with (a) perceived exertion, (b) self-efficacy for future exercise, (c) physical activity, and (d) age self-concept?

We examined the above hypotheses and research question during an exercise phase and a voluntary exercise phase when the participants embodied their assigned avatars. We also explored engagement in physical activity and self-efficacy the day after the experiment in the follow-up phase.

MATERIALS AND METHODS

Design and Participants

The experiment used a 2 (avatar age: young vs. older) × 2 (sex: male vs. female) between-subjects design. The participants embodied an older or a younger avatar of the same sex as themselves and exercised following along with a video in a virtual gym. In addition, since this study aims to motivate elderly individuals to engage in more exercise, we focused on recruiting those who aged 60 or older (United Nations, 2019) and recruiting those who did not engage in vigorous physical activity. According to the American Heart Association (2018), vigorous physical activity involves considerable exertion through activities such as running, aerobic dancing, lap swimming, tennis, jumping rope, and cycling 10 miles per hour or faster. Those reporting engaging in 0 min of vigorous exercise were chosen for this study.

The participants were recruited in three ways. First, recruitment invitations were sent via a campus announcement email to all staff at a national university in northern Taiwan. Second, recruitment was conducted in community centers near the university. Third, with the assistance of the District Health Center, recruitment information was handed out by community nurses during home visits to elderly individuals. Individuals who were aged 60 and over, were not cognitively impaired and did not require a walking stick or walking frame were invited to join this study. In total, 121 people were recruited for the study. After selecting those who did not engage in vigorous exercise, 104 elders participated in the experiment (age range: 60–88 years, M = 70.39, SD = 6.51; 26 female and 25 male participants embodying older avatars and 27 female and 26 male participants embodying young avatars). The participants were stratified by sex and randomly assigned to either the young avatar group or the older avatar group.

Stimulus

The participants viewed the virtual world using an hTC VIVE head-mounted display (HMD). A 3 × 2.5-m space was established for this experiment, and the participants could walk freely inside the preset space (**Figure 1**). The virtual scene began with the participant standing in a gym facing a mirror wall, and the body of the participant was replaced with a virtual body of the same sex as himself or herself. The virtual environment was built using Unity game engine.[1] The participants' actual body positions and movements were tracked using a Microsoft Xbox One Kinect Sensor and were mapped onto the virtual body so that the virtual body moved in accordance with the movements of the participant's actual body in real-time. The avatars were created using MakeHuman,[2] an open-source tool for 3D character creation. Four avatars were created: a young male, a young female, an older male, and an older female (**Figure 2**). The self-avatar of the same sex (either the young or the older avatar) was embodied, and the participants could see the virtual body of their self-avatars from a first-person perspective or in the mirror in front of them. A virtual television screen was hung on the upper left side of the mirror wall and played a workout video for seniors so that the participants could check their actions in the mirror while watching the video on TV (**Figure 3**).

Procedure

All participants completed a pre-intervention questionnaire that collected demographic information and asked questions about their exercise behaviors the week before they were invited to the laboratory. Upon arriving at the laboratory, the participants signed the consent form, which informed them that they would participate in a VR experience. The research team helped the participants place an ActiGraph wGT3X-BT accelerometer unit on their waist to record their continuous physical activity (**Figure 1B**). Then, they were assisted in putting on the VR goggles and were instructed to follow the prerecorded voice instructions in the virtual scene.

During experimental phase one (1 min), the participants entered a virtual gym and saw themselves facing a large mirror wall. The voice instructions guided the participants to become familiar with the surroundings and their virtual bodies by looking around, looking down and looking in the mirror. Then, they were instructed to perform a series of simple movements, such as knee lifts and arm raises, to help them associate their actual bodies' physical movements with their avatars' movements. During phase two, a workout video played on the virtual TV, and the participants were asked to exercise following the video. The video featured 7 simple exercises, such as marching in place, tap out, heel down in the front, and chest stretch (**Figure 4**). The length of the video was 4 min and 30 s. In phase three, the participants were told that there was still some extra time and that they could keep exercising, practice the movement in the video freely in front of the mirror or hang out in the virtual environment until the time was up. The voluntary phase lasted 3 min. After the voluntary exercise phase, the research team helped the participants take off the VR goggles and ActiGraph wGT3X-BT accelerometer and asked the participants to assess their perceived level of exertion. Then, the participants were asked to sit in front of a computer and complete an Implicit Association Test (IAT) and Affect Grid in order and then complete a questionnaire on their self-concept, self-efficacy regarding engaging in exercise and demographic information.

[1] https://unity.com/

[2] http://www.makehumancommunity.org/

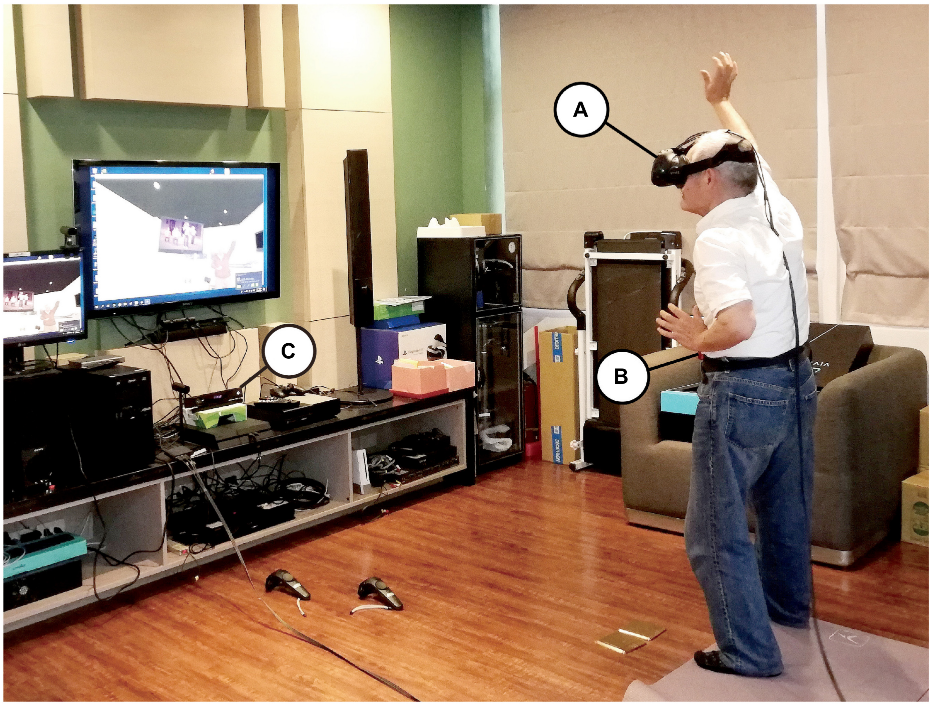

FIGURE 1 | Experimental setup. **(A)** hTC VIVE head-mounted display. **(B)** ActiGraph wGT3X-BT accelerometer. **(C)** Microsoft Xbox One Kinect Sensor.

The follow-up phase was conducted the next evening after the participant left the laboratory. The research team called the participants to ask about their engagement in physical activity that day and their self-efficacy for future exercise.

Measurements

Perceived exertion (M = 11.66, SD = 2.72) was assessed using the Borg Rating of Perceived Exertion Scale (Borg, 1998). This scale ranges from 6 (no exertion at all) to 20 (maximal exertion). The participants were asked to select a number from the scale that best represented their exertion during the physical activity based on their overall feelings of effort and fatigue.

Self-efficacy for exercise (α = 0.86, M = 6.04, SD = 0.85) was measured using a four-item scale modified from Lorig et al. (1996). The participants rated their degree of agreement (1 = strongly disagree and 7 = strongly agree) with statements such as "After the VR experience, I am confident that I can do some simple daily workout" and "In the next six months, I am confident that I can do aerobics regularly."

Physical activity was measured by the ActiGraph wGT3X-BT accelerometer, which collected vector magnitude of the body movements (experimental phase, M = 3948.84, SD = 1936.08; voluntary phase, M = 2747.52, SD = 2271.10) and step counts (experimental phase, M = 33.03, SD = 27.06; voluntary phase, M = 25.45, SD = 42.49). Please note that these are the sum of all vector movements and step counts during the phases. The device records the acceleration on the three axes, and the raw data is summed into chunks of data called "epochs" and the G-values are converted to activity counts (ActiGraph Corporation, 2018). The term "counts" does not mean that the vector magnitude data is also generated by counting (ActiGraph Corporation, 2008). Rather, "Activity that caused the acceleration signal to exceed the threshold was 'counted' as activity; anything below this threshold was ignored. At the end of the measurement period, the number of activity 'counts' would be recorded" (ActiGraph Corporation, 2008). The vector magnitude was the Euclidean vector of the three axes, that is, the square root of the sum of the squares of all three axes. Step counts represent one participant's steps made during the experimental period. We collected data at 100 Hz, which means there would be 100 samples per second. The data was exported to a CSV file using the official software, ActiLife.[3] The exporting epoch was set to 10 s, which means the software will sum the acceleration data and produce one data point every 10 s. All the epochs during the measurement time were added up to represent the total activity during the phase (e.g., 4.5 min for the experimental phase, and 3 min for the voluntary practice phase). Higher numbers of the sum of the vector magnitude counts indicates greater body movements. Taking all indicators together, we can determine whether the participants engage in more physical movements based on these data (Lin, 2015; Peng et al., 2015).

Self-concept was assessed using both explicit and implicit methods. The explicit self-concept (α = 0.94, M = 4.04, SD = 1.44) was measured using a four-item semantic differential scale developed by this study. The participants were asked to answer how they would describe themselves using a 7-point

[3] https://actigraphcorp.com/support/software/actilife/

FIGURE 2 | Avatars. **(A)** Young male. **(B)** Young female. **(C)** Older male. **(D)** Older female.

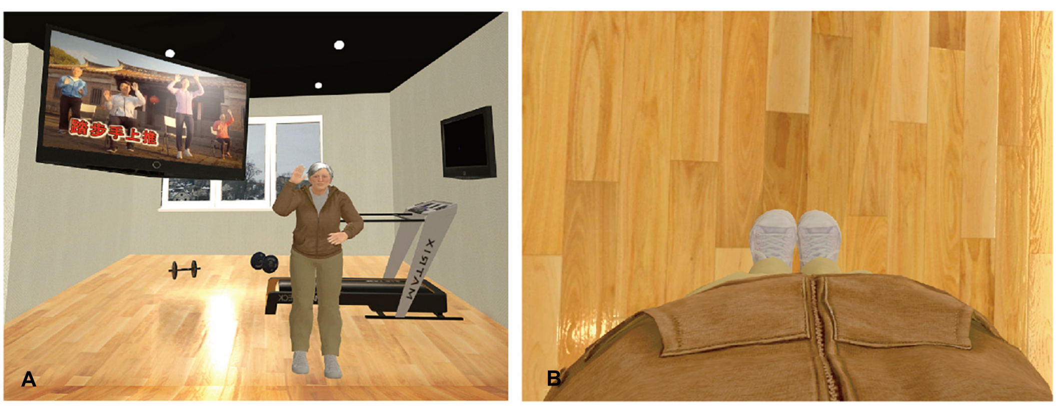

FIGURE 3 | The environment of the virtual gym. **(A)** Overview of the virtual environment for the elderly self-avatar in the exercise phase. **(B)** Participants could see their virtual body from a first-person perspective.

FIGURE 4 | The exercises featured in the video.

scale between two polar adjectives (young/old related adjectives written in Chinese). We also employed IAT to measure the implicit beliefs that the participants may be unable to report (Greenwald et al., 1998). This test has been widely used for the assessment of self-concept (Schnabel et al., 2008; Suslow et al., 2014). Participants are asked to quickly sort words into categories on the left and right sides of the computer screen using two response keys on the keyboard. The self-concept is assessed based on how long it takes a person to sort the words. Shorter response times indicate stronger associations between concepts assigned to the same key.

The IAT has been successfully used to measure the alternation of self-concept resulting from avatar embodying or game character identification experiences. For instance, Klimmt et al. (2010) used the IAT to demonstrate that after playing a military first-person shooter, players tend to associate themselves with military-related concepts. Banakou et al. (2013) employed the IAT to assess the self-concept changes of participants who embody a child or adult avatar. Banakou et al. (2013) demonstrated that participants in the child avatar group reacted significantly faster to classifications of the self with child-like rather than adult-like attributes. Starr et al. (2019) also employed the IAT to examine the effects of a first-person perspective virtual reality experience on participants' self-concept in relation to physical science, technology, engineering, and mathematics (pSTEM). Based on the literature mentioned above, the IAT was considered an ideal tool for assessing implicit changes in self-concept through the mediated experiences.

Followed the procedure in Greenwald et al. (1998), the IAT in this study consisted of five blocks. In the first and second blocks, the participants practiced a target concept discrimination task by categorizing words into "self" or "others" categories and an attribute discrimination task by categorizing words into "young" or "older" categories separately. In the third block, the participants sorted words into two combined categories, each including one target and one attribute concept that were assigned to the same key in the preceding two steps (e.g., "self" and "older" shared the left key, and "others" and "young" shared the right key). In the fourth block, the participants practiced another attribute discrimination task with reversed key assignments. The fifth block was similar to the third, but the concepts that shared the same keys were switched (e.g., "self" and "young" shared the left key, and "others" and "older" shared the right key). The orders of blocks 2–3 and blocks 4–5 were counterbalanced to prevent possible effects caused by order. The IAT score ($M = -390.36$, $SD = 409.73$) was computed by subtracting the mean response time for the block in which others and young shared the same key and self and older shared the same key (Step 3) from the block in which self and young shared one key and others and older shared another key (Step 5). Subjects whose error rate was higher than 20% were dropped in the IAT analysis, response times greater than 3,000 ms were recoded as 3,000 ms, and those less than 300 ms were recoded as 300 ms before computing. We considered participants to perceive themselves as younger rather than older if they more quickly categorized words when "self" and "youthful" shared a response key and when "others" and "aged" shared a response key than when the opposite was true.

Emotion was assessed using the Affect Grid (Russell et al., 1989), which is a means of measuring human emotions along the dimensions of valence (pleasant—unpleasant) and arousal (high arousal—sleepiness) using a 9 × 9 grid. Participants were asked to rate their current emotional state and place a checkmark

TABLE 1 | Descriptive statistics and correlations of study variables.

		1	2	3	4	5	6	7	8	9	10	11	12
1	RPE	1											
2	SE	−0.154	1										
3	IAT score	−0.006	0.179	1									
4	ESC	0.093	−0.228*	0.022	1								
5	Steps-E	−0.118	0.316**	−0.048	−0.198*	1							
6	VM-E	0.156	0.169	−0.008	−0.038	0.623**	1						
7	Steps-V	−0.108	0.210*	−0.022	−0.225*	0.377**	0.109	1					
8	VM-V	0.018	0.141	0.178	−0.142	0.379**	0.396**	0.703**	1				
9	PL	−0.041	0.332**	−0.131	−0.130	0.071	0.051	0.132	0.157	1			
10	AR	−0.152	0.453**	−0.157	−0.109	0.274**	0.207*	0.157	0.152	0.646**	1		
	Next-day variables												
11	SE-N	0.112	0.623**	−0.131	−0.117	0.171	0.111	−0.041	−0.057	0.294**	0.293**	1	
12	EX-N	0.075	0.186	−0.134	−0.082	0.209*	0.071	0.152	0.010	0.187	0.127	0.270**	1
	Mean	11.66	6.04	−342.00	4.14	33.03	3948.84	25.45	2747.52	6.22	6.03	5.84	37.72
	SD	2.72	0.85	447.06	1.51	27.06	1936.08	42.49	2271.10	1.06	1.15	1.05	52.73

*RPE, Perceived exertion; SE, Self-efficacy; IAT score, Implicit self-concept; ESC, Explicit self-concept; Steps-E, Step counts during the exercise phase; VM-E, Vector magnitude during the exercise phase; Steps-V, Step counts during the voluntary phase; VM-V, Vector magnitude during the voluntary phase; SE-N, Next-day self-efficacy; EX-N, Next-day exercise. *p < 0.05, **p < 0.01.*

somewhere in the grid to indicate this state [pleasant (M = 6.22, SD = 1.06) and arousal (M = 6.03, SD = 1.15)].

Age (Range: 60–88; M = 70.39, SD = 6.51) was assessed by inquiring the participants' birth years. In Taiwan, the elderly frequently lose track of their age, but most can remember their birth year correctly. Therefore, we asked participants about their birth year and calculated their current age. The participants vary enough in age for us to use age as a covariate.

Next-day exercise (M = 37.72, SD = 52.73) was assessed by asking the participants which physical activities they engaged in that day and the duration of the activities. The amount of time the participants spent on moderate and high-intensity exercise were added and calculated (in minutes). *Next-day self-efficacy for exercise* (α = 0.89, M = 5.84, SD = 1.05) was measured using the same scale as that used after the intervention.

RESULTS

The descriptive statistics and correlations of all of the study variables are listed in **Table 1**. This study employed a 2 (avatar age: young vs. older) × 2 (sex: male vs. female) factorial design. We first examined the perceived exertion outcome **(RQ1)** during the exercise phase. Levene's test was not significant (p = 0.49); thus, no adjustment was adopted for the following analysis. However, Bonferroni adjustment was employed because we included covariates in this analysis. The 2 × 2 ANCOVA controlling for age and emotion (i.e., pleasant and arousal) indicated a significant main effect of avatar age on perceived exertion (**Figure 5**), F = 4.14 (1, 97), p = 0.045, partial η^2 = 0.041. Regardless of sex, the participants who embodied young avatars reported higher perceived exertion (adjusted M = 12.19, SE = 0.37, N = 53) than those who embodied older avatars (adjusted M = 11.13, SE = 0.37, N = 51). We conducted a simple main effect analysis and found that among older male adults, the young avatar group (raw M = 12.77, SD = 2.86, N = 26; adjusted M = 12.76; SE = 0.52) reported higher levels of perceived exertion than the older avatar group (raw M = 11.2, SD = 2.55, N = 25; adjusted M = 11.297; SE = 0.539), F = 4.49 (1, 97), p = 0.036. Among the female participants, there was no significant difference in the perceived exertion of the female participants who embodied young (raw M = 11.48, SD = 2.83, N = 27; adjusted M = 11.63; SE = 0.516) vs. old (raw M = 11.19, SD = 2.25, N = 26; adjusted M = 10.956; SE = 0.549) avatars, F = 0.16 (1, 97), p = 0.69. Therefore, the main effect of avatar age on perceived exertion mainly came from male participants. The main effect of sex, F = 1.93 (1, 97), p = 0.17, partial η^2 = 0.02, and the interaction effect of avatar age with sex **(RQ3a)**, F = 0.51 (1, 97), p = 0.48, partial η^2 = 0.005, were not significant.

Regarding self-efficacy regarding engagement in future exercise on the day of the experiment **(H1a and RQ3b)**, for participants who did not engage in vigorous activity, an interaction effect of avatar age and sex **(RQ3b)** was found (**Figure 6**), F = 4.88 (1, 100), p = 0.03, partial η^2 = 0.05. The result of Levene's test was not significant, p = 0.34. The simple effect analysis indicated that in the young avatar group, the female participants (M = 6.41, SD = 0.60, N = 27) reported significantly greater self-efficacy for exercise than the male participants (M = 6.41, SD = 0.60, N = 27), p = 0.01. Among the female participants, the young avatar group (M = 6.41, SD = 0.60, N = 27) also reported greater self-efficacy for exercise than the older avatar group (M = 5.96, SD = 0.96, N = 26), p = 0.05. The main effects of avatar age, F = 0.293 (1, 104), p = 0.59, partial η^2 = 0.003, and sex, F = 3.19 (1, 109), p = 0.007, partial η^2 = 0.03, were not significant. H1a was not supported. However, regarding RQ3b, the interaction effect on exercise self-efficacy was significant.

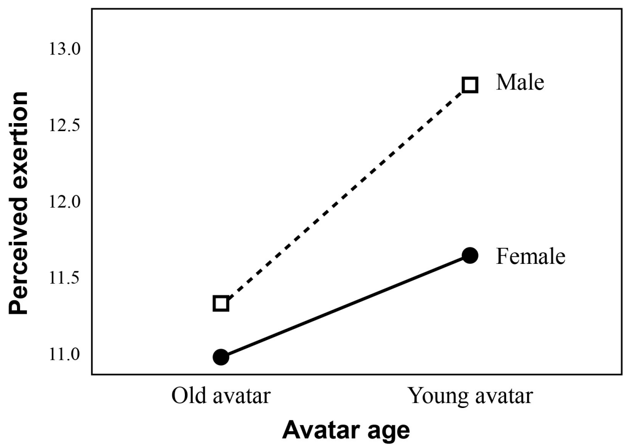

FIGURE 5 | The main effect of avatar age on perceived exertion during the exercise phase (controlling for age and emotion).

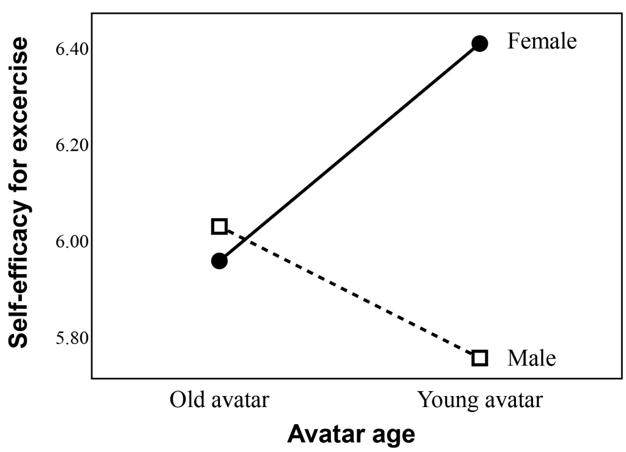

FIGURE 6 | Interaction between avatar age and sex of participants in predicting self-efficacy for exercise.

Regarding physical activity during the exercise phase (main effect, H1b and interaction effects, RQ3c), 2 × 2 ANOVAs were performed on the vector (overall magnitude regardless of direction) and on the step counts. When examining the distribution of the vector magnitude of physical activity, the outlier analysis through the boxplot identified three outliers in the data. Analyses including or excluding the outliers did not affect the results. However, for transparency, we report these separate analyses with and without outliers in **Table 2**. Here in the report we presented the analysis with the outliers. For the analysis with the outliers, regarding the vector magnitude of physical activity, no main effects were found: avatar age, $F = 0.60$ (1, 100), $p = 0.44$, partial $\eta^2 = 0.006$; participant sex, $F = 0.25$ (1, 100), $p = 0.62$, partial $\eta^2 = 0.003$. Regarding the main effect of avatar age on step counts, no significant main effects were found: avatar age, $F = 2.18$ (1, 100), $p = 0.143$, partial $\eta^2 = 0.021$; participant sex, $F = 3.66$ (1, 100), $p = 0.059$, partial $\eta^2 = 0.035$. Therefore, avatar age did not have the significant impact on physical activity; H1b was not supported.

For RQ3c, regarding the interaction effect on the vector magnitude of physical activity, the significant interaction effect of avatar age and sex was found for the vector of physical activity, $F = 6.57$ (1, 100), $p = 0.012$, partial $\eta^2 = 0.062$. The result of Levene's test was not significant, $p = 0.90$. To further explore the significant interaction effect (**Figure 7**, we presented the results with the outliers), we conducted a simple main effect analysis, which indicated that among the female participants, the young avatar group ($M = 4657.88$, $SD = 1965.94$, $N = 27$) demonstrated significantly greater vector physical activity than the older avatar group ($M = 3416.91$, $SD = 2266.55$, $N = 26$), $p = 0.01$. In addition, in the young avatar group, the female participants ($M = 4657.88$, $SD = 1965.94$, $N = 27$) had a significantly higher vector of physical activity than the male participants ($M = 3519.22$, $SD = 1566.74$, $N = 26$), $p = 0.01$. Regarding step counts, the interaction effects of avatar age and sex were not significant, $F = 1.43$ (1, 100), $p = 0.234$, partial $\eta^2 = 0.014$.

To conclude, regarding physical activity, the significant interaction effect was found for the vector of physical activity. Young vs. older avatar embodiment had effects on the female participants' physical activity. No main effects or interaction effect were found for step counts.

In addition to the exercise phase, we also explored the Proteus effect and sex differences in the above exercise outcomes during the voluntary phase and the next day. During the voluntary phase, no avatar effects were found on physical activities. Regarding next-day exercise self-efficacy and actual exercise, no significant effect was found for next-day exercise self-efficacy: avatar age, $F = 1.31$ (1, 100), $p = 0.256$, partial $\eta^2 = 0.013$; participant sex, $F = 0.202$ (1, 100), $p = 0.654$, partial $\eta^2 = 0.002$; interaction, $F = 0.064$ (1, 100), $p = 0.83$, partial $\eta^2 = 0.00$. Regarding next-day actual exercise, the female participants reported significantly higher overall exercise, including vigorous, moderate, and light exercise time, than the male participants, $F = 6.48$ (1, 104), $p = 0.012$, partial $\eta^2 = 0.022$.

No effects were found for self-concept (H2). For implicit self-concept, avatar age, $F = 0.18$ (1, 83), $p = 0.670$, partial $\eta^2 = 0.002$; participant sex, $F = 2.48$ (1, 83), $p = 0.119$, partial $\eta^2 = 0.029$; interaction, $F = 0.12$ (1, 83), $p = 0.733$, partial $\eta^2 = 0.001$. Regarding explicit self-concept, avatar age, $F = 1.16$ (1, 100), $p = 0.284$, partial $\eta^2 = 0.011$; participant sex, $F = 3.60$ (1, 100), $p = 0.061$, partial $\eta^2 = 0.035$; interaction, $F = 0.23$ (1, 100), $p = 0.630$, partial $\eta^2 = 0.002$. However, self-concept concerned whether the participants perceived themselves as young or old. In addition, the participants might have been affected by the arousing VR content, which may have affected their self-concept. Therefore, we controlled for age and perceived arousal as covariates of self-concept. After we controlled for age and perceived arousal, the main effect of sex on explicit self-concept was significant, $F = 4.84$ (1, 98), $p = 0.03$, partial $\eta^2 = 0.05$. The female participants generally perceived themselves to be significantly younger ($M = 3.87$, $SD = 1.39$, $N = 53$; adjusted $M = 3.854$; $SE = 0.19$) than the male participants ($M = 4.43$, $SD = 1.59$, $N = 51$; adjusted $M = 4.451$; $SE = 0.194$).

TABLE 2 | Statistics of the 2 × 2 ANOVAs for the vector magnitude of physical activity with and without outliers.

	With the outliers				Without the outliers			
	F(1, 100)	p	η^2	Simple main effect	F(1, 97)	p	η^2	Simple main effect
Avatar age	0.60	0.44	0.006		0.03	0.87	0.000	
Sex	0.25	0.62	0.003		0.75	0.39	0.008	
Avatar age × sex	6.57	0.01	0.062	Among Female: Young > Older * Young Avatar Group: Female > Male*	13.87	< 0.001	0.125	Among Female: Young > Older *** Young Avatar Group: Female > Male ** Older Avatar Group: Female < Male *

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

However, no such effects were found for implicit self-concept. H2 was not supported.

H3 and RQ2 explored whether self-concept mediated the relationship of avatar age with exercise outcomes. A series of bootstrapping analyses using the macro from Hayes (2017) shows that none of the mediating effects was significant (i.e., all confidence intervals include 0, indicating non-significance). H3 was not supported.

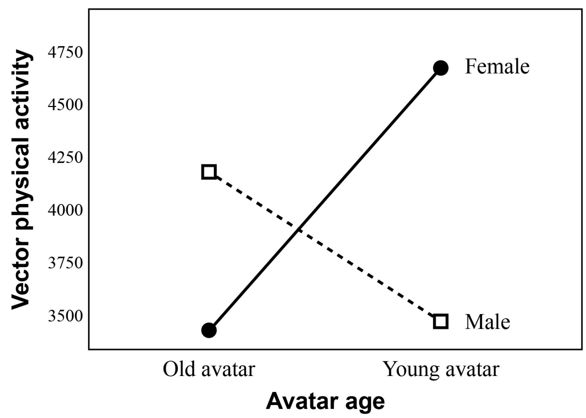

FIGURE 7 | Interaction between avatar age and sex of participants in predicting vector physical activity.

DISCUSSION

This study demonstrated that the Proteus effect through the manipulation of avatar age in VR is effective among elderly individuals in the context of exercise. The results showed that among elders who did not engage in vigorous exercise, the embodiment of younger avatars in VR leads to greater perceived exercise exertion, as male older adults with young avatars perceived themselves to contribute greater efforts to exercise. This finding shows that perceived exertion can have different interpretations; similarly, in Kocur et al. (2020), participants who embodied a muscular avatar perceived lower exertion than those embodying normal body avatars. In the present study, younger avatar age led to greater perceived exertion, which indicated that more efforts are devoted to aerobic exercise. Our conclusion of the Proteus effect is consistent with Kocur et al. (2020), in which different interpretations of perceived exertion as exercise outcome were observed. Future research and practitioners should predict different directions of perceived exertion based on various types of exercise.

This study found that sex moderated the effects of avatar age on self-efficacy for exercise and physical activity (i.e., vector magnitude). Greater Proteus effects on these parameters were observed for female than male elderly individuals. Female older adults who embodied young avatars reported greater self-efficacy regarding engagement in future exercise and greater physical activity (i.e., vector magnitude) during the exercise phase than those who embodied older avatars. This finding supports the assumption based on the previous literature that females more easily internalize thin or idealized bodies (Twamley and Davis, 1999; Murnen and College, 2019). This study suggests that females are more likely to be motivated to continue exercising through young avatar embodiment, indicating that young avatars are also a type of ideal body image. In addition, the female participants demonstrated that embodying young avatars motivated them to engage in more physical activity than the female participants who embodied older avatars. Among males, only a direct effect of young avatar embodiment on perceived exertion was observed, and no differences in other exercise outcomes were found. Our observations indicated that female participants were more willing to engage in various dimensions of the aerobic exercise moves, whereas male participants performed small-range moves. In the practice phase, the female participants were also more willing to try different exercise moves than male participants.

Moreover, older females who embodied old avatars reported significantly fewer vectors of physical activity than older males who embodied old avatars. This result indicated that females not only are prone to internalize the ideal body type into their physical activities but also are more easily affected by the Proteus effect of older avatars. The Proteus effect therefore was stronger and more significant among older females than among older males. Future studies should further examine the underlying mechanisms of such sex differences in VR embodiment.

This study also reported that perceived exertion is not significantly correlated with the vector magnitude of physical activity, implicitly suggesting that the psychological perception of efforts devoted to the exercise may not represent the counts of physical activities engaged in aerobic exercise. The evidence of the significant main effect of avatar age on the perceived exertion showed that the Proteus effect effectively led to psychological outcome mainly from subjective perception. The Proteus effect on physical activity is moderated by sex, which is significant only among female participants, suggesting the importance of sex regarding the physical outcomes. Indeed, one can engage in fewer physical activities but perceive that he/she had devoted great efforts to the exercise. Therefore, our study demonstrated that Proteus effect contributed to psychological outcomes (e.g., perceived exertion) regardless of sex and had conditional effect on physical outcomes moderated by sex. Our data showed that psychological and physical outcomes can be independent of the Proteus effect, which requires further investigation.

This study also found that female elderly individuals perceived themselves to be younger than male elderly individuals, and this trend persisted regardless of the type of avatar embodiment. Indeed, additional analysis showed that sex had an indirect effect on exercise self-efficacy through self-concept, with females having a younger self-concept, leading to their greater exercise self-efficacy. However, the moderated mediation model in which avatar embodiment was added as a moderator was not significant. Therefore, avatar age manipulation had a direct interaction effect with sex on exercise self-efficacy and physical activity but did not have an indirect interaction effect.

Although self-concept (Greenwald et al., 1998) was theorized to be the underlying mechanism of VR avatar embodiment on exercise outcomes, this study did not support this hypothesis. This might be due to the limitation of the timing of the measurement of self-concept. In this study, elderly individuals completed the IAT after they took off their VR goggles after the exercise and voluntary exercise phases. As character identification is a fleeting experience (Cohen, 2001), its measurement after the stimulus had ended may not have captured the participants' temporarily altered self-concept. The participants were once again reminded of their age and actual bodies when completing the IAT. In addition, the null effect of the underlying mechanism might also have been due to the test itself. The IAT is a reaction association test, which seemed to be another task requiring cognition and hand-eye coordination for these elderly individuals. We also conducted additional analysis to explore body ownership (Slater, 2009) as a potential mechanism, and the data did not support this hypothesis either. Explicit self-concept was not a mediator either, but we found that after controlling for age and perceived arousal, the females perceived themselves as younger than the males. Future research should consider the sex difference in terms of the explicit self-concept of age. To address these limitations, future research could adopt simple self-concept measurements that ask participants to rate their self-perceived age during their exercise phase when they are embodying avatars.

This study also showed that Proteus effects were very short—they occurred only during the exercise phase and not during the voluntary phase and did not affect next-day self-efficacy and actual exercise. This finding implies that short-term avatar embodiment has a limited influence on exercise outcomes when participants are provided with instructions. This result is also consistent with a previous study (Reinhard et al., 2020) that found a Proteus effect in the first half of the experiment but not the second half. Nevertheless, during the experiment setting, the participants may not have felt free to continue to engage in more exercise during the voluntary phase. Intervention-based programs will be an ideal approach to further understand the Proteus effect among elderly individuals in future research.

This study is limited in some aspects. First, the short stimulus may not have allowed us to explore potential lasting effects on the next day. Merely reporting next-day exercise and next-day self-efficacy might not enable us to understand the potential effects of VR-based exercise. Nevertheless, the short exposure showed significant exercise outcomes through the manipulation of the age of the VR avatar. Future work can design a study covering a longer period to explore the duration, changes, and direction of effects to eliminate possible novelty effects of avatars on elders in exercise contexts. Second, the measurement approach for self-concept may not have fully represented the participants' self-concept during VR embodiment. Furthermore, for elderly individuals' safety, only simple exercise movements were designed in this study. Some participants noted that these movements were too easy for them to perform and that they would prefer more intense stimuli in the future. Future research could also compare the effects of young and old avatars on younger and older participants engaged in the same movements to explore the potential effects of avatar age on exercise. In addition, using several versions of young and old avatars could allow researchers to explore effects of visual differences and age on participants' exercise. Despite some limitations, this study contributes to the literature as the first to provide empirical evidence for the Proteus effect among elderly individuals in the context of exercise. It also indicated that avatar age manipulation is an effective means to promote exercise among elderly individuals who do not engage in vigorous exercise and help them achieve exercise outcomes. The effect size obtained from this study is relatively moderate and higher than the average weighted r identified in Ratan's meta-analysis regarding Proteus effects. Thus, manipulating elderly individuals' age through avatars can have moderate effects on psychological and physical exercise outcomes. This study further demonstrated that female elderly individuals responded to young avatars differently than male elderly individuals, with female elderly individuals showing more positive effects of young avatar embodiment than males. These findings also have practical implications. Designers can focus on avatars' age appearance and allow the manipulation of avatar age in exercise programs. Regarding sex differences, designers can allow male participants to customize their own avatars to best motivate them to exercise and increase their enjoyment. More research is needed to further examine the underlying mechanism and effective VR design for elderly individuals.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: https://osf.io/63uw4/.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the National ChengChi University IRB. The patients/participants provided their written informed consent to participate in this study. Permission was obtained from the individual(s) for the use of any identifiable data or images included in this publication.

AUTHOR CONTRIBUTIONS

J-HT designed the study, wrote the entire manuscript, and worked on the revisions and proof. D-YW executed the entire experiment, including recruiting, executing, and follow-up, cleaned the data, prepared the data, and assisted in the method part during revisions. Both authors contributed to the article and approved the submitted version.

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REFERENCES

ActiGraph Corporation (2018). *Raw and Summary (Epoch) Data Explained*. Available online at: https://actigraphcorp.force.com/support/s/article/Raw-and-Summary-Epoch-Data-Explained (accessed July 30, 2021).

ActiGraph Corporation (2008). *ActiGraph White Paper: What is a Count?* Available online at: https://actigraphcorp.com/white-papers/ (accessed July 30, 2021).

Allman, B. L., and Rice, C. L. (2003). Perceived exertion is elevated in old age during an isometric fatigue task. *Eur. J. Appl. Physiol.* 89, 191–197. doi: 10.1007/s00421-002-0780-4

American Heart Association (2018). *American Heart Association Recommendations for Physical Activity in Adults and Kids*. Available online at: https://www.heart.org/en/healthy-living/fitness/fitness-basics/aha-recs-for-physical-activity-in-adults (accessed May 20, 2021).

Anderson, E. S., Wojcik, J. R., Winett, R. A., and Williams, D. M. (2006). Social-cognitive determinants of physical activity: the influence of social support, self-efficacy, outcome expectations, and self-regulation among participants in a church-based health promotion study. *Health Psychol.* 25:510. doi: 10.1037/0278-6133.25.4.510

Banakou, D., Groten, R., and Slater, M. (2013). Illusory ownership of a virtual child body causes overestimation of object sizes and implicit attitude changes. *Proc. Natl. Acad. Sci. U.S.A.* 110, 12846–12851. doi: 10.1073/pnas.1306779110

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychol. Rev.* 84:191. doi: 10.1037/0033-295X.84.2.191

Barha, C. K., Hsiung, G. Y. R., Best, J. R., Davis, J. C., Eng, J. J., Jacova, C., et al. (2017). Sex difference in aerobic exercise efficacy to improve cognition in older adults with vascular cognitive impairment: secondary analysis of a randomized controlled trial. *J. Alzheimer's Dis.* 60, 1397–1410. doi: 10.3233/JAD-170221

Borg, G. (1998). *Borg's Perceived Exertion and Pain Scales*. Champaign, IL: Human kinetics.

Brassington, G. S., Atienza, A. A., Perczek, R. E., DiLorenzo, T. M., and King, A. C. (2002). Intervention-related cognitive versus social mediators of exercise adherence in the elderly. *Am. J. Prevent. Med.* 23, 80–86. doi: 10.1016/S0749-3797(02)00477-4

Chuang, T.-Y., Chen, C.-H., Chang, H.-A., Lee, H.-C., Chou, C.-L., and Doong, J.-L. (2003). Virtual reality serves as a support technology in cardiopulmonary exer-cise testing. *Presence: Teleoperators Virtual Environ.* 12, 326–331. doi: 10.1162/105474603765879567

Cohen, J. (2001). Defining identification: a theoretical look at the identification of audiences with media characters. *Mass Commun. Soc.* 4, 245–264. doi: 10.1207/S15327825MCS0403_01

Cyarto, E. V., Batchelor, F., Baker, S., and Dow, B. (2016). "Active ageing with avatars: a virtual exercise class for older adults," in *Proceedings of the 28th Australian Conference on Computer-Human Interaction* (New York, NY: Association for Computing Machinery) 302–309. doi: 10.1145/3010915.3010944

Fox, J., and Bailenson, J. N. (2009). Virtual self-modeling: the effects of vicarious reinforcement and identification on exercise behaviors. *Media Psychol.* 12, 1–25. doi: 10.1080/15213260802669474

Greenwald, A. G., McGhee, D. E., and Schwartz, J. L. (1998). Measuring individual differences in implicit cognition: the implicit association test. *J. Person. Soc. Psychol.* 74:1464. doi: 10.1037/0022-3514.74.6.1464

Hargreaves, D., and Tiggemann, M. (2003). The effect of "thin ideal" television commercials on body dissatisfaction and schema activation during early adolescence. *J. Youth Adolescence* 32, 367–373. doi: 10.1023/A:1024974015581

Hayes, A. F. (2017). *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach*. New York, NY: Guilford publications.

Hwang, E. H., and Chung, Y. S. (2008). Effects of the exercise self-efficacy and exercise benefits/barriers on doing regular exercise of the elderly. *J. Korean Acad. Nurs.* 38, 428–436. doi: 10.4040/jkan.2008.38.3.428

Joo, Y. K., and Kim, K. (2017). When you exercise your avatar in a virtual game: the role of avatars' body shape and behavior in users' health behavior. *Interact. Comput.* 29, 455–466. doi: 10.1093/iwc/iwx003

Kim, J., Son, J., Ko, N., and Yoon, B. (2013). Unsupervised virtual reality-based exercise program improves hip muscle strength and balance control in older adults: a pilot study. *Archives Phys. Med. Rehabil.* 94, 937–943. doi: 10.1016/j.apmr.2012.12.010

Klimmt, C., Hefner, D., and Vorderer, P. (2009). The video game experience as "true" identification: a theory of enjoyable alterations of players' self-perception. *Commun. Theory* 19, 351–373. doi: 10.1111/j.1468-2885.2009.01347.x

Klimmt, C., Hefner, D., Vorderer, P., Roth, C., and Blake, C. (2010). Identification with video game characters as automatic shift of self-perceptions. *Media Psychol.* 13, 323–338. doi: 10.1080/15213269.2010.524911

Kocur, M., Kloss, M., Schwind, V., Wolff, C., and Henze, N. (2020). "Flexing muscles in virtual reality: effects of Avatars' muscular appearance on physical performance," in *Proceedings of the Annual Symposium on Computer-Human*

Interaction in Play (New York, NY: Association for Computing Machinery) 193–205. doi: 10.1145/3410404.3414261

Lee, Y., Choi, W., Lee, K., Song, C., and Lee, S. (2017). Virtual reality training with three-dimensional video games improves postural balance and lower extremity strength in community-dwelling older adults. *J. Aging Phys. Activity* 25, 621–627. doi: 10.1123/japa.2015-0271

Levine, M. P., and Murnen, S. K. (2009). "Everybody knows that mass media are/are not [pick one] a cause of eating disorders": a critical review of evidence for a causal link between media, negative body image, and disordered eating in females. *J. Soc. Clin. Psychol.* 28, 9–42. doi: 10.1521/jscp.2009.28.1.9

Li, B. J., Lwin, M. O., and Jung, Y. (2014). Wii, myself, and size: the influence of Proteus effect and stereotype threat on overweight children's exercise motivation and behavior in exergames. *Games Health: Res. Dev. Clin. Appl.* 3, 40–48. doi: 10.1089/g4h.2013.0081

Lin, J. H. (2015). "Just Dance": the effects of exergame feedback and controller use on physical activity and psychological outcomes. *Games Health J.* 4, 183–189. doi: 10.1089/g4h.2014.0092

Lorig, K., Stewart, A., Ritter, P., González, V., Laurent, D., and Lynch, J. (1996). *Outcome Measures for Health Education and Other Health Care Interventions*. Thousand Oaks, CA: Sage.

Monteiro-Junior, R. S., Figueiredo, L. F. D. S., Maciel-Pinheiro, P. D. T., Abud, E. L. R., Engedal, K., Barca, M. L., et al. (2017). Virtual reality-based physical exercise with exergames (PhysEx) improves mental and physical health of institutionalized older adults. *J. Am. Med. Direct. Assoc.* 18, 454.e1-454.e9. doi: 10.1016/j.jamda.2017.01.001

Murnen, S. K., and College, K. (2019). Gender differences in responses to thin, athletic, and hyper-muscular idealized bodies. *Body Image* 30, 1–9. doi: 10.1016/j.bodyim.2019.03.010

Peña, J., Hancock, J. T., and Merola, N. A. (2009). The priming effects of avatars in virtual settings. *Commun. Res.* 36, 838–856. doi: 10.1177/0093650209346802

Peña, J., Khan, S., and Alexopoulos, C. (2016). I am what I see: how avatar and opponent agent body size affects physical activity among men playing exergames. *J. Comput.-Mediat. Commun.* 21, 195–209. doi: 10.1111/jcc4.12151

Peña, J., and Kim, E. (2014). Increasing exergame physical activity through self and opponent avatar appearance. *Comput. Hum. Behav.* 41, 262–267. doi: 10.1016/j.chb.2014.09.038

Peng, W., Lin, J. H., and Crouse, J. (2011). Is playing exergames really exercising? A meta-analysis of energy expenditure in active video games. *Cyberpsychol. Behav. Soc. Network.* 14, 681–688. doi: 10.1089/cyber.2010.0578

Peng, W., Pfeiffer, K. A., Winn, B., Lin, J. H., and Suton, D. (2015). A pilot randomized, controlled trial of an active video game physical activity intervention. *Health Psychol.* 34:1229. doi: 10.1037/hea0000302

Plante, T. G., Aldridge, A., Bogden, R., and Hanelin, C. (2003). Might virtual reality promote the mood benefits of exercise? *Comput. Hum. Behav.* 19, 495–509. doi: 10.1016/S0747-5632(02)00074-2

Ratan, R. A., Beyea, D., Li, B. J., and Graciano, L. (2019). Avatar characteristics induce users' behavioral conformity with small-to-medium effect sizes: a meta-analysis of the Proteus effect. *Media Psychol.* 23, 651–675. doi: 10.1080/15213269.2019.1623698

Ratan, R. A., and Dawson, M. (2016). When Mii is me: a psychophysiological examination of avatar self-relevance. *Commun. Res.* 43, 1065–1093. doi: 10.1177/0093650215570652

Reinhard, R., Shah, K. G., Faust-Christmann, C. A., and Lachmann, T. (2020). Acting your avatar's age: affects of virtual reality avatar embodiment on real life walking speed. *Media Psychol.* 23, 293–315. doi: 10.1080/15213269.2019.1598435

Russell, J. A., Weiss, A., and Mendelsohn, G. A. (1989). Affect grid: a single-item scale of pleasure and arousal. *J. Pers. Soc. Psychol* 57, 493–502. doi: 10.1037/0022-3514.57.3.493

Schnabel, K., Asendorpf, J. B., and Greenwald, A. G. (2008). "Using Implicit Association Tests for the assessment of implicit personality self-concept," in *Handbook of Personality Theory and Testing. Personality Measurement and Testing*, Vol. 2, eds G. J. Boyle, G. Matthews, and H. Saklofske (London, UK: Sage), 508–528. doi: 10.4135/9781849200479.n24

Slater, M. (2009). Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. *Philosoph. Trans. R. Soc. B: Biol. Sci.* 364, 3549–3557. doi: 10.1098/rstb.2009.0138

Song, H., Kim, J., and Lee, K. M. (2014). Virtual vs. real body in exergames: reducing social physique anxiety in exercise experiences. *Comput. Hum. Behav.* 36, 282–285. doi: 10.1016/j.chb.2014.03.059

Starr, C. R., Anderson, B. R., and Green, K. A. (2019). "I'm a computer scientist!": virtual reality experience influences stereotype threat and STEM motivation among undergraduate women. *J. Sci. Educ. Technol.* 28, 493–507. doi: 10.1007/s10956-019-09781-z

Suslow, T., Lindner, C., Kugel, H., Egloff, B., and Schmukle, S. C. (2014). Using implicit association tests for the assessment of implicit personality self-concepts of extraversion and neuroticism in schizophrenia. *Psychiatry Res.* 218, 272–276. doi: 10.1016/j.psychres.2014.04.023

Tacikowski, P., Weijs, M. L., and Ehrsson, H. H. (2020). Perception of our own body influences self-concept and self-incoherence impairs episodic memory. *iScience [Online ahead of print]* 101429. doi: 10.1016/j.isci.2020.101429

Tajadura-Jiménez, A., Banakou, D., Bianchi-Berthouze, N., and Slater, M. (2017). Embodiment in a child-like talking virtual body influences object size perception, self-identification, and subsequent real speaking. *Sci. Rep.* 7:9637. doi: 10.1038/s41598-017-09497-3

Twamley, E. W., and Davis, M. C. (1999). The sociocultural model of eating disturbance in young women: the effects of personal attributes and family environment. *J. Soc. Clin. Psychol.* 18, 467–489. doi: 10.1521/jscp.1999.18.4.467

United Nations (2019). *World Population Ageing 2019 Highlights*. Available at: https://www.un.org/en/development/desa/population/publications/pdf/ageing/WorldPopulationAgeing2019-Highlights.pdf

van Schooten, K. S., Rispens, S. M., Elders, P. J., Lips, P., van Dieën, J. H., and Pijnappels, M. (2015). Assessing physical activity in older adults: required days of trunk accelerometer measurements for reliable estimation. *J. Aging Phys. Activity* 23, 9–17. doi: 10.1123/JAPA.2013-0103

Waddell, T. F., Sundar, S. S., and Auriemma, J. (2015). Can customizing an avatar motivate exercise intentions and health behaviors among those with low health ideals? *Cyberpsychol. Behav. Soc. Network.* 18, 687–690. doi: 10.1089/cyber.2014.0356

World Health Organization [WHO] (2020). *Physical Activity*. Available online at: https://www.who.int/news-room/fact-sheets/detail/physical-activity (accessed May 20, 2021).

Yee, N., and Bailenson, J. (2007). The Proteus effect: the effect of transformed self-representation on behavior. *Hum. Commun. Res.* 33, 271–290. doi: 10.1111/j.1468-2958.2007.00299.x

Yee, N., and Bailenson, J. N. (2006). "Walk a mile in digital shoes: the impact of embodied perspective-taking on the reduction of negative stereotyping in immersive virtual environments," in *Proceedings of PRESENCE 2006: The 9th Annual International Workshop on Presence* (Cleveland, OH: Cleveland State University) 1–9.

Yee, N., and Bailenson, J. N. (2009). The difference between being and seeing: the relative contribution of self-perception and priming to behavioral changes via digital self-representation. *Media Psychol.* 12, 195–209. doi: 10.1080/15213260902849943

Yee, N., Bailenson, J. N., and Ducheneaut, N. (2009). The Proteus effect: implications of transformed digital self-representation on online and offline behavior. *Commun. Res.* 36, 285–312. doi: 10.1177/0093650208330254

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BRIEF RESEARCH REPORT
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One Ring Fit to Rule Them All? An Analysis of Avatar Bodies and Customization in Exergames

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With the growing popularity of exergames, researchers have noted the importance of presenting players with customizable avatars to encourage the long-term adoption of healthy behaviors offline. However, the "idealized" avatar bodies presented in avatar customization interfaces can represent limited body types and often problematically represent gender as binary. In this paper, we present a systematic analysis of the avatar customization interfaces of six console-based exergames. Results of our analysis indicate that customization options tend to be limited in exergames, especially with regard to body type and gender. Implications for avatar self-priming, self-identification, and healthy behavior adoption are discussed.

Keywords: avatars, avatar customization, exergame, inclusive design, ring fit adventure

INTRODUCTION

The growing popularity of exergames in both the public and research spheres has mobilized several game-based exercise interventions on an international scale (e.g., see Ho et al., 2017; Matallaoui et al., 2017). One of the most recent commercial off the shelf exergames, *Ring Fit Adventure* (2019), is an exercise action-role-playing game (RPG) game. Before starting the game, the user creates an avatar that will not only serve as a virtual stand-in for the user, but also a visual feedback mechanism for the exercises performed in-game (see **Figure 1**). For example, when performing squats, the glutes and legs of the avatar light up. However, if the squats are performed perfectly, these sections of the body light up brightly and appear to be on fire, which indicates that the exercise is being performed most effectively.

Avatar customization options in exergames are typically limited in both quality and quantity, focusing on the customization of athletic gear rather than the avatar's body. In this paper, we present an analysis of avatar body customizations available in console-based exergames that offer avatar customization, focusing on the choices pertaining to body type and gender. We propose that more options for avatar bodies – choices that not only move beyond the gender-binary but also take different body types into account – would ensure a more socially inclusive design in future exergames involving customizable avatars.

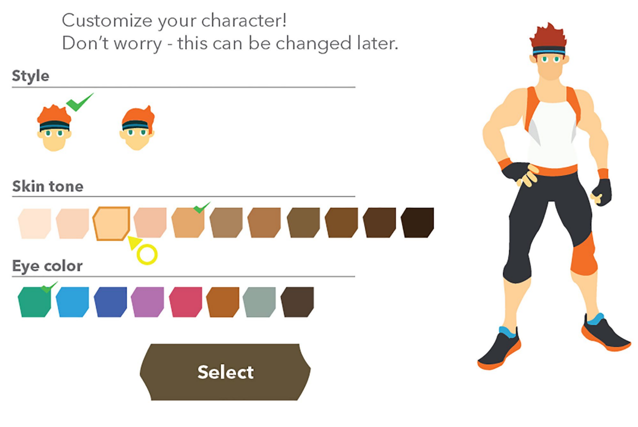

FIGURE 1 | Depiction of the Avatar Customization in *Ring Fit Adventure* (Nintendo Switch).

RELATED WORK

Avatars

Avatar customization options in games are typically presented to users *via* graphical user interfaces. The quantity and quality of customization options varies greatly from game to game, as does the presentation of these options. Although avatar customization is commonly considered a form of identity expression, researchers have also studied the psychological effects of avatar appearance on user behavior in games and virtual worlds. For example, Yee and Bailenson (2007) proposed the theory of the "Proteus Effect" to characterize the ways in which avatar modification affects how the avatar interacts with others in virtual environments (e.g., users with taller avatars behave more assertively in virtual environments). Interestingly, the authors found that these behaviors can also persist outside of the virtual environment, showing that the transformation is not limited to how users behave in the virtual environment. Their findings are important as they illustrate not only how much effect we have on our avatars, but also how much effect our avatars have on us.

Researchers have also studied the effects of self-priming on avatar self-connection (Jin, 2009, 2010). For example, Jin presents a between-subjects study in which participants created either a realistic Mii or an idealized Mii, studying the effects of self-priming on avatar self-connection (Jin, 2009). Jin noted that participants who created an ideal-self avatar felt a stronger connection to their Mii and their Mii's in-game achievements. In a subsequent study, Jin studied the effects of realistic and idealized self on users' perceived interactivity and immersion in *Wii Fit*, an exergame game that uses Miis as player avatars (Jin, 2010). Jin conducted a 2×2 factorial design experiment and noted a greater perceived interactivity among participants who were able to play with an idealized self-avatar (Jin, 2010).

A recent review by Sibilla and Mancini (2018) of 43 studies on user-avatar relationships found that the most frequent types of relationships were *actualization* and *idealization*. They concluded that having an avatar that was closer in appearance to the player correlated with high self-esteem and higher presence and flow and that excessive idealization resulted in negative effects.

In the last decade of user-avatar research, we have noted a departure from the more traditional parasocial perspective in player-avatar relationships in favor of a more social perspective that goes beyond a user-tool connection and recognizes avatar customization as a broader actor-network (e.g., see Banks, 2015; McArthur et al., 2015; Banks and Bowman, 2016; McArthur, 2018; Bowman and Banks, 2020). In each of these works, researchers challenge the user-avatar dichotomy in avatar research and recognize that avatars cannot be studied as a heterogeneous "object," nor can customized user avatars be studied without understanding the ways in which user interfaces "act" upon their creation as well as the effects of socio-cultural and socio-technical affordances in which they are entangled.

Exergames

The growing popularity of exergames in both the public and research spheres has mobilized a number of game-based exercise interventions on an international scale (Rosenberg et al., 2010; Song et al., 2011; Staiano and Calvert, 2011; Uzor and Baillie, 2014). Early technologies facilitating console-based exergaming include the EyeToy: Kinetic (Playstation 2, released in 2005) and the Nintendo Wii Remote (2006) and Balance Board (2007). Since then, a number of input devices and peripherals have been developed to support user input in exergames, including the leg strap and Pilates wheel which support gameplay in *RingFit Adventure*.

As with other gaming genres, many console-based exergames offer avatar customization as a feature. In some cases, the avatar being customized serves as a stand-in for the user, and in other cases, the player is customizing their in-game personal trainer. Nintendo's *Wii Fit* used the user's own Mii (an avatar tied to their account that could also be used in other games) as their in-game avatar. Although the Mii's body type can be customized outside of *Wii Fit*, the Mii's in-game weight was modified when the user stepped onto the Wii Balance Board, a game controller that the users stood on to calculate their weight and track their balance during gameplay. Wii Fit used body mass index (BMI) to determine what the body shape or weight of a player's Mii should be within the game. Research has shown that BMI is not a very accurate way to track health, as it does not take into account the variability in distribution of lean mass and adipose tissue of individuals (Romero-Corral et al., 2008), meaning that many users who are indeed fit, may be forced to play Wii Fit with an obese-looking avatar due to the fact that lean muscle mass weighs more than fat (Öhman et al., 2014).

A 2018 systematic review in the Journal of Medical Internet Research of 10 randomized trials studying the social effects of exergames on older adults found that "the majority of exergame studies demonstrated promising results for enhanced social well-being, such as reduction of loneliness, increased social connection, and positive attitudes toward others" (Li et al., 2018). Researchers have studied the long-term impacts of exergames on intrinsic motivation and changes in health awareness among participants in longitudinal studies (e.g., see:

Brauner et al., 2013; Macvean and Robertson, 2013). According to Bandura (1993), "Self-Efficacy beliefs contribute to motivation in several ways; they determine the goals people set for themselves, how much effort they expend, how long they persevere in the face of difficulties, and their resilience to failures." Strecher et al. (1986) note that self-efficacy seems to be a predictor of both short- and long-term success in achieving health behavior change.

In addition to self-efficacy beliefs, researchers have also noted the importance of presenting users with fit avatars and avoiding problematic stereotypes relating to body size in encouraging long-term behavioral changes among users (Li et al., 2014; Peña and Kim, 2014). Peña and Kim (2014) report on a study investigating how virtual social cues can be leveraged to influence health behaviors *via* avatar appearance in exergames. The authors explored a combination of player and opponent avatar body types (normal weight vs. obese) and the relationship between these pairings and player exertion in real life. Results of the study indicated that physical activity was boosted when self and opponent avatars had a normal weight, and that it decreased when self or opponent avatars were obese. We take these results to indicate that, as with the Proteus effect described by Yee and Bailenson (2007), which states that the characteristics of an avatar impacts the player's behavior, the ability to use an idealized avatar in exergames can impact physical exertion and health behaviors in real life.

However, we argue that the notion of an idealized body is personal and will differ from user to user. For example, there are many different types of "fit" bodies (e.g., lean muscle vs. bodybuilders). Furthermore, many avatar customization interfaces notoriously and problematically represent gender as a binary when presenting users with body types in-game (Sundén, 2009). To productively explore the relationship between avatar appearance and offline health behaviors, we propose that first a comparative analysis of avatar customization options in exergames must be conducted.

METHOD

We are motivated to study avatar customization in exergames as related work suggests that there is a strong relationship between avatar appearance and the potential long-term changes in health behaviors among players. Considering both Yee's work on the proteus effect (Yee and Bailenson, 2007), and work of Li et al. (2014) investigating the relationship between fit avatars and long-term healthy behavior adoption, we are interested in a comparative analysis of avatar customization interfaces presented in exergames focusing on customization options relating to the gender and body shape of the avatar. The impetus of this research is to mobilize this analysis in the study of social inclusion in exergame avatar customization interfaces and the effect of social inclusion on player motivation to adopt long-term healthy behavior adoption. This paper presents the first phase of this research: interface analysis. Directions for future work involving longitudinal participant observation are discussed in the final sections of this paper.

Sample

In this paper, we have opted to focus on console-based games exergames that include avatar customization as a feature. Initially, we had intended to focus on exergames where the player is customizing their own avatar (stand-in) but opted to include any game where players customize an on-screen avatar's appearance (e.g., games where the on-screen avatar is a personal trainer and not the player's stand-in) to ensure a larger sample size for analysis. We have excluded games that use a camera capture of the player's own body (e.g., Shape Up for Kinect) as well as games that fall in the exergame genre but do not include avatar customization features that impact the players' in-game bodily presence (e.g., Just Dance).

This paper was inspired by the recent release of *Ring Fit Adventure*. In this game, players connect a Joy-Con, one of two one-handed controllers accompanying the Nintendo Switch system, to a Pilates wheel and place the other in a leg strap. The game is a turn-based RPG style in which the player performs movements and battle actions by completing various real-world exercises, such as jogging on the spot, squats, and yoga poses. At the start of the game, the player creates an avatar (see **Figure 1**) that will serve as their virtual stand-in for gameplay. The player then meets a sentient ring-shaped character (similar in size to the Pilates ring peripheral used to play the game) and they team up to defeat the game's main antagonist, a bodybuilding dragon named Drageaux.

Wii Fit, released in 2007 in Japan and 2008 in North America was an exergame that used a unique platform peripheral called the Wii Balance Board – a device which tracked the user's center of balance. The game featured yoga, strength training, aerobics, and balance games. The game was considered a breakthrough title in exergaming and spawned more than a decade of exergaming research, including applications in rehabilitation and improving balance in older adults (Nitz et al., 2010).

Yoga Master (2019) is an exergame focused entirely on yoga. The game features more than 150 poses that the player can use to build custom 30-min exercise sessions. Player movements can be tracked by the PlayStation Camera or by holding the PS Move controllers, which track real-world movements. The game does not offer player-avatar customization, but rather allows the user to select one of three pre-made avatar trainers named Monica, Sharon, or Asha. Only minor customization options are available for these avatars.

Kinect Sports Rivals (2014) was a sports video game developed by Rare and Microsoft Studios for the Xbox One. The game utilizes the Kinect motion-sensing camera to track player movement in several sports activities, including bowling, jet ski racing, target shooting, and tennis. The game uses a combination of traditional avatar customization widgets and facial recognition to support player-avatar creation.

Fitness Boxing is an exergame developed by Rocket Company and published by Nintendo for the Nintendo Switch console. Released in 2018 in Japan and 2019 in North America, the game serves as the successor to Gold's Gym: Cardio Workout for the Nintendo Wii. Players use the Joy-Con controllers to perform boxing moves. Fitness Boxing is another example of an exergame that does not provide a customizable player-avatar but does allow players to customize the in-game trainer's avatar. The default coach is Lin, but there are five other coaches (three female and two male), and players can customize their skin tone and hair color *via* the avatar customization interface. Players can also unlock further customization options in the form of athletic clothing and accessories *via* gameplay.

EA Sports Active: Personal Trainer was a video game developed by EA Canada for the Nintendo Wii Console. The game was released in 2009 in North America and its sequel was released in 2010. Player movement was tracked by holding the Wii Remote in the right hand while using the leg strap to place the Nunchuck controller, a wired one-handed controller that connects to the Wii Remote, on the player's thigh to track lower body movements. The game featured a series of 20-min workout regimens and a 30-day challenge mode. Players can customize their avatar using the avatar customization interface.

Method and Methodology

Critical analysis of avatar customization interfaces is largely discursive, providing narrative accounts of limitations on self-representation that are strongly grounded in relevant theories, but fall short at producing productive discourses that contextualize these results in a meaningful way. Recent work by McArthur et al. (2015) presents an analytical framework capable of producing meaningful analyses of the affordances of character creation interface widgets (individual user-interface components), referred to as the Avatar Affordances Framework. The framework is a design ontology that provides a foundation for analyzing the design process as well as designed objects, based on the Function-Behavior-Structure framework proposed by Gero and Kannengiesser (2004):

Function describes the purpose(s) for the interface widget (e.g., select hairstyle, etc.).

Behavior attributes derivable from the widget (e.g., choose 1 of *n* options, etc.).

Structure a technical description of the interface widget (e.g., slider, button, etc.). Additional specifications pertaining to the widget are appended with a colon (e.g., slider: discrete). Where the quantity of choices is derivable from the widget, this number is indicated in round brackets immediately following the structure's name.

This breakdown allows us to code avatar customization interfaces in a meaningful way and enables direct comparison between games. The Avatar Affordances Framework (McArthur et al., 2015) adds three components to Gero's framework: Identifier, Hierarchy, and Default.

Identifier – what text and/or icons are used to convey the widget's purpose? (e.g., text: select a gender).

Hierarchy – a numerical value indicating a widget's position in relation to the customization section of a hierarchical interface. For example, a hierarchy value of "2" indicates that the widget is part of a sub-section, while a hierarchy value of "0" indicates that it exists outside the customization section.

Default – indicates whether the widget consistently defaults to a particular selection.

By utilizing these six components to categorize different avatar customization interfaces, we can better understand the level of enabled self-representation for different demographics, as well as the interface's ingrained assumptions about ideal players. This is relevant to the customization options available in exergames, as players with varying body types may want to be represented as a realistic or idealized version of themselves and may be limited by the customization options available. We applied the Avatar Affordances Framework to the character customization interfaces of the selected games, focusing on widgets that modified the avatar's body shape or physique and gender. This was done by a singular coder, who analyzed video recordings of the avatar customization interfaces of each game to identify the affordances present.

RESULTS

Using the Avatar Affordances Framework as an analytical method, we were able to break down the interface widgets that allow the player to modify the avatar's body shape. Ontological data for these widgets are shown in **Tables 1, 2**. For this analysis, we included any widgets used to adjust the avatar's physique and/or gender. In modern avatar customization interfaces, players are often limited to the gender binary of male/female, conflating biological sex with gender *via* interface text (Drenten, 2019). This language is relevant in the context of avatar customization, where several interfaces use the term gender when they really offer a binary choice between male and female.

Of the six games included in this study, four include a customizable player-avatar and two have a customizable in-game personal trainer. The games that use in-game avatars are *Ring Fit Adventure*, *Wii Fit*, *Kinect Sports Rivals*, and *EA Sports Active: Personal Trainer*. Of these games, *Ring Fit Adventure* is the only game that defaults to a male avatar. The other three games allow the player to make the selection before populating the avatar customization interface. In *Ring Fit Adventure*, players can change the sex of their avatar (presented as "style"), skin tone, and eye color. Other features, such as hair style, hair color, and body shape are pre-set and cannot be changed. All six of the games present customization options related to gender and body type at the top hierarchy level, therefore ensuring that certain customization options are not hidden unintentionally.

Unfortunately, all of the games included in this study conflate sex and gender, offering a binary choice for avatar bodies. The one exception to this is *Yoga Master*, which only offers female trainer avatars. *Wii Fit*, *Kinect Sports Rivals*, and *EA Sports Active* are the only games in this sample that allow users to change the physique of avatar bodies. *Kinect Sports Rivals* presents a slider that allows the user to discretely adjust the physique of the avatar between an idealized fit body and an overweight body. *EA Sports Active* presents the user with a list that allows them to select one of four pre-configured bodies in a similar range. The other three games present the user with a default avatar physique that matches the ideology

TABLE 1 | Avatar affordances data for Gender.

Game	Identifier	Function	Behavior	Structure	Hier.	Default
RingFit Adventure	Style	Select sex	Choose 1 of 2	Button(2)	0	Male
Wii Fit	Select a gender	Select sex	Choose 1 of 2	Button(2)	0	Player selected
Yoga Master	Change coach	Select body	Choose 1 of 3	List(3)	0	Female
Kinect Sports Rivals	Now select your Champion's gender	Select sex	Choose 1 of 2	Button(2)	0	Player selected
Fitness Boxing	Change instructor	Select body	Choose 1 of 6	Button(6)	0	Female
EA Sports Active	Gender	Select sex	Choose 1 of 2	List(2)	0	Player selected

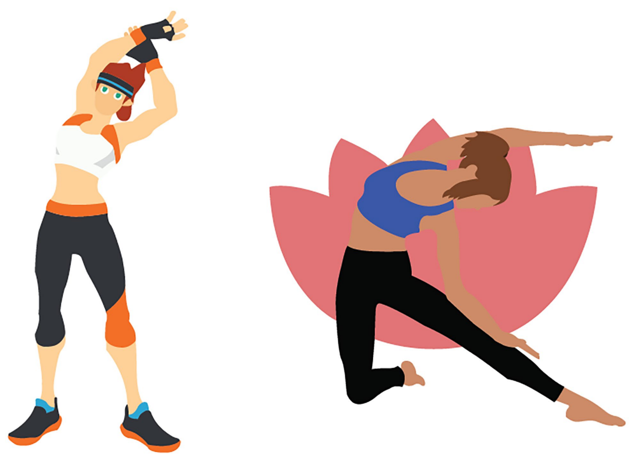

FIGURE 2 | Depiction comparing the female avatar bodies available in *Ring Fit Adventure* and *Yoga Master*.

of the type of exercise offered in-game. For example, *Ring Fit Adventure* presents the user with a body-builder type physique and the avatar bodies in *Yoga Master* are all very slender, stereotypically feminine bodies similar to those that are commonly featured as idealized yogi bodies on Instagram (Hinz et al., 2021).

The structure of the avatar affordances across all six games takes the form of either buttons or lists, except in the case of *Wii Fit*, which uses the player's own weight to set the avatar body. Additionally, *Kinect Sports Rivals* uses a discrete slider to adjust avatar physique. Both *Kinect Sports Rivals* and *Wii Fit* take advantage of atypical input devices when setting the user's body shape. Although both games present the user with customization interfaces to fine tune the physical appearance of their avatar, *Kinect Sports Rivals* sets the default physique of the avatar based on images captured by the console's camera and *Wii Fit* uses BMI measurements generated by the Balance Board.

The way that the *Wii Fit* calculates BMI has been critiqued by researchers. Öhman et al. (2014) note that the game is designed with a BMI of 22 as an ideal body. During player weigh-in, Miis jump up and down with anticipation of their BMI. If the player scores an ideal BMI or lower, the avatar reacts in a positive manner. If the player scores a BMI above the idealized 22, the Mii appears to be sad or embarrassed. In this way, the authors suggest that the game uses shame as a major strategy, even though BMI is known to be a problematic way to determine whether an individual is at a healthy weight (Romero-Corral et al., 2008).

Compared to other genres that offer avatar customization, the number of customizations available in these games was considerably lower (e.g., see McArthur et al., 2015). Customization options offered *via* these interfaces were largely geared toward fitness attire and accessories, rather than body shape. The exception to this is *Ring Fit Adventure*, where upgraded attire provides stat bonuses. Otherwise, most of the additional attire options available in the other games offered aesthetic appeal only.

It is unfortunate that our findings did not reveal more variety in body types available given that there are many different types of bodies that are accepted as healthy. Although the aforementioned research by Peña and Kim (2014) found that being able to choose an idealized body helps to motivate users in exergames, we argue that a broader definition of "idealized" avatar bodies in exergames should be considered by industry to match the more body-positive messaging that is becoming more prevalent in real life. For instance, a visual comparison of the female avatar bodies available in *Ring Fit Adventure* and *Yoga Master* represent two drastically different "fit" or "idealized" women's bodies (see **Figure 2**). Thus, we argue that greater inclusion must be built into avatar customization interfaces (e.g., the ability to customize avatar body shapes) and that more nuanced research into motivation in exergames and "idealized" body times is needed. Most importantly, this research must consider that body types are not a binary (e.g., fit vs. obese) and that people who engage in exercise do not all have the same body composition and health goals.

DISCUSSION

As we have shown in this study, exergames provide users with the ability to create their own avatar – an opportunity for players to try on new identities, or to visually place themselves at the center of an interactive digital adventure. Within this context, the issue of social exclusion arises when players who want to recreate themselves *via* their avatars are limited by interface affordances. As we found in our study, the majority of exergames sampled did not provide an adequately customizable avatar with inclusive options for gender, body type, etc. When this happens, games go from being places where we can be who we want to be, to becoming places where we can only be who we are allowed to be.

The study of affordances is important, as it not only makes visible the ways in which these interfaces may be socially exclusive, but also provides an opportunity to systematically study industry

TABLE 2 | Avatar affordances data for Avatar Body.

Game	Identifier	Function	Behavior	Structure	Hier.	Default
RingFit Adventure	None	N/A	N/A	N/A	N/A	N/A
Wii Fit	Body Test	Modify physique	Modify avatar physique	N/A	N/A	Set by player weight
Yoga Master	None	N/A	N/A	N/A	N/A	N/A
Kinect Sports Rivals	Physique	Modify physique	Modify avatar physique	Button(2) as discrete slider	0	Set by camera input
Fitness Boxing	None	N/A	N/A	N/A	N/A	N/A
EA Sports Active	Body Shape	Modify physique	Choose 1 of 4	List(4)	0	"Fit"

practice and to propose guidelines to help developers design character creation interfaces with social inclusion in mind. This is especially important when considering the advantages of allowing users to create idealized avatars in exergames. We urge industry practitioners to consider a more inclusive model of avatar physique when developing exergames that offer avatar customization.

Although the analysis in this paper offers a point of critique in the study of exergame avatar customization interfaces, we are especially interested in the measured impact of these interface options on long-term player motivation and subsequent healthy behavior changes made in the real world. Additionally, advancements in input technologies present many interesting possibilities for inclusive design in exergaming. We hope that avatar customization interfaces in exergames enjoy similar advancements, working toward socially inclusive avatars in the genre.

LIMITATIONS AND FUTURE WORK

We recognize that our study has limitations that may impact the results and therefore our perception of avatar customization in exergames. Due to our inclusion criteria, our sample size is much smaller than similar studies of other genres would be (e.g., RPGs). In our future work, we intend to connect our results longitudinal studies with participants observing how such interfaces impact their long-term behaviors, self-efficacy, and motivation.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material; further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

SC, AA, and VM contributed to the writing and revision of the article. VM contributed to the design of the work and the methodology. All authors contributed to the article and approved the submitted version.

REFERENCES

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educ. Psychol.* 28, 117–148. doi: 10.1207/s15326985ep2802_3

Banks, J. (2015). Object, me, symbiote, other: a social typology of player-avatar relationships. *First Monday* 20. doi: 10.5210/fm.v20i2.5433

Banks, J., and Bowman, N. D. (2016). Emotion, anthropomorphism, realism, control: validation of a merged metric for player–avatar interaction (PAX). *Comput. Hum. Behav.* 54, 215–223. doi: 10.1016/j.chb.2015.07.030

Bowman, N., and Banks, J. (2020). "The oxford handbook of entertainment theory," in *Player-Avatar Identification, Interaction, and Relationships*. eds. P. Vorderer and C. Klimmt (Oxford: Oxford University Press), 691–716.

Brauner, P., Valdez, A. C., Schroeder, U., and Ziefle, M. (2013). "Increase physical fitness and create health awareness through exergames and gamification." in *International Conference on Human Factors in Computing and Informatics*; July, 2013; Springer, Berlin, Heidelberg; 349–362.

Drenten, J. (2019). "Video gaming as a gendered pursuit" in *Handbook of Research on Gender and Marketing*. ed. S. Dobscha (Cheltenham, United Kingdom: Edward Elgar Publishing), 28–44.

Gero, J. S., and Kannengiesser, U. (2004). The situated function-behaviour structure framework. *Des. Stud.* 25, 373–391. doi: 10.1016/j.destud.2003.10.010

Hinz, A., Mulgrew, K., De Regt, T., and Lovell, G. (2021). Is this what a female yogi looks like? A content analysis of yoga images on Instagram. *Body Image* 36, 117–126. doi: 10.1016/j.bodyim.2020.11.003

Ho, S. S., Lwin, M. O., Sng, J. R., and Yee, A. Z. (2017). Escaping through exergames: presence, enjoyment, and mood experience in predicting children's attitude toward exergames. *Comput. Hum. Behav.* 72, 381–389. doi: 10.1016/j.chb.2017.03.001

Jin, S. A. A. (2009). Avatars mirroring the actual self versus projecting the ideal self: the effects of self-priming on interactivity and immersion in an exergame, Wii fit. *CyberPsychol. Behav.* 12, 761–765. doi: 10.1089/cpb.2009.0130

Jin, S. A. A. (2010). "I feel more connected to the physically ideal mini me than the Mirror-image mini me": theoretical implications of the "malleable self" for speculations on the effects of avatar creation on avatar–self connection in Wii. *Cyberpsychol. Behav. Soc. Netw.* 13, 567–570. doi: 10.1089/cyber.2009.0243

Li, J., Erdt, M., Chen, L., Cao, Y., Lee, S. Q., and Theng, Y. L. (2018). The social effects of exergames on older adults: systematic review and metric analysis. *J. Med. Internet Res.* 20:e10486. doi: 10.2196/10486

Li, B. J., Lwin, M. O., and Jung, Y. (2014). Wii, myself, and size: the influence of proteus effect and stereotype threat on overweight children's exercise motivation and behavior in exergames. *Games Health J.* 3, 40–48. doi: 10.1089/g4h.2013.0081

Macvean, A., and Robertson, J. (2013). "Understanding exergame users' physical activity, motivation and behavior over time." in *Proceedings of CHI*; April-May, 2013; 1251–1260.

Matallaoui, A., Koivisto, J., Hamari, J., and Zarnekow, R. (2017). "How effective is "exergamification"? A systematic review on the effectiveness of gamification features in exergames." in *Proceedings of the 50th Hawaii International Conference on System Sciences*; January, 2017.

McArthur, V. (2018). Challenging the user-avatar dichotomy in avatar customization research. *Eludamos* 9, 75–94.

McArthur, V., Teather, R. J., and Jenson, J. (2015). "The avatar affordances framework: mapping affordances and design trends in character creation interfaces." in *Proceedings of CHI Play*; October, 2015; 231–240.

Nitz, J. C., Kuys, S., Isles, R., and Fu, S. (2010). Is the Wii fit™ a new-generation tool for improving balance, health and well-being? A pilot study. *Climacteric* 13, 487–491. doi: 10.3109/13697130903395193

Öhman, M., Almqvist, J., Meckbach, J., and Quennerstedt, M. (2014). Competing for ideal bodies: A study of exergames used as teaching aids in schools. *Crit. Public Health* 24, 196–209. doi: 10.1080/09581596.2013.872771

Peña, J., and Kim, E. (2014). Increasing exergame physical activity through self and opponent avatar appearance. *Comput. Hum. Behav.* 41, 262–267. doi: 10.1016/j.chb.2014.09.038

Romero-Corral, A., Somers, V. K., Sierra-Johnson, J., Thomas, R. J., Bailey, K. R., Collazo-Clavell, M. L., et al. (2008). Accuracy of body mass index to diagnose obesity in the US adult population. *Int. J. Obes.* 32, 959–966. doi: 10.1038/ijo.2008.11

Rosenberg, D., Depp, C. A., Vahia, I. V., Reichstandt, J., Palmer, B. W., Kerr, J., et al. (2010). Exergames for subsyndromal depression in older adults: a pilot study of a novel intervention. *Am. J. Geriatr. Psychiatry* 18, 221–226. doi: 10.1097/JGP.0b013e3181c534b5

Sibilla, F., and Mancini, T. (2018). I am (not) my avatar: a review of the user-avatar relationships in massively multiplayer online worlds. *Cyberpsychology* 12:4. doi: 10.5817/CP2018-3-4

Song, H., Peng, W., and Lee, K. M. (2011). Promoting exercise self-efficacy with an exergame. *J. Health Commun.* 16, 148–162. doi: 10.1080/10810730.2010.535107

Staiano, A. E., and Calvert, S. L. (2011). Exergames for physical education courses: physical, social, and cognitive benefits. *Child Dev. Perspect.* 5, 93–98. doi: 10.1111/j.1750-8606.2011.00162.x

Strecher, V. J., McEvoy DeVellis, B., Becker, M. H., and Rosenstock, I. M. (1986). The role of self-efficacy in achieving health behavior change. *Health Educ. Q.* 13, 73–92. doi: 10.1177/109019818601300108

Sundén, J. (2009). "Play as transgression: an ethnographic approach to queer game culture." in *DiGRA Conference*; September, 2009.

Uzor, S., and Baillie, L. (2014). "Investigating the long-term use of exergames in the home with elderly fallers." in *Proceedings of CHI, ACM*; April-May, 2014; 2813–2822.

Yee, N., and Bailenson, J. (2007). The proteus effect: the effect of transformed self-representation on behavior. *Hum. Commun. Res.* 33, 271–290. doi: 10.1111/j.1468-2958.2007.00299.x

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Explicating How Skill Determines the Qualities of User-Avatar Bonds

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Many frameworks exist that explain how people interact with avatars. Our core argument is that the primary theoretical mechanisms of a user-avatar bond (i.e., UAB) rest with the way people engage avatars and, thereby, the broader digital environment. To understand and predict such engagement, we identify a person's skill in handling/engaging the avatar in the digital environment as an ordering parameter (i.e., organizing predictor). Accordingly, we define skill as a person's ability to enact their agency successfully to achieve desired states. To explain how skill orders experience, we ground our theorizing in ecological perception and systems theory. In our explication, we describe how stable action coupling (i.e., the linking of action inputs to perceived outcomes) enables a state of embeddedness (i.e., when the environment facilitates and constrains behaviors) in the digital environment. Then, we explain how embeddedness promotes motivational attunement (i.e., orienting of motivational systems) and what the digital environment affords to users at different levels of skill. Throughout, we consider how our theoretical scaffolding generates tractable contentions regarding how skill influences UABs.

Keywords: avatars, information processing, skill, affordances, action coupling, embeddedness, video games, motivation

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INTRODUCTION

User-avatar bonds (UABs) are relational bonds that emerge from experiences a user has with an avatar in a digital environment. Definitions relevant to the broader construct of UABs abound in the literature (see Nowak and Fox, 2018 for a relevant review). As with any other relationship, a UAB develops over time through experiences the user has with the avatar. Similar to interpersonal relationships, users may experience stages in bonding with their avatar characterized by initiating contact and integrating identities (Knapp, 1978). Similar to parasocial relationships established with others in one-way digitally mediated contexts (Horton and Wohl, 1956), users may experience feelings of intimacy and closeness to their avatars. However, the relationship formed between a user and an avatar is distinct from interpersonal and parasocial relationships because users fundamentally transmit their agency through avatars. The user objectifies the avatar by manipulating it in ways that vary depending on its construction and presentation. The immediate and persistent thoughts, feelings, and behaviors the user has during and following interaction with the avatar in a digital environment characterize the nature of the bond. Accordingly, the UAB can take many qualitatively distinct forms as captured by scholars who have considered avatar relations (e.g., Banks, 2015).

In this writing, we define the *avatar* as the representation of the user's agency in a digital environment. We define the *digital environment* as a system comprised of information transmitted digitally to the user *via* the hardware and software that hosts the avatar. We exclude the avatar from this definition to preserve its conceptual distinctiveness. Social scientists studying video games and other digital environments have long focused research on the interactions of a user (e.g., a video game player) and an avatar (e.g., the player's character). Accordingly, many frameworks exist seeking to articulate specific phenomena that occur during or following these interactions. For example, identification (e.g., Klimmt et al., 2009) explains the adoption of an avatar's characteristics into one's own self-perception. Player-avatar relationships (PAR; Banks, 2015) describe how interactions with avatars can produce connections with avatars that vary in characterization (e.g., as useful tools, psychologically merged symbiotes, and distinct social others). And, the Proteus effect (Yee and Bailenson, 2007) demonstrates that characteristics of avatars' representations can influence users' social behaviors predictably.

In this work we centralize a person's skill in handling or engaging the avatar in the digital environment. The argument we make in this paper is that the primary theoretical mechanisms of a UAB rest with the way the person engages the avatar and, thereby, the broader digital environment. Consequently, the full scope of UABs is not available to all players by default. Instead, skill-based prerequisites limit the range of possible experiences and, therefore, qualities of the relationship (e.g., a person must have some ability to control an avatar to feel competent). Despite this focus on characteristics of the person, we acknowledge that characteristics of the avatar and the digital environment influence the likelihood and nature of these states in important ways (e.g., both the avatar and the environment can vary in terms of form and function). Yet, as we will illustrate, even in similar digital environments with similar avatars, a person's skill can differentiate the action patterns that form the basis of experiences. Because these experiences build to form UABs, skill differentiates UABs.

In this writing, we focus our theorizing on the highly interactive and complex digital environments of video games to demonstrate the applicability of our contentions. A number of scholars have promoted the notion that video game contexts are unique. Thus, we end by speculating on how the characteristics of video games and other highly interactive media experiences may produce unique relational bonds in addition to those already identified in the literature (e.g., monadic identification).

SKILL DIFFERENTIATES EXPERIENCES WITH AVATARS IN DIGITAL ENVIRONMENTS

In the context of video games, *skill* is a player's ability to successfully enact their agency in the digital environment. Skill varies between users with some individuals having relatively lower levels (i.e., novice) to higher levels (i.e., expert) than others. Users also, however, have varying levels of skill at different types of games. For example, Binta may have a high level of skill in a turn-based role-playing game, but she may have a low level of skill in a first-person shooter. Similarly, Binta may have had a high level of skill in a game at a point in the past that she has not maintained and, thus, her skill may have diminished over time. To meaningfully experience interactions that form the basis of a user-avatar bond, users must attend to and, to some degree, process information from those experiences. The variance that exists in a user's skill produces variance in the nature of the experiences that a user will have with their avatar and their memory for those experiences.

In many video games, avatars translate a user's commands from the input source (e.g., pressing the A-button on a controller to jump) into feedback the user can perceive in the digital environment (e.g., the avatar performing a jumping animation). Although certain conventions (e.g., control schemes, genre, etc.) allow skill to translate from game to game, it is a *situated* concept, meaning that its manifestation depends on a specific environmental context of task-relevant inputs and outputs (Wilson, 2002). For example, a user's skill may take the form of a high kill-death ratio in a first-person shooter game, a short completion time (i.e., speed run) in a platformer game, complete exploration of a large map in a survival adventure game, or establishing and leading a guild in a massive multiplayer online game. Therefore, skill does not necessarily determine the likelihood of a certain outcome (e.g., winning, goal achievement). Rather, skill determines both *what* a digital environment affords the player and the degree to which a user can enact their agency effectively.

Action Coupling as a Key Component of Skill

Successfully enacting one's agency in the digital environment through an input source (e.g., a controller) requires that the user develop a proficiency at inputting commands to produce desired outcomes in the digital environment. More simply, this process requires the establishment of cognitive associations between inputs with the outcomes of those actions (i.e., outputs). Action coupling is one way to conceptualize such input-output associations. *Action coupling* is the associative linking of an action to its perceptual effect or outcome (see Novembre and Keller, 2014 for review). Action coupling has been studied in a variety of contexts (e.g., the coupling of instrumentalists' movements and the musical sounds produced). Behavioral and neurophysiological studies of action coupling indicate that it functions to support prediction of outcomes (e.g., action planning; Pfordresher, 2005) and behavioral adjustment (e.g., cooperation; Keller et al., 2014) during task performance.

Other dimensions of skill aside from coupled action exist (e.g., knowledge of rule systems), but here we argue that action coupling is a central component that potentiates other dimensions of skill that are relevant in scenarios involving avatars. The more stably action is coupled, the higher the potential for skill. Initially, as players use a controller or other input system to manipulate the avatar in the digital environment, they are establishing associative links between behaviors (e.g., button presses, trigger pulls, or mouse clicks) and the subsequent actions they perceive the avatar performing onscreen. With continued use of the avatar, these links strengthen (i.e., become more stable).

With sufficient practice, the user's ability to couple input actions to outcomes executed can become automatized/intuitive (i.e., entirely/very stable). To illustrate, initially as a novice player, Binta may have needed to look down at the control system to know which button to press to achieve her desired outcome. Being a novice player, Binta would accordingly be oscillating her attention from the controller to the screen to establish the link between the input and output systems. With time, Binta may become an intermediate or expert user who has practiced to the point that the input-output link is well-established as a stable cognitive association (i.e., a deep attractor). At this stage of skill development, Binta may have so thoroughly coupled her input behavior to the outcomes that her button presses no longer require attentional oscillation (Lang et al., 2018). As players focus their attention on the avatar and digital environment, rather than artifacts of the physical environment (e.g., the control system), their action coupling produces an ongoing feedback loop from the user to the digital environment through the avatar. In other words, the highly interactive context of games facilitates ongoing opportunities in which the user responds automatically and thoughtfully to information from the digital environment.

Given the connection to automaticity, action-coupling influences information processing by reducing the processing demands related to using an input system (e.g., a controller). Users have limited resources with which to process information in their environments. Humans evolved perceptual and cognitive adaptations such as action coupling that support the conservation of energy. This notion is summarized in varying areas and sometimes appears described as the concept of limited capacity processing (e.g., Lang, 2006) in which a finite pool of cognitive (and perhaps perceptual; Fisher et al., 2018) resources exist within the human body. Automatic or thoughtful allocation of those resources occurs depending on users' motivations and the characteristics of artifacts in the informational environment. Humans' limited capacity to process information influences what they remember *via* subprocesses of *encoding*, *storage*, and *retrieval* (Lang, 2006). Encoding is creating a mental representation of information. Storage is connecting encoded information to existing memories. Retrieval is reactivating relevant stored information. As explained by Fisher et al. (2018, p. 271), "cognitive resource limitations can inhibit the successful performance of any of [the three memory] subprocesses, reducing processing performance and influencing outcomes such as enjoyment, learning, persuasion, and many others."

Ultimately, humans' limited capacity to process information influences what aspects of an experience with an avatar a player attends to, how thoroughly users store information related to those experiences, and the player's ability to later recall and ruminate on those experiences. More thorough action coupling should reduce the resources necessary to process video game events thoroughly. Thus, once a player's action coupling has become automatized, they should have more resources available to thoroughly process experiences with avatars. In video game contexts, this means that expert players should be able to form a robust basis for the UAB compared to novice players.

Embedding in Digital Environments Provides Experiential Spaces

The sensory presentations of digital environments sometimes mimic terrestrial (i.e., earthly) environments. The exact presentation of this information may range in visual styling from realistic simulations (e.g., the mountain environments of *The Elder Scrolls V: Skyrim*) to artistic abstractions (e.g., the cel-shaded island environments of *The Legend of Zelda: Windwaker*). Other times, digital environments depart greatly from terrestrial environments (e.g., the gravity-defying loops in *Sonic the Hedgehog*, the aquatic blitzball fields in *Final Fantasy X*). Sensory renderings (e.g., graphical display, sound) primarily serve to transmit information for perceptual intake and responsive action. In other words, digital environments present information to which users attend and respond and those responses become more stable as digital environments draw users in.

As action coupling stabilizes and a user's attention shifts to focus on stimuli of the digital environment (i.e., the artifacts and events), they become embedded in the digital environment. Embeddedness occurs when an environment facilitates and constrains behaviors (Clark, 2008). Digital environments often present rich sensory information that can encourage feelings of being located in the environment (i.e., feeling present; Wirth et al., 2007). Embeddedness is related to concepts such as presence (i.e., the psychological sense of non-mediation in a digitally mediated environment; Lombard and Ditton, 1997); yet, embeddedness is distinct from these experiential concepts as it is premised on the behavioral input from the user and subsequent constraining of behavior by the digital environment. Indeed, feelings of presence in an environment are likely outcomes of embeddedness (Lynch, 2017).

Embeddedness and Nested Systems

People exist simultaneously in various environmental systems. We contend that these systems are nested based on the relative permanence of the system's elements. Systems that have high degrees of permanence are those that people generally cannot leave and, thus, are constantly constraining and facilitating behaviors. These types of systems are *obligate* systems and are "more or less permanent, at least relative to the lifetime of their parts" (Wilson, 2002, p. 630). The physical environment, for instance, is an obligate system with elements that constrain and facilitate behavior. For instance, the physical environment of Earth has gravity, which is one of its elements. As people go about their daily lives, gravity allows them to adhere to the surface of the ground, affording behaviors such as walking. However, this same element (i.e., gravity) also constrains behaviors, as well. People generally account for gravity as they descend staircases lest they find their way to the bottom in a faster and more painful way than they had intended. Systems that have low degrees of permanence are those that people may enter and leave at will. Wilson (2002) refers to these sorts of systems as *facultative*, describing them as "temporary, organized for a particular occasion and disbanded readily" (p. 630). While embedded within a facultative system, the system constrains and facilitates behaviors, but people can abandon the bounds of the system at any moment. We contend that digital environments are examples of facultative systems.

Given that digital environments are facultative systems, they are nested within obligate (and superordinate) physical environments (see **Figure 1**; adapted from Lynch, 2017). Although the obligate physical environment constrains/facilitates behaviors continuously, a user can still strongly attend to the facultative digital environment. Specifically, the more thoroughly and stably a user's action is coupled, the more they are attending to ongoing events and elements of the digital environment. Put another way, the more expert a player, the more thoroughly they can become embedded in the digital environment. We note that this does not necessarily mean that they *do* become more thoroughly embedded in the digital environment, as we will consider further in this section. However, generally, as a user perceives information from the digital environment and acts in response to it, motivational systems within the user should begin to attune to the digital environment more than the physical environment. Thus, the degree of a user's embeddedness in a digital world predicts the focus of motivational resource allocation and subsequent information processing.

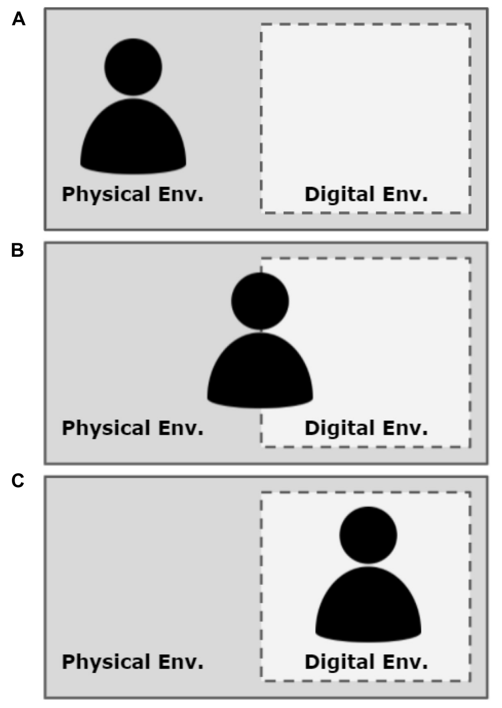

FIGURE 1 | (A–C) Illustrating Binta's states of embeddedness and nested physical (obligate) and digital (facultative) environmental systems. The solid bounding box of the physical (obligate) environment aims to illustrate its relative permanence/impermeability as compared to the dashed bounding box of the digital (facultative) system.

Embeddedness and Motivational Attunement

A user's skill can determine how much they attend to a digital environment. Accordingly, skill may predict the way that the user's body and mind respond to the artifacts of the digital environment. Users have embodied motivational systems that orient and direct human feeling, thinking, and behaving. Specific to UABs, the artifacts and events of the digital environment can present motivationally relevant stimuli (e.g., threats, opportunities) that, in many instances, require the user-avatar to respond to them. Motivational systems automatically (i.e., preconsciously) invigorate in response to perceived stimuli in the environment. Specifically, there are two evolved motivational systems (Cacioppo et al., 1997; Cacioppo and Gardner, 1999). The appetitive system promotes opportunity seeking behaviors (e.g., finding food) and the aversive system supports threat avoidance (e.g., evading predators; Lang et al., 2000). These systems also underlie the experiences of emotions (e.g., joy and sorrow). Accordingly, motivational activity gives rise to emotional response, motivated cognition (e.g., affective states, attitudes), and subsequent behavior (Lang, 2006).

When the user is not embedded in a digital environment, characteristics of the physical environment dominate the user's motivational system activation (Lee, 2017). Referring to **Figure 1A**, in this scenario if Binta receives a text message on her phone, she would likely notice it, read it, and respond to it quickly. However, as she becomes more embedded in the digital environment, characteristics of the digital environment increasingly dominate her motivational systems activity. When deeply embedded in the digital environment, characteristics of the physical environment become minimized (see **Figure 1C**). In other words, the digital world cognitively displaces the physical world. In this scenario, if Binta receives a text message on her phone, she may consciously ignore it or fail to recognize the notification altogether. Finally, Binta may be minimally/moderately embedded in both environments (see **Figure 1B**). In this scenario, if Binta receives a text message on her phone, she would likely notice it and may even read the notification while trying to maintain her control over the avatar in the digital environment.

In particular, comparing Binta's experience illustrated in **Figure 1A** to her experience illustrated in **Figure 1C** is useful for understanding how embeddedness orders motivational system activation and subsequent information processing. Because Binta in **Figure 1A** is fully embedded in her physical environment, her motivational systems are oriented to seek opportunities and avoid threats in the physical environment. As a result, she processes information from, and relevant to, her physical environment (e.g., responding to hunger, responding to her phone, recognizing the states of others in the room, etc.). In contrast, Binta in **Figure 1C** is deeply embedded in the digital environment. Therefore, the opportunities and threats present in the digital environment orient her motivational systems and direct information processing. When fully embedded in the digital environment (i.e., **Figure 1C**), Binta may fail to recognize her own hunger, her phone, or the state of her physical environment (e.g., time of day). This would be quite a different experience for Binta compared to times when she is not embedded in the digital environment whatsoever (i.e., **Figure 1A**).

Skill and Affordances

As a user channels motivational invigoration through coupled actions to have the avatar act in the digital environment, they are engaging in behaviors the environment facilitates. Considering affordances is one way to conceptualize the behaviors an environment potentiates for a user. *Affordances* are action potentials that emerge from the interaction of a person in an environment (Gibson, 1986). Certain features of environments afford certain behaviors (e.g., the ground enables standing; another person affords conversing) whereas other features do not afford certain behaviors (e.g., a body of liquid water restricts standing; rocks do not afford conversation; Gibson, 1986). Similarly, digital environments and avatars offer affordances to users (e.g., Eden et al., 2018; Lee et al., 2021). Because affordances emerge based on interactions between the user and the environment, variance in characteristics of the environment or the user should produce distinct affordances. Here, we will first briefly consider variance in the digital environment and then consider the ways that skill produces distinct affordances.

Digitally mediated environments structure and form human thought and behavior through their organizing elements. We consider a digital environment's organizing elements to be sensory presentations (e.g., what the user perceives), mechanics, and rules (Meyrowitz, 1993; Strate, 2008). Mechanics are of central importance when considering affordances, as they are the coding parameters that dictate what *can* occur in a digital environment (Boyan and Banks, 2017). Mechanics also usually determine the exact way an action manifests in the digital environment for users to perceive, which contributes to the action coupling process.

Mechanics formally bound the affordances of the digital environment by limiting what actions are possible. Digitally rendered surfaces may enable standing and liquids may not, but the opposite could just as easily be true given different coding parameters (see Gaver, 1991 and Eden et al., 2018 for further consideration of simulated environments and affordances). Accordingly, users may perceive environments to afford behaviors that do not align with actual affordances of the environment (Gaver, 1991). Although this phenomenon occurs in physical environments (e.g., wax fruit does not afford eating), digital environments abound with these scenarios because they are artificially rendered. In other words, it is often the case in digital environments that simulated approximations of physical world artifacts do not afford their usual behaviors. For example, in the *Fallout* series, some doors afford opening for users to explore an indoor space; yet, many doors in this series appear to function as doors, but do not afford opening. Similarly, some environments afford unexpected outcomes. For instance, many video games feature bodies of water that afford avatars drowning rather than swimming (e.g., some games in the *Grand Theft Auto* series).

Although environments can produce distinctions in affordances, the human centric factors that produce these distinctions are where we focus our theorizing. Skill predicts what digital environments afford to users. This is, in part, because the action coupling that underscores skill predicts distinct behaviors available to the user. The afforded actions of a digital environment and avatar likely increase rapidly (e.g., logarithmically) as skill advances from zero (i.e., complete novice) and then increases more slowly as the user transitions from moderate- to high-skill (i.e., expert; see **Figure 2**). In many video games, an expert user would have a broader range of actions available to execute than a novice user. Thus, skill should determine the scope (i.e., the number and type) of afforded actions in digital environments. For example, a digital environment may afford only walking straight forward to a novice user; even looking in specific directions may not be afforded to a user whose action is barely coupled from input to output. For the expert player, however, the same digital environment may afford walking, gazing accurately in 360 degrees, climbing, swimming, and more.

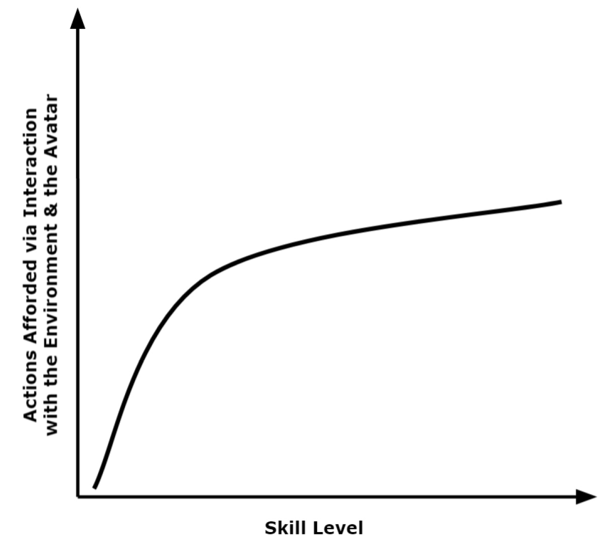

FIGURE 2 | The proposed logarithmic shape characterizing the relationship between user skill and afforded behaviors.

Returning to the intersection of a user's skill and the characteristics of a digital environment, we now advance more theoretically compelling statements than those advanced when solely considering the environment. The organizing elements (e.g., mechanics) of some digital environments are very simple. Other environments can be incredibly complex in terms of their organizing elements. Colloquially, players and game creators often describe the relationship between skill acquisition and afforded behaviors as the learning (or skill) curve. Some games (e.g., the *Souls* series) have garnered reputations for having "steep" learning curves characterized by the high degree of challenge the environments present. Players must invest significant time and effort in playing to surmount these challenges. By contrast, some games present "shallow" learning curves (e.g., *Mario Kart*) in which players have to invest relatively less time and effort to achieve mastery over the challenges.

For instance, in the game *Morkredd,* the mechanics and rules are nearly one-dimensional. The only actions afforded are walking the avatar across the environment's ground to progress and flipping levers. The only rule is simply to avoid the dark areas of the level to progress. Similarly, the control systems for *Morkredd* are also low in complexity; players use one joystick and one button of a controller to navigate the avatar through the lit areas of the otherwise shadowed digital environment. Given these parameters, action coupling in this game should happen quite quickly even for novice players and would seem to cascade to produce similar patterns of affordances between expert and novice players. Thus, some games have conditions in which it seems unlikely that novice and expert players' actions and experiences would be distinct. However, research indicates that even in games with simple mechanics, rules, and control systems, novice and expert players engage in distinct action patterns based, we contend, on how skill distinguishes affordances.

Using the digital game *Tetris*, Kirsh and Maglio (1994) demonstrated how skill influences several principles of the connections between action, perception, and cognition. Specifically, Kirsh and Maglio (1994) distinguished between *pragmatic action* and *epistemic action*. Pragmatic actions are those that function to allow an individual to advance toward a goal. Epistemic actions are those that facilitate easier, faster, or more reliable computations within an individual. In *Tetris*, users must rotate and situate blocks (i.e., zoids) to completely fill rows in a playing grid. The organizing elements of *Tetris* will be familiar to many, but the point here is that the game is relatively simple. However, Kirsh and Maglio's (1994) findings showed that expert players more frequently and more quickly engaged in extra rotations of the *Tetris* zoids compared to novice players. The extra rotations performed by experts did not directly bring the players closer to their goals. In fact, at first glance, the extraneous rotations seem to expend precious moments of time for the players, yet their proficiency in the game compared to the novice players could not be questioned.

Kirsh and Maglio (1994) describe three primary reasons why the extra rotations performed by the expert *Tetris* players allowed them to outperform the novice players. First, the rotations *reduced the computational resources* necessary for the experts to effectively determine where the zoid was in space relative to the stacked blocks at the base of the level. Second, the rotations *reduced the time* it took for expert players to identify matches between the shapes of zoids and the contours located at the level's base. And third, the actions *increased the consistency* with which the expert players extracted information to find advantageous resolutions to the zoid and contour matching. In other words, experts leverage epistemic action to reduce computational processing and action decision costs. Therefore, the "rotate zoid" button on a controller may merely afford rotation for novice/intermediate *Tetris* players (i.e., rotate to fit). By comparison, the same button affords rotation for the expert, but also experimentation (i.e., rotate to find)—akin to shuffling Scrabble tiles rather than merely staring at the jumble of letters.

Oftentimes epistemic actions, as compared to pragmatic actions, may seem to be ineffective or adverse to goal achievement. However, Kirsh and Maglio (1994) challenged the notion that epistemic actions were, in fact, disadvantageous by comparing the actions of expert and novice players of the game. The mechanics of *Tetris* allow novice and expert players similar actions (i.e., rotations; translations, or the left-to-right horizontal shifts of zoids). However, as Kirsh and Maglio (1994) demonstrate, the extra rotations and translative actions produced different affordances for the expert players that resulted in reduced computational costs. Expert players' actions provided new information earlier in the game than novice players and simplified the process of matching zoid and contour.

Taking the implications of Kirsh and Maglio's (1994) findings and considering them in the context of digital environments that feature avatars, the potential for vastly different experiences emerges. We argue that their findings provide evidence that affordances of digital environments may differ based on distinctions in user skill. Given that certain affordances are unavailable to novice users, the experiences that underscore and give rise to certain types/qualities of UABs also remain unavailable to these low skill users. As skill builds, users should come to respond automatically to the digital environment and changes therein. Accordingly, a user may manipulate the avatar in certain ways to understand what is afforded by the digital environment. Take, for example, the differences in the way a player may use their avatar to learn more about the environment and actions afforded in a platformer game. Platformer games typically require a player to progress by maneuvering their avatar across uneven surfaces, often jumping, climbing, or performing other similar actions to reach distant locations. Expert players may use the avatar to learn more about the environment, for example, jumping across a pit and attempting to jump again despite the character being in midair (i.e., performing a double jump).

The expert player's advancement is afforded by double jumping, whereas advancement might not be afforded to the novice player for whom the affordance of double jumping is unavailable. This also illustrates how skill advances with time. Even if the novice attempts to jump and the avatar dies by falling into the pit of lava below, the novice may now understand that this simple act of a single jump does not afford advancement. The novice player might initially become frustrated at having their goal impeded, experiencing aversive motivational activity and the corresponding changes to information processing. These processes should characterize the nature of the novice player's experience with the avatar, perhaps even resulting in a strained UAB that the user may not find meaningful or enjoyable.

Yet, if the novice user persists, over time they may begin to initiate creative, epistemic actions that may not obviously advance toward the goal (e.g., returning to the level start to see if they missed something, attempting to walk rather than jump across the pit, etc.). These actions would allow them to understand what is possible in the digital environment. The expert player may use their avatar to explore the limits of what is possible by discovering new ways to act in the digital environment. The explorations may function to offload cognitive resources into the environment, as Kirsh and Maglio (1994) contend. The explorations could also reveal new ways to play that ultimately change how the player thinks about the digital environment and their avatar. Returning to Binta as an example, she may discover a glitch that allows her avatar to clip through a section of a level (i.e., walk through an object intended to be solid and untraversable), reducing her overall play time and quickening a speed run (i.e., a rapid completion of a game level). Binta may also discover novel sequences or combinations of items she can equip to her avatar to produce new affordances. For example, she might stack augmentations to create an exceptionally damage-resistant avatar. These explorations may also have complex social considerations. For example, in many massive multiplayer online games, players use avatars to engage in group-level cooperation and conflict. Users may form, maintain, or end allyships that have implications for understanding social affordances. The expert player should have experiences in the digital environment that would allow them to capitalize on the afforded actions of a given digital environment. As expert players do so, they should–by comparison to the novice–experience stronger emotional responses potentiating meaningful bonds with their avatar (e.g., feeling efficacious, powerful, etc.).

ADVANCING SKILL AS A PREDICTOR OF USER AVATAR BONDS

A great deal of work exists on the nature of user-avatar interactions (see Nowak and Fox, 2018). Our focus on explicating user skill as a mechanism inherent in all users aims to provide a conceptual foundation that explains the UAB and its associated outcomes across, if not all, at least a broad range of contexts. In pursuit of our goal, we have applied a definition of an avatar to encompass all representations of the user's agency in a digital environment. Thus, avatars may be crude or sophisticated, simple or complex, but not necessarily human, animal-like, or even in a centralized form. Our focus on the transmission of agency through the avatar provides a theoretical context in which skill produces tractable contentions (Chaffee and Berger, 1987). Below we consider how scholars can apply our conceptual definition of skill operationally and detail a few studies that have informed our theorizing in order to demonstrate skill's influence on users' attention and responses to stimuli that inform the development of bonds with avatars.

Operationalizing Skill Defined as a Situated Concept

We contend that skill is most likely to be useful to scholars when operationalized idiosyncratically. Accordingly, it is relevant for scholars to understand and use specific input-output parameters when considering how skill should influence player experience. Scholars taking this approach may find it fruitful to validate skill conceptually through measurement of related psychological states such as feeling competent (e.g., Ryan et al., 2006; Lynch, 2017). As we previously considered, the same abilities and experience developed in a first-person shooter would not necessarily translate into a platformer or a role-playing game. Action coupling would occur differently (e.g., faster) in some games than others and similarly differentiate affordances. The control systems that produce user actions *via* avatars range from very low complexity (e.g., simply pressing a single button to advance a conversation) to having great complexity (e.g., navigating environments with 360 eye gaze control and movement while using items in real time). Importantly, complexity can vary dynamically over the course of a game and is often determined by decisions of users (Klimmt et al., 2009). For example, in many fighting games players can choose between selecting technical controls, which demand precise timing and inputs to control the avatar to their full potential, or simple controls, which limit the avatar's range of function, but are easier to use.

Although considering the idiosyncrasies of digital environment input-output systems may seem overwhelming to researchers developing their study designs, as described previously, certain conventions (e.g., genre) effectively summarize types of skills reducing the breadth of how scholars might operationalize skill. As in the example of the expert who navigates the platformer game with ease, mechanics such as double-jumps are common in games of this sort, but may have no relevance outside of games in this genre. Thus, scholars may find it useful to differentiate between the exact parameters that define skill within a situated context.

For instance, Matthews and Weaver (2013) identified distinct patterns of outcomes between novice and expert players in violent video games. The authors also made these observations across two distinct video games–*Call of Duty: World at War* (COD) and *Grand Theft Auto IV* (GTA IV). Had the authors considered the distinct characteristics of the skills required to meet the challenges of these different games, they may have gleaned additional insights into the experiences of players in their study. For instance, in GTA IV, players have a broad array of tasks they can spend time with whereas in COD nearly the entire focus of the experience is perpetrating and avoiding violence. Accordingly, expert players' experiences likely differed in other ways that would have potentiated distinct bonds to the avatar among other outcomes of interest to social scientists.

Characterizing Relationships Between Skill, Motivation, and User-Avatar Experiences

Ultimately, users need some level of skill to accomplish what they want to do in digital environments. In some instances, this means having sufficient skill to achieve a desired goal, but this may also be more broadly achieving desired *states* (e.g., feeling competent, beautiful, competitive, etc.). To reiterate, we do not suggest that skill is simply a mechanism to outcomes such as winning or completing experiences. Instead, skill is the ordering parameter for what a game affords, facilitating the user's ability to manipulate the avatar in such a way to produce intended states.

As we have reviewed, motivational systems fuel emotional, cognitive, and behavioral responses within the user (Cacioppo et al., 1997). These systems are constantly operational and invigorating automatically in response to the dynamic environment. Expert players may achieve desired motivational states more easily than novice players (e.g., feeling dominant at will), which in turn may potentiate stronger (or more diverse) bonds with avatars early in the development of the interaction. Although avatars themselves may have inherent motivational relevance to users (e.g., an avatar designed to look and act like a puppy may have appetitive motivational relevance because it is cute and friendly), the more interesting point in our view is that the user's skill should shape their motivational response to the avatar. Furthermore, the nature of the user's motivational response should change as the user's skill changes. To illustrate how skill helps users achieve desired states, below we detail the nature of a specific pattern of motivational system activation and how user skill influences the pattern.

As explained, general principles of motivational system activation apply readily to explaining UABs. Generally, motivational systems automatically allocate resources toward processing certain types of information (e.g., threats) in a given context. For example, more proximate stimuli typically evoke stronger motivational system activation and especially so if the stimuli are dangerous, which would lead to greater consumption of cognitive resources. Motivational systems respond automatically to stimuli with distinct patterns of activity emerging over time in the appetitive and aversive systems, respectively. Positivity offset and negativity bias (i.e., PONB) is among the most notable of these activation patterns. *Positivity offset* describes the subtle invigoration of the appetitive system that occurs when in a resting state (i.e., at low levels of arousal; Cacioppo et al., 1997). Low-level appetitive activation promotes opportunity-seeking behaviors. This subtle activation does not occur in the aversive system in a resting state. Instead, a *negativity bias* characterizes activation of the aversive system. Negative stimuli invigorate the aversive system powerfully and rapidly, producing a bias in processing where aversive activation draws greater levels of resources in a shorter span of time compared to appetitive activation (Cacioppo et al., 1997). Take, for example, a scenario in which a hiker encounters a bear. This scenario would likely elicit a strong aversive response (i.e., fear) in the hiker. On the other hand, a hiker who is resting by a stream and sees a butterfly fluttering above the water would likely experience minimal invigoration of appetitive systems (i.e., contentment).

Despite their immateriality, digital environments encourage ongoing attention and subsequent behavioral enactment. Human perceptual and motivational systems do not immediately distinguish digitally mediated stimuli from those physically in the environment (Reeves and Nass, 1996). People then act in motivated cognitive states to either approach/avoid different things in the environment. Functionally, motivational activation serves to promote cognition and adaptive behavior, but how those outcomes manifest depends on characteristics of the person in a given environment (Buck, 2014). For instance, the strong invigoration of aversive systems in response to a proximate threat promotes fight *or* flight behavior (Lang et al., 2000). Skill may very well differentiate whether a person fights or flees in the face of a threat (e.g., Lang et al., 2018). An expert may have the ability to engage in defensive and offensive maneuvering whereas a novice may only have escape behaviors available to them. Furthermore, as users' skills develop, they likely become increasingly capable of manipulating avatars to achieve desired motivational states intentionally (e.g., coordinating social events in games among a team of players to satisfy a need for relatedness). This possibility is poignant, as a user's ability to create an intended motivational state in themselves opens experiential opportunities.

Summarizing Short- and Longer-Term Outcomes for User-Avatar Bonds

Because user skill helps determine the likelihood of motivational states, skill should influence the way the user manipulates the avatar in response to motivationally relevant stimuli. To elaborate, an avatar's current state can result in fleeting motivationally relevant states for a user (e.g., the avatar is in danger of taking damage). Motivational responses to that stimulus should invigorate relatively universally, but skill would predict the nature of how the user's agency flows through the avatar (i.e., how a user-avatar responds to the stimulus). For example, imagine Binta is guiding her avatar's descent down a snowy slope during a skiing event and capturing flags as she passes check points. Binta's appetitive motivational system should invigorate and perhaps more so as she embeds deeply in the environment and nears the end of the event. In the short-term Binta may feel excitement and use the subsequent motivational invigoration (i.e., appetitive systems activity) to have the avatar respond to challenges in the environment. If Binta were an expert player in this scenario, she may perform jumps and tricks to gain advantages in the game that would speed up her descent and improve her overall performance. If Binta were a novice player, she might simply attempt to navigate without crashing her avatar into trees.

Some recent empirical evidence supports this theorizing. For example, Lang et al. (2018) investigated how experience in a digital environment differentiated people's patterns of behaviors and afforded outcomes. Specifically, they content analyzed people's driving behaviors in *Grand Theft Auto IV* (GTA IV). They found that novice players performed less risky behaviors while driving and, as a result, hit fewer objects and people while playing the game than expert players. Although this outcome seems counterintuitive, the authors posited that expert players took greater risks and caused more mayhem because they understood that such behaviors could confer benefits (e.g., enjoyment, in-game resources, etc.) with minimal in-game losses. Novice players, on the other hand, drove in ways that mirrored driving in the physical environment (e.g., driving slow, not hitting cars, etc.). In other words, the skill possessed by expert players facilitated patterns of behavior among them that were more consistent with the digital environment of GTA IV than the physical environment.

Similarly, Lynch (2017) investigated whether a user's skill influenced their emotional reactions when being hunted by a monster in a digital environment. The avatar in the selected game possessed no offensive abilities. As a result, players had to hide or otherwise engage in avoidance behaviors for their avatar to survive the experience. A central independent variable in this study was the size of the avatar. Those who used a small and slender avatar reported less fear when playing the game compared to people playing as a large and muscular avatar. Similar to the previous example, this outcome seems counter intuitive. However, this effect only emerged for expert players. In interpreting this finding, Lynch suggested that higher skilled players may have recognized that a smaller avatar afforded better threat avoidance than a larger avatar. By comparison, novice players reported no differences in fear across condition. Notably, however, novice players reported less fear overall than expert players lending support to the notion of motivational attunement when embedded. Other recent work demonstrates that the principles of motivational systems and subsequent behavioral enactment do indeed emerge reliably in highly interactive digital environments (Lee et al., 2021).

The relationship between skill and fostering specific motivational states also underlies more persistent, longer-term feelings about avatars (i.e., attitudes about or feelings toward one's avatar). Returning again to Binta, she may customize her avatar's appearance with the motivation to achieve an esthetically attractive form. This action would require a base level of skill to navigate the digital environment and successfully manipulate the avatar to afford appearance customization. If Binta is pleased with the appearance of her avatar, then her appetitive systems may invigorate at low levels any time she interacts with the avatar. This could produce positive attitudes in Binta toward her avatar such that she reports liking the avatar. This generally positive orientation may also then influence the way that Binta uses her avatar. For example, Binta may avoid engaging in activities that would temporarily mar the avatar's appearance because she is motivated to maintain the avatar's esthetics. Likewise, she may engage in epistemic actions that seemingly undermine goal attainment in pursuit of motivational states distinct to her as an expert player. For instance, she might choose esthetically pleasing equipment at the expense of power or capability (e.g., a suitcoat instead of armor). Her skill, however, would allow her to capitalize on a range of affordances that would effectively recoup on an otherwise reduced advantage.

As another hypothetical example, if Binta has used her avatar to explore tragic narrative themes over the course of the game experience, she may develop feelings of sadness or pity with respect to her avatar. The avatar would thus have negative (i.e., aversive) motivational relevance for Binta based on her experiences using the avatar. Accordingly, Binta may feel motivated to finish extra narrative or exploratory content to achieve a positive rather than negative ending to the avatar's narrative. This hypothetical trajectory illustrates a player experience that would offer an opportunity for social scientists to learn more about the influence of skill on long term patterns in player behavior.

Information Processing and Experiential Outcomes Distinguished by Skill

Notable work does exist examining information processing with respect to avatars (e.g., Ganesh et al., 2012; Ratan and Dawson, 2016; Taylor and Dando, 2018). Yet, memory processes are central factors in understanding characteristics of UABs that remain underexamined by researchers. Because skill influences motivational attunement and activation, we contend that skill would likewise predict the processing of information by reducing processing demand and influencing outcomes such as working memory (e.g., Read et al., 2018).

Accounting for motivation and information processing provides a framework for researchers to classify and predict outcomes of interacting with an avatar in a digital environment. For example, the motivational tenants of positivity offset and negativity bias predict what content is likely to demand the user's attention (Cacioppo et al., 1997). For example, Reeves and Nass (1996) explain how aversive content commands attention and influences the storage of information predictably. People tend to store details *immediately before* the onset of an aversive stimulus poorly (i.e., retroactive interference). In contrast, people tend to store details *following* the onset of an aversive stimulus well (i.e., proactive enhancement). Yet, skill may predict distinctions in processing this information because it may differentiate the amount of resources dedicated to aversive systems' activity in this moment. Generally, if Binta was guiding her avatar through a complex maze to reach a treasure chest and a horde of monsters attacked as she reached the room with the chest (i.e., an aversive event), her memory of the maze—especially the portion encountered immediately prior to the aversive event—would be poor. By comparison, Binta would better remember the route she took when escaping the hoard (i.e., details *after* the aversive event).

These divergent outcomes in memory occur because strong aversive reactions motivate people to encode what is happening in the moment at the cost of reduced storage and retrieval. However, skill should influence such well documented patterns of memory construction predictably. For example, a skillful player may resist negativity's influence on processing due to their ability to anticipate conflict and react accordingly. Principles such as this abound in the literature on motivational systems. We contend that they present opportunities to specify how users at differing levels of skill interact with the motivationally relevant characteristics of the avatar and the digital environment to specify what parts of the UAB users find memorable.

Finally, skill should help predict broader experiential outcomes by considering the relationship between embeddedness in systems and motivational attunement. Researchers have studied experiential phenomena with respect to how immersive technologies can facilitate states that dominate one's senses (e.g., pain management *via* virtual reality technologies; Pourmand et al., 2018) and have used a variety of measurement techniques to observe the allocation of resources during psychologically immersive states (e.g., secondary task reaction time; Keene and Lang, 2016). However, less attention has been given to ways in which skill predicts how resources are expended as users' embeddedness oscillates between the physical environment and the digital environment in video games. For example, in cooperative games, it is common for skillful users to engage in complex strategizing and coordination through verbal conversation with their partner while maintaining focused attention in the digital environment.

The users are oscillating between perceiving and acting in the digital environment while communicating with others. These individuals may be co-located in their physical environment or located remotely, which likely matters in ways related to motivation and information processing. The extent to which the avatar draws additionally on users' resources likely also oscillates during such interactions, but this provides just one example of how social scientists might explore how skill predicts embeddedness and its subsequent outcomes. Work on attention and information processing during media multitasking (e.g., Wang et al., 2015) would likely serve as excellent connecting points to advance knowledge on these phenomena in contexts with avatars.

Experiences With Avatars Produce Distinct Relationships

Existing research describes how the highly interactive nature of video games and similar technologies facilitate different types of experiences relative to other types of media (e.g., film). For example, Klimmt et al. (2009) describe the experience of monadic identification with an avatar in which the player adopts and merges characteristics of the avatar temporarily into their own self-perception. Similar to our thinking, Klimmt et al. (2009) elaborate that the central mechanism driving this phenomenon is the interactive control the player holds over the avatar and that the link established through this interactive connection facilitates the psychological merger of the avatar and player. We contend that skill is a crucial, human centric concept that is, as yet, under considered in this literature.

However, working from perspectives that advance concepts of action coupling, embeddedness, and affordances, we suggest that monadic identification and similar constructs already identified in the literature of user-avatar interactions (e.g., embodiment) may present excellent junctions in the avatar literature to advance our understanding of how skill predicts what avatars afford users in digital environments. Specifically, we suggest that avatars may afford *cognitive extension* into the digital environment for expert players. Cognitive extension is when people control or otherwise exert power over an object and the object itself becomes part of the cognitive system. Cognitive extension exists within a broader construct that conceptualizes cognition as embodied, embedded, and extended (see Clark, 2008). Communication researchers (e.g., Clayton et al., 2015; Bailey et al., 2021) ground cognitive extension in perspectives such as Gibson's articulations of affordances and perception-action linkage (Gibson, 1986), Belk's extended-self theory (1988), and Clark's notion of the negotiable body (2008).

The components that define the broader construct of cognitive extension are robust, complex, and paradigm-defining. With time and effort, people can come to view an object as part of themselves (McClelland, 1951; Belk, 1988; Clayton et al., 2015; Bailey et al., 2021). For instance, smartphone users describe viewing the device as an extension of themselves that not only enhances their physical or intellectual capabilities (i.e., functional extensions), but one that has user-like characteristics (i.e., anthropomorphic extensions) and becomes difficult to uncouple from themselves (i.e., ontological extensions; Park and Kaye, 2019). However, it is not simply the coupling of the object and the person that produces cognitive extension. Rather, the object–in our case, the avatar–becomes part of the person's cognitive system, facilitating a new way of thinking and perceiving the environment (e.g., *via* epistemic action). We assert that this presents a provocative direction for considering how skill determines user-avatar interactions and one, to our knowledge, that scholars have not formally considered. Future work could do more to advance these ideas in compelling ways.

CONCLUSION

Summarizing the relevance of skill in these processes, expert players' action input should be stably and deeply coupled to perceived outcomes in the digital environment. Their attention should be strongly attuned to the digital environment, potentiating motivational invigoration to stimuli in the digital environment. Accordingly, they would typically recognize challenges and opportunities in the digital environment quickly. The relative strength of their action coupling should reduce the processing demands of input, leaving plentiful processing resources for encoding, storing, and retrieving information from the digital environment. And, finally, the diminished effort in coupling input to perceived outcomes facilitates more masterful expressions of the user's agency and greater ability to meet or overcome the challenges a digital environment may present (e.g., solving puzzles).

For expert players, then, the experiences they have with an avatar when embedded in a digital environment should seem proximate, invigorating, and consequential. For novice players, the experiences they have with their avatar may feel less robust and inconsequential. The expert and the novice player likely experience qualitatively distinct UABs even if the avatar is fundamentally the same. If the bond that a user has with their avatar is formed by their experiences together, then the nature of what the user can do in the digital environment is consequential.

AUTHOR CONTRIBUTIONS

TL, NM, and MG contributed to the conception of the framework. TL and NM wrote the first draft of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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REFERENCES

Bailey, R. L., Read, G. L., Yan, Y. H., Liu, J., Makin, D. A., and Willits, D. (2021). Camera point-of-view exacerbates racial bias in viewers of police use of force videos. *J. Commun.* 71, 246–275. doi: 10.1093/joc/jqab002

Banks, J. (2015). Object, me, symbiote, other: a social typology of player-avatar relationships. *First Monday* 20. doi: 10.5210/fm.v20i2.5433

Belk, R. W. (1988). Possessions and the extended self. *J. Consumer Res.* 15:139. doi: 10.1086/209154

Boyan, A., and Banks, J. (2017). "Rules & mechanics: parameters for interactivity," in *Avatars, Assembled: The Sociotechnical Anatomy of Digital Bodies*, ed. J. Banks (Bern: Peter Lang Publishing).

Buck, R. (2014). *Emotion: A Biosocial Synthesis*. Cambridge: Cambridge University Press.

Cacioppo, J. T., and Gardner, W. L. (1999). Emotion. *Annu. Rev. Psychol.* 50, 191–214.

Cacioppo, J. T., Gardner, W. L., and Berntson, G. G. (1997). Beyond bipolar conceptualizations and measures: the case of attitudes and evaluative space. *Pers. Soc. Psychol. Rev.* 1, 3–25. doi: 10.1207/s15327957pspr0101_2

Chaffee, S. H., and Berger, C. R. (1987). "What communication scientists do," in *Handbook of Communication Science*, eds C. R. Berger and S. H. Chaffee (Thousand Oaks, CA: Sage).

Clark, A. (2008). *Supersizing the Mind: Embodiment, Action, and Cognitive Extension*. Oxford: Oxford University Press.

Clayton, R. B., Leshner, G., and Almond, A. (2015). The extended iSelf: the impact of iphone separation on cognition, emotion, and physiology. *J. Computer-Mediated Commun.* 20, 119–135. doi: 10.1111/jcc4.12109

Eden, A., Ewoldsen, D. R., Lee, J., and Beyea, D. (2018). "Behavioral demands as behavioral affordances in video games," in *Video Games: A Medium that Demands Our Attention*, 1st Edn, ed. N. D. Bowman (Milton Park: Taylor & Francis).

Fisher, J. T., Keene, J. R., Huskey, R., and Weber, R. (2018). The limited capacity model of motivated mediated message processing: taking stock of the past. *Ann. Int. Commun. Assoc.* 42, 270–290. doi: 10.1080/23808985.2018.1534552

Ganesh, S., van Schie, H. T., de Lange, F. P., Thompson, E., and Wigboldus, D. H. J. (2012). How the human brain goes virtual: distinct cortical regions of the person-processing network are involved in self-identification with virtual agents. *Cereb. Cortex* 22, 1577–1585. doi: 10.1093/cercor/bhr227

Gaver, W. W. (1991). "Technology affordances," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems Reaching through Technology - CHI*. (New York, NY: ACM), 79–84. doi: 10.1145/108844.108856

Gibson, J. J. (1986). *The Ecological Approach to Visual Perception*. Milton Park: Taylor & Francis.

Horton, D., and Wohl, R. (1956). Mass communication and para-social interaction: observations on intimacy at a distance. *Psychiatry* 19, 215–229. doi: 10.1080/00332747.1956.11023049

Keene, J. R., and Lang, A. (2016). Dynamic motivated processing of emotional trajectories in public service announcements. *Commun. Monographs* 83, 468–485. doi: 10.1080/03637751.2016.1198040

Keller, P. E., Novembre, G., and Hove, M. J. (2014). Rhythm in joint action: psychological and neurophysiological mechanisms for real-time interpersonal coordination. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* 369:20130394. doi: 10.1098/rstb.2013.0394

Kirsh, D., and Maglio, P. (1994). On distinguishing epistemic from pragmatic action. *Cogn. Sci.* 18, 513–549. doi: 10.1207/s15516709cog1804_1

Klimmt, C., Hefner, D., and Vorderer, P. (2009). The video game experience as "true" identification: a theory of enjoyable alterations of players' self-perception. *Commun. Theory* 19, 351–373. doi: 10.1111/j.1468-2885.2009.01347.x

Knapp, M. L. (1978). *Social Intercourse: From Greeting to Goodbye*. Needham Heights, MA: Allyn & Bacon.

Lang, A. (2006). Using the limited capacity model of motivated mediated message processing to design effective cancer communication messages. *J. Commun.* 56, S57–S80. doi: 10.1111/j.1460-2466.2006.00283.x

Lang, A., Han, J., Zheng, X., Almond, A., Lynch, T., and Matthews, N. L. (2018). "Learning to play: an evolved dynamic systems analysis of grand theft auto," in *Evolutionary Psychology and Digital Games: Digital Hunter-Gatherers*, eds J. Breuer, D. Pietschmann, B. Liebold, and B. P. Lange (Milton Park: Routlege).

Lang, P. J., Davis, M., and Öhman, A. (2000). Fear and anxiety: animal models and human cognitive psychophysiology. *J. Affect. Disord.* 61, 137–159. doi: 10.1016/s0165-0327(00)00343-8

Lee, J. (2017). *Scared of the Dark: Examining Aversive Activation During a Virtual Navigation Task*. Master's thesis, Bloomington, IND: Indiana University.

Lee, J., Eden, A., Park, T., Ewoldsen, D. R., and Bente, G. (2021). Embodied motivation: spatial and temporal aspects of approach and avoidance in virtual reality. *Media Psychol.* doi: 10.1080/15213269.2021.1968439

Lombard, M., and Ditton, T. (1997). At the heart of it all: the concept of presence. *J. Computer-Mediated Commun.* 3:JCMC321. doi: 10.1111/j.1083-6101.1997.tb00072.x

Lynch, T. (2017). *Assessing the Relevance of Formidability on Fear in Playful Simulations of Predation*. PhD thesis, Bloomington, IND: Indiana University.

Matthews, N. L., and Weaver, A. J. (2013). Skill gap: quantifying violent content in video game play between variably skilled users. *Mass Commun. Soc.* 16, 829–846. doi: 10.1080/15205436.2013.773043

McClelland, D. (1951). *Personality*. New York, NY: Holt, Rinehart, & Winston.

Meyrowitz, J. (1993). Images of media: hidden ferment—and harmony—in the field. *J. Commun.* 43, 55–66. doi: 10.1111/j.1460-2466.1993.tb01276.x

Novembre, G., and Keller, P. E. (2014). A conceptual review on action-perception coupling in the musicians' brain: what is it good for? *Front. Hum. Neurosci.* 8:603. doi: 10.3389/fnhum.2014.00603

Nowak, K. L., and Fox, J. (2018). Avatars and computer-mediated communication: a review of the definitions, uses, and effects of digital representations. *Rev. Commun. Res.* 6, 30–53. doi: 10.12840/issn.2255-4165.2018.06.01.015

Park, C. S., and Kaye, B. K. (2019). Smartphone and self-extension: functionally, anthropomorphically, and ontologically extending self via the smartphone. *Mobile Med. Commun.* 7, 215–231. doi: 10.1177/2050157918808327

Pfordresher, P. Q. (2005). Auditory feedback in music performance: the role of melodic structure and musical skill. *J. Exp. Psychol. Hum. Percept. Perform.* 31, 1331–1345. doi: 10.1037/0096-1523.31.6.1331

Pourmand, A., Davis, S., Marchak, A., Whiteside, T., and Sikka, N. (2018). Virtual reality as a clinical tool for pain management. *Curr. Pain Headache Rep.* 22, 1–6. doi: 10.1007/s11916-018-0708-2

Ratan, R. A., and Dawson, M. (2016). When mii is me: a psychophysiological examination of avatar self-relevance. *Commun. Res.* 43, 1065–1093. doi: 10.1177/0093650215570652

Read, G. L., Lynch, T., and Matthews, N. L. (2018). Increased cognitive load during video game play reduces rape myth acceptance and hostile sexism after exposure to sexualized female avatars. *Sex Roles* 1, 683–698. doi: 10.1007/s11199-018-0905-9

Reeves, B., and Nass, C. (1996). *How People Treat Computers, Television, and New Media Like Real People and Places*. Stanford, CA: CSLI Publications and Cambridge University Press.

Ryan, R. M., Rigby, C., and Przybylski, A. K. (2006). The motivational pull of video games: a self-determination theory approach. *Motivation Emot.* 30, 344–360. doi: 10.1007/s11031-006-9051-8

Strate, L. (2008). Studying media AS media: McLuhan and the media ecology approach. *MediaTropes* 1, 127–142.

Taylor, D. A., and Dando, C. J. (2018). Eyewitness memory in face-to-face and immersive avatar-to-avatar contexts. *Front. Psychol.* 9:507. doi: 10.3389/fpsyg.2018.00507

Wang, Z., Irwin, M., Cooper, C., and Srivastava, J. (2015). Multidimensions of media multitasking and adaptive media selection. *Hum. Commun. Res.* 41, 102–127. doi: 10.1111/hcre.12042

Wilson, M. (2002). Six views of embodied cognition. *Psychonomic Bull. Rev.* 9, 625–636. doi: 10.3758/BF03196322

Wirth, W., Hartmann, T., Böcking, S., Vorderer, P., Klimmt, C., Schramm, H., et al. (2007). A process model of the formation of spatial presence experiences. *Media Psychol.* 9, 493–525. doi: 10.1080/15213260701283079

Yee, N., and Bailenson, J. (2007). The proteus effect: the effect of transformed self-representation on behavior. *Hum. Commun. Res.* 33, 271–290. doi: 10.1111/j.1468-2958.2007.00299.x

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