TOWARDS A SCIENCE OF COMPLEX EXPERIENCES

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TOWARDS A SCIENCE OF COMPLEX EXPERIENCES

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EDITORIAL
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Editorial: Toward a Science of Complex Experiences

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Editorial on the Research Topic

Toward a Science of Complex Experiences

Complexity has been always a part of an individual's life under different guises. However, it has always been hard to provide a clear definition of what complexity really is. For instance, in the field of science, complexity has been defined in terms of systems [vol. 284, Issue 5411, pp. 1-212]. A system can be deemed as complex when multiple interactions occur among different components or when the system evolves over time, where a recognizable structure is still present but varies in different ways in response to small perturbations or by being sensitive to initial conditions. This definition, as well as the concept of a system, can also be applied to human experience (e.g., Cipresso, 2010), whose unfolding takes place through the interactions of specific cognitive, perceptual, and emotional components bringing forth peculiar phenomena, which we labeled as "complex experiences."

Among these phenomena it would be possible to include the following complex experiences: complex thinking, flow experiences, the sublime, awe, Turning Points, body illusions, diversifying experiences, paradoxical experiences, expectation violations, transformation, and mental imagery.

Complex experiences can now be studied by means of sophisticated simulations able to act as a tradeoff between the uncontrollability of natural settings and the reductionism of the lab. It is the case of Virtual Reality—defined as 3D simulations—where it is also possible to interact with the objects present within the synthetic environment, thus leading to a sense of presence i.e., the illusion of being "there," as if it was real life (Waterworth et al., 2015). However, there are also special conditions, such as light deprivation or blindness, which may be deemed as natural simulations of "as if" situations. Therefore, these complex phenomena range from an altered perception of one's own and others' bodies (Petkova and Ehrsson, 2008; Keizer et al., 2016) and powerful experiences based on the violation of laws of physics and logic (Ritter et al., 2012, 2014), to paradoxical situations almost impossible before the coming of new advanced technologies such as virtual reality, augmented reality, and mixed reality. Complex experiences are possible not only thanks to new technologies but especially through their intersection with artistic practices and storytelling. Indeed, the semiotic framework provided by art can be used to amplify the potential of these experiences. Within this arising framework, being "complex" has often been referred to as human experiences featured—at the emotional level—with several even conflicting nuances, often overlapping opposing components, - at the cognitive level—with a novel way of thinking based on complex systems' theory and schema violations, - at the perceptual level—with the ability to generate new states of consciousness or awareness regarding themselves, others, and the world, in individuals. Finally, at the overall level, all these components can be merged to generate an emerging phenomenon not easily separable in its subcomponents.

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This tentative definition can be considered as data driven, since, before collecting all the articles in this research topic, it would have been hard to accrue a sufficient number of recurrent features that could be associated with the same class of phenomena.

Indeed, the theoretical and methodological endeavor of researchers in both shaping new conceptual models, as well as in defining new methodological guidelines regarding these experiences, has been the main focus point of this research topic. With the hope to build a growing community of researchers around this editorial work, we systemized all the contributions by outlining where complexity dwells within all the works and phenomena investigated within this research topic. To this end, we discussed complexity associated with human experiences in terms of (i) emotional experiences including conflicting nuances and often overlapping opposing components, (ii) complex thinking and violations of basic worldviews, and (iii) overall experiences encompassing all the previous levels along with a perceptual level, which includes the ability to generate new states of consciousness or awareness regarding themselves, others, and the world, in individuals.

STUDYING EMOTIONAL EXPERIENCES: A STORY STILL TO BE WRITTEN

Within this broad category, it would be possible to include, especially, all the studies focusing on complex emotional experiences (Grossmann et al., 2016; Berrios, 2019), such as awe and the sublime, as well as their impact on human behavior and cognition and those researches providing new methodological advancements for the study of emotions in general. The emotion of awe and the sublime are closely intertwined—if not overlapped—and their nature is far from being fully elucidated due to the complex interplay between negative and positive emotional subcomponents (Arcangeli et al.), along with the appraisal themes of vastness and the need for accommodation, which were suggested as underlying dimensions of both phenomena (Arcangeli et al.). Understanding of awe's complexity has been deepened by Chirico and Gaggioli, and it was featured as a long-lasting experience unfolding over time across different levels of complexity, from the electrical to the existential. Crucially, the key effects of awe have been indicated as potentially able to counteract some major symptoms of depression, such as hopelessness and rumination (Chirico and Gaggioli), given the transformative impact of this emotion, which emerged in the work of Sawada and Nomura. In this study, (positive) awe resulted as a driver of tolerance toward others' norm violations, thus hinting at a link with cognitive flexibility, another asset to modulate depressive symptoms (Soltani et al., 2013).

METHODOLOGICAL ADVANCEMENTS IN STUDYING EMOTIONAL EXPERIENCES

At the methodological level, Balsamo et al. proposed a new framework for validating emotional stimuli suitable for experimental testing, which takes into account the complex interplay between emotions and their evolutionary function (in terms of elicitors' relevance and salience), overcoming standard dimensional and discrete models. This bottom-up validation approach allowed the selection of a new set of emotional images as well as common stimuli metrics researchers can rely on, thus respecting the complex interplay between emotions and their implicit effects on cognition and behavior. Things get more complex when dealing with a special kind of emotional stimuli, that is, faces. This is the field of emotionally expressive face recognition, in which a recent study by Zsido et al. showed that both adults and children were able to detect happy faces significantly faster than angry or fearful faces. Crucially, children also took significantly less time to find angry faces compared to fearful ones. Moreover, while children were slower than adults in recognizing the emotional expressions of other children or adults (regardless of the emotion displayed), adults were more sensitive than children in detecting emotions on the faces of other peers (adults) vs. faces of children. These results also suggested the intervention of an implicit component, that is, meaning, in the perceiver of emotional facial expression, thus opening up further research questions concerning the developmental trajectory of this process.

DEVELOPMENTAL TRAJECTORIES IN WORLDVIEWS AND COMPLEX THINKING

To approach a complex phenomenon—such as the typical co-existence of multiple perspectives, theories, and models occurring within the didactics of psychology—a new way of thinking relying on complexity theory can be applied (Harmat and Herbert). Complexity thinking adopts a wide range of methods to study complex phenomena (Davis and Sumara, 2014), and it has been recently proposed for mapping teaching practices concerning psychology within Swedish secondary schools (Harmat and Herbert). One of the major challenges emerging from this study concerned the transformation of theories into practice, which should be operated by the pupils according to their own experiences and always in relation to a meso level (i.e., teachers' practices and knowledge) until a macro societal level of analysis has been reached. This constant self-reflection should be at the base of self-knowledge as an emergent property of interactions between the micro-level (i.e., students' knowledge), meso level (i.e., teachers' knowledge), and the macro one (i.e., societal). Overall, this approach should help students to see beyond the fragmentation of theories and models within psychology and to capture the sight of the whole by integrating new knowledge into existing knowledge, and, if necessary, also to restructure their implicit assumptions of lay psychology, which should be replaced with new incoming information (Harmat and Herbert; Tulis, 2018).

Indeed, all individuals are characterized by their inner assumptions regarding themselves, other people, and the world. In this last case, these generalized beliefs about how the world works are called Primals or Primal world beliefs (Clifton et al., 2019). While past theories usually endorsed a retrospective

account of primals as shaped by past experiences e.g., (Janoff-Bulman, 1989; Foa and Rothbaum, 2001), (Clifton), instead, supported an interpretative approach and reported preliminary evidence in favor of this latter theory, coming from his past works on Primals (Clifton et al., 2019). However, since the core question concerning the potential of specific experiences in shaping Primals or vice versa persisted, a novel model was developed—the Cube Framework—mapping human experiences on three continua: (i) chronic-acute, (ii) internal-external, and (iii) positive-negative. From the permutations of these three dimensions, the author derived eight types of experiences that are worth further investigation in relation to Primals: bad choices, good choices, bad habits, good habits, bad luck, good luck, bad times, and good times. The author concluded with some pessimism concerning the reliability of some natural life experiences in shaping Primals. In the following paragraph, we illustrated some studies investigating the transformative potential of some ecological experiences on specific cognitive and emotional processes, including some relatively stables ones (Chirico et al., submitted).

We concluded here, focusing on a specific population: the elderly. Special attention has been devoted to a pervasive experience—the use of internet—which resulted in participants being able to change their accustomed attitudes, perceptions, and beliefs toward their life, others, and the world. Individuals who spent more time on the Internet perceived more Online Social Support, but developed more negative evaluations regarding themselves (i.e., self-esteem) and regarding their own life (i.e., Satisfaction with life). Therefore, change in relatively stable attitudes, beliefs, and perceptions was seen to be possible across the entire life span. However, some core beliefs—which are usually more resistant—may need peculiar complex experiences to change.

COMPLEX EXPERIENCES IN NATURALISTIC AND ECOLOGICAL CONTEXTS

Awe and the sublime resulted as hardly definable emotions, and recently have been better described as experiences due to their inner complexity (Chirico and Gaggioli, 2018). This change was not required for another more frequent complex experience often labeled as "optimal," which is flow. Flow can be defined as the optimal psychological state in which perceived challenges are perfectly in balance with perceived skills required to perform a task, with clear goals, a sense of altered time, loss of self-consciousness, and increased sense of control over the task, which provides unambiguous feedback and a sense of being fused with the task itself (Csíkszentmihályi, 1990; Csikszentmihalyi and Csikszentmihalyi, 1992). Flow can be improved and solicited by means of different practices—which usually require active involvement- but recently, recurrent Qigong meditative practices were shown to be able to increase flow intensity over time along with positive affect (Pölönen et al.).

There is another pervasive multifaceted experience deemed as complex, which concerns individual's ability to hear with their "mind's ear" while not physically present, that is, musical imagery. Cotter showed that by endorsing a complexity thinking approach—by integrating multiple theories, evidenced from different literatures on this topic—in order to capture the sight of the whole, was also possible to recognize the basic rules underlying this "system" as well as to capture all its nuances. Specifically, two dimensions were identified to explain mental control in music-imagery, namely, the extent to which this experience begun voluntarily, and the degree of control after the experience occurred.

On the other hand, some classes of complex experiences were shown to be rarer than flow, and usually occur in response to novel, unexpected events able to drag people far from their realm of normality. This is the case of Diversifying Experiences (DEs). A natural setting of occurrence of this class of experiences was provided by an artistic format called "Dialogue in the Dark" (DD), which was proposed in Milan to normal sighted people and concerns a path in the absence of light. The format seeks to answer the question of what it would be like to live as a blind person for some time. A recent study (Chirico et al.) aimed to test the transformative potential of this experience in terms of increase in creative thinking vs. an equivalent experience in a park. Although results did not show a significantly higher creative thinking ability in the group undergoing the DD (vs. control group in the park), this experience resulted as more impacting, and generated significantly more intense positive emotions than the control. A key variable missed in this study was the effect of time on creative performance.

In another recent study, the effect of time was, instead, taken into consideration in the domain of blindness (Rindermann et al.). Specifically, preliminary evidence showed that visually impaired children performed significantly better in working memory tasks compared to children without visual impairment, but worse in terms of verbal comprehension (Rindermann et al.). A condition of visual impairment, alike the deprivation of light, if protracted, may be considered as a specific natural complex experience whose transformative potential unveils in the cognitive domain of memory and language.

Finally, traumatic life events have been always considered as potentially transformative experiences able to re-shape individuals' mental schema and assumptions regarding the word, themselves, and the others. By means of Virtual Reality (VR) simulations, nowadays, it would be possible to help women who lost their child to manage their complex emotions in a safe and controlled environment. Specifically, Corno et al. proposed an intervention protocol for women who lost their child consisting of VR emotional environments featuring events with their various emotional state related to the loss of their child. The multifaceted emotional experience characterizing perinatal loss, thus, could be simulated, managed, and overcome within a safe, controlled setting, under the supervision of expert clinicians and professionals.

CONCLUSIONS

These contributions enabled the outlining of an emerging perspective in which complexity can be seen as a general attitude to study long-standing constructs (e.g., emotions, musical imagery, and working memory) in a novel way, by looking at

the whole picture instead of stopping at the fragmented existing literatures and methods. Then, complexity was included as an adjective qualifying some experiences, which were the main object of interest of this research topic. For instance, some emotions have already been deemed as complex by other scholars (Berrios, 2019), and some cognitive processes already relied on the complex system theory as a general framework (Harmat and Herbert). Other phenomena have been explicitly labeled as "complex" only within this RT for the first time, and the method adopted for their analysis drew from and advanced existing models and methodological approaches to create a new one (Balsamo et al.). Some boundaries to study complex experiences within social science have been drawn. However, more systematic works collecting all these types of experiences would still be required.

Specifically, we learnt that it is possible to "think" in a complex way—which does not mean think of something complicated, instead, it entails dealing with the multifaceted nature of a phenomenon avoiding excessive reductionism or determinism. Then, complexity, often, resulted as related to something relatively stable, such as our beliefs toward the world, which may be violated to generate a sort of "update" of the whole system. Sometimes, complexity unfolds from a mixed emotion to an optimal experience, and some other times, it requires something more disruptive or diversifying, stemming from a basic violation—such as leaving our routine in the absence of life—to something transformative, both in a positive and in a negative way, that is, a traumatic way. All these experiences can shape our view of the world across the lifespan, and also, elderly people are not exempt from these phenomena. Crucially, methods adopted to consider the complexity associated with a natural experience can reveal new ways to see long-lasting phenomena.

A natural question that could be asked is: what's next? We would say, a lot.

First, researchers should orient their attention toward a systematic analysis of the theoretical link between complexity and experience. If for the former scholars can rely on the works of the psychology of complexity, for the latter aspect, it would be reasonable to draw from philosophy, still, to nurture a more substantial dialogue with philosophers. Finally, the Cube framework looks like a promising lens to capture the inner transformative potential of some experiences.

Then, the concept of schema violation may need a more ecological paradigm to be investigated—such as some art installations reproducing paradoxical scenarios, like the Dialogue in the Dark or some conditions such as blindness—and more comprehensive measures to be analyzed, thus, primal world beliefs are already showing themselves to be a good candidate. Crucially, the design of complex experiences still occupied a small portion of this research topic. Nevertheless, this aspect is usually a driver for translating sophisticated models and theories into something accessible to all individuals. The applied side of complex experience is urgently needed.

Finally, if living deals with complexity, and if psychology—as a social and human science—deals with experiences, then it is urgent to reconcile complexity and experience even in science, since one cannot exist without the other.

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AC wrote the first draft. AG supervised the entire process. AC and AG gave contributions on the future steps, rhetoric, and rational. Both authors have contributed to conceptualizing and writing this Editorial and approved this version of the manuscript.

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Mental Control in Musical Imagery: A Dual Component Model

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Hearing music in your head is a ubiquitous experience, but the role mental control plays in these experiences has not been deeply addressed. In this conceptual analysis, a dual-component model of mental control in musical imagery experiences is developed and discussed. The first component, initiation, refers to whether the musical imagery experience began voluntarily or involuntarily. The second component, management, refers to instances of control that occur after the experience has begun (e.g., changing the song, stopping the experience). Given the complex nature of this inner experience, we propose a new model combining and integrating four literatures: lab-based auditory imagery research using musical stimuli; involuntary musical imagery; mental rehearsal and composition in musicians; and *in vivo* studies of musical imagery in everyday environments. These literatures support the contention that mental control of musical imagery is multi-faceted. Future research should investigate these two components of mental control and better integrate the diverse literatures on musical imagery.

Keywords: musical imagery, mental control, involuntary musical imagery, auditory imagery, conceptual analysis

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INTRODUCTION

Engagement with music is pervasive—we subscribe to music-listening services, star in mini-concerts during our showers and commutes, and are bombarded by upbeat, bopping tunes when shopping. Our musical experiences are not limited to our external environment, however—we also hear music in our "mind's ear." Musical imagery can broadly be described as hearing music in one's head not simultaneously present in the environment (Bailes, 2007; Cotter et al., 2018). People report hearing musical imagery often in everyday life (approximately 25% of the time, Liikkanen, 2011; Cotter et al., 2018).

These common internal experiences also vary in their complexity. In some experiences, people only imagine select components of the music (e.g., melody, vocals) but in others report experiencing more subtle components of the music, such as harmonic lines or different timbres of instruments (Bailes, 2007). Further, these experiences need not be solely auditory. In many cases, people's musical imagery experiences are multimodal and include visual or kinesthetic imagery (e.g., Bowes, 2009) or involve moving or humming to the imagined music (e.g., Cotter et al., 2018). Musical imagery can be embedded in rich internal narratives, such as envisioning yourself performing in a desired role (Bowes, 2009), or echo our current state of mind and personal concerns (Floridou et al., 2015). Musical imagery is a dynamic, complex phenomenon; however, here I focus on only the auditory components of these experiences.

One multi-dimensional model of musical imagery (Cotter et al., 2018) identifies five qualities of everyday musical imagery experiences—valence, repetitiveness, vividness, length, and mental

control. Most research on musical imagery in daily life has emphasized describing the what of the experience—what song, what trigger, what valence, what length. Less attention has been given to how these experiences unfold, change, or stop. The dimension regarding the mental control of musical imagery—an intriguing process involved in starting, stopping, shaping, and maintaining musical imagery—is complex, nuanced, and relatively understudied. Mental control can be further broken down into two primary components—initiation and management (Cotter et al., 2018). Initiation refers to how the episode of musical imagery begins—was it started on purpose or did it appear spontaneously? Management refers to attempts to control the musical imagery episode after it has begun. Management can take different forms, and research has focused on a few flavors of management: altering components of the music (e.g., pitch, tempo), sheltering and sustaining the experience amid distractions, and stopping the experience (e.g., Holmes, 2005; Beaman and Williams, 2010; Williamson et al., 2014; Cotter and Silvia, 2018). When thinking about control this way, it becomes evident that one episode of musical imagery can be controlled in one way but involuntary in another.

By discussing mental control of musical imagery this way, we can reflect on what the field has already examined and where we have yet to go. When re-examining the research traditions in musical imagery, it's evident this framework provides new ways of organizing and interpreting what we know about mental control of musical imagery and demonstrates that seemingly different musical imagery experiences have more in common than they first appear to. Additionally, by having a common language with which to describe these mental control processes, we can better articulate what we already know, develop research questions that become obvious once operating within this framework, and refine our assessment of mental control.

In this conceptual analysis, I focus on only the dimension of mental control and examine what is known about the mental control of musical imagery in psychology and musicology. I demonstrate that mental control of musical imagery can be broken down into two distinct components—initiation and management. I analyze lab-based auditory imagery work using musical stimuli and explore how the principles of mental control established through auditory imagery research can be applied to musical imagery experiences in daily life. Because musical imagery in the lab and in daily life are related experiences, these principles can be further refined to address the greater complexity inherent in musical imagery in everyday life. This conceptual analysis also applies the dual component model to three everyday musical imagery approaches: involuntary musical imagery, mental rehearsal and composition, and ecological musical imagery (which emphasizes assessing musical imagery as it is happening in people's everyday lives).[1]

[1]Here, I emphasize the cognitive and behavioral aspects of mental control in musical imagery; of course, such a review of imagery invites a discussion of the brain and its underlying neurobiological correlates, but the complex neuroscience of musical imagery is best reserved for a separate paper.

KEY CONCEPTS FROM AN AUDITORY IMAGERY APPROACH TO MUSICAL IMAGERY

Musical imagery is one example of auditory imagery. Auditory imagery research, rooted in cognitive psychology, has often used tonal and musical stimuli in its lab-based paradigms to investigate principles of people's auditory imagery experiences—this section focuses only on studies using musical stimuli. These music-based auditory imagery studies assess a range of people's auditory imagery capabilities, from simple imagery-assisted pitch discrimination to complex mental transformations of melodies. Although this literature does not formally discuss mental control, the natures of the tasks provide support for the two proposed components of mental control—initiation and management. **Table 1** provides descriptions of the tasks used in auditory imagery research.

Initiating Musical Imagery

Inherent in any auditory imagery task is the need to construct a mental image. In early work, the imagery tasks were relatively simple—imagining the pitch of a presented tone and completing a signal detection task (Farah and Smith, 1983). These results suggest that people can form images of single tones at will, and these images facilitate auditory perception via a reduced detection threshold for imagined pitches as compared to non-imagined pitches. In Pitch Discrimination tasks (see **Table 1**), participants imagine specified tones, chords, or short passages of music (e.g., musical scales, simple melodies) and assess whether auditory probes match the pitch of their constructed image (Janata and Paroo, 2006; Herholz et al., 2008). On average, people demonstrated the ability to form the requested images with reasonable accuracy for single tones and chords (60–95% correct; Hubbard and Stoeckig, 1988), musical scales (78% correct when probe in tune; Janata and Paroo, 2006), and simple melodies (60 and 87% correct for non-musicians and musicians, respectively; Herholz et al., 2008). Overall, this suggests people can initiate musical images when asked.

Sustaining Musical Imagery

Several studies also assess people's ability to manage their established images, such as deliberately sustaining the image—Hubbard's (2018) recent review of auditory imagery suggests this may be an overlooked dimension of control. In several Pitch Discrimination and Timing Judgment studies (see **Table 1**), participants hear the first few notes of a musical passage and imagine the remainder of the passage to determine whether a subsequent probe tone matches the pitch or timing of the imagined music (Bailes and Bigand, 2004; Janata and Paroo, 2006; Herholz et al., 2008; Weir et al., 2015). In one Timing Judgment study, participants were instructed to imagine the continuation of music for as long as possible and, when they were no longer able to continue the imagined music, to "check in" with the actual progression of the song by raising the volume of the stimulus song (Bailes and Bigand, 2004). The results indicated that the check-ins were related to structural properties in the music, suggesting

TABLE 1 | Descriptions of auditory imagery tasks.

Methodology	Description	Studies
Pitch Discrimination	Participants are presented with auditory stimuli (e.g., tones, song excerpts) and imagine music related to the initial stimuli, such as replicating it or imagining the continuation of the excerpt. People's images are then probed for pitch accuracy by determining whether a target tone or musical notation matches their imagery. These tasks often require people to sustain their images.	Janata and Paroo, 2006; Herholz et al., 2008; Bailes et al., 2012; Weir et al., 2015
Timing Judgment	Participants listen to the beginning of a song excerpt and imagine the continuation of the excerpt. People's images are then probed for timing accuracy—participants are presented with music from the same excerpt and determine whether it is in time with their image or is appearing too early or late. These tasks often require people to sustain their images.	Bailes and Bigand, 2004; Janata and Paroo, 2006; Weir et al., 2015
Temporal Accuracy	Participants are instructed to imagine music excerpts of varying lengths. For each excerpt, participants indicate when they have imagined the full excerpt. These tasks often require people to sustain their images.	Halpern, 1988; Halpern and Zatorre, 1999
Lyric Comparison	People are shown lyrics from well-known songs with two of the lyrics capitalized (e.g., happy BIRTH-day to YOU). Participants then determine whether the second capitalized lyric is on a pitch higher or lower than the first capitalized lyric. These tasks often require people to sustain their images.	Zatorre and Halpern, 1993; Aleman et al., 2000
Loudness Profile	People listen to a musical excerpt that varies in loudness during the passage. Participants then imagine the same excerpt, including its loudness profile, and use a slider to indicate the loudness profile of their image. These tasks often require people to sustain their images.	Bailes et al., 2012; Bishop et al., 2013a
Contour Tracking	People hear short melodies. People imagine each melody and indicate whether the pitch of a note was higher, lower, or the same as the prior note. These tasks often require people to sustain their images.	Weber and Brown, 1986
Tempo Judgment	People listen to or imagine excerpts of well-known and familiar songs. People then indicate the tempo of the music by tapping with their finger to the beat or by using a dial to adjust the speed of a click track so it matches the beat of the music. These tasks often require people to sustain their images.	Jakubowski et al., 2015, 2016
Pitch Manipulation	Participants are presented with initial tone(s) and manipulate the pitch of the tones to be higher or lower as specified. People then complete a pitch discrimination task. These tasks require people to alter the pitches of their images.	Hubbard and Stoeckig, 1988; Gelding et al., 2015
Melody Transformation	Participants hear a melody and are presented with a test melody that has been transformed—in a new key or reversed—or an untransformed control melody. People indicate if the test melody, when transformed, matches the first melody. These tasks require people to alter the key or temporal order of an excerpt using imagery.	Foster et al., 2013

that people can sustain images of sections of music, but when the piece shifts to a new section, people have difficulties imagining these transitions.

Other sustention work uses Temporal Accuracy tasks (see **Table 1**), which ask participants to indicate when their image of the passage reached the end (Halpern and Zatorre, 1999) or when they reach a specific point in the excerpt (Halpern, 1988). In Lyric Comparison studies (see **Table 1**), people are presented with two lyrics from a well-known tune (e.g., "Happy Birthday") and are asked which of two lyrics has an associated note higher in pitch (Zatorre and Halpern, 1993; Aleman et al., 2000). In these basic sustention studies, people are able to maintain short images of familiar tunes (Zatorre and Halpern, 1993; Aleman et al., 2000; Herholz et al., 2008; Weir et al., 2015) and musical scales (Janata and Paroo, 2006) to perform the Pitch Discrimination and Timing Judgment tasks, but they tend to have more accurate pitch discrimination than timing judgments (Janata and Paroo, 2006; Weir et al., 2015).

Researchers have also used more complicated sustention tasks that involve continuous monitoring of an image. A more complex Pitch Discrimination task involved listening to a melody and judging whether the subsequently presented notation matched the heard melody (Bailes et al., 2012). To evaluate similarity, participants needed to generate an image of the notation and monitor their image for deviations from the target melody—on average, participants made accurate judgments approximately 70% of the time. Additionally, Contour Tracking work (see **Table 1**) finds that people can monitor changes in pitch across a musical passage via reporting whether a pitch is higher or lower than the one that immediately preceded it (Weber and Brown, 1986).

In Loudness Profile studies (see **Table 1**), participants listened to passages of music, paying special attention to the loudness throughout the piece. They then imagined the musical passage and indicated the dynamic contour of the piece using a slider during both the listening and imagining portions (Bailes et al., 2012; Bishop et al., 2013a). People were able to produce a dynamics profile of the imagined passage similar to the dynamics profile produced when listening to the passage.

Other studies using Tempo Judgment paradigms (see **Table 1**) ask participants to listen to or imagine specific pieces of music and indicate what they believed to be the correct tempo (Jakubowski et al., 2015, 2016). Unsurprisingly, people are most accurate when listening to a song (Jakubowski et al., 2016). Interestingly, increased physiological arousal influences tempo judgments—people chose faster tempos for both perceived and imagined music after a physical versus mental task (Jakubowski et al., 2015). In both Tempo Judgment studies, however,

people were able to sustain their image to complete the tasks. Collectively, this work demonstrates people's ability to maintain a musical image and suggests that in addition to making single, isolated judgments about their musical imagery (i.e., pitch discrimination, timing accuracy) people can monitor temporal qualities of their musical imagery.

Manipulating Musical Imagery

Although sustaining musical imagery is one example of management, the more intuitive sense of management is the ability to manipulate and alter aspects of an image. In one Pitch Manipulation study (see **Table 1**), participants were presented with a single tone or chord and asked to imagine the tone or chord one step higher—their image was then probed for accuracy (on average 60–95% correct; Hubbard and Stoeckig, 1988). In a more complex Pitch Manipulation study, participants were presented with the first few notes of ascending or descending scales and imagined subsequent notes that were higher or lower in pitch as specified via up or down arrows (Gelding et al., 2015). After imagining multiple notes, a probe tone was presented for a pitch discrimination judgment to assess the accuracy of participant's images. Musicians tended to be more accurate than non-musicians (82 vs. 76% accuracy, respectively).

Researchers have also examined people's ability to perform complex mental manipulations using a Melody Transformation task (see **Table 1**; Foster and Zatorre, 2010; Foster et al., 2013). Musicians were presented with a target melody and needed to determine whether the test melody was the same as or different from the target. The test melody, however, was heard in one of three forms: reversed melodies (i.e., the melody was played from the end to the beginning), transposed melodies (i.e., the melody was played in a different key), and control melodies (i.e., the melody had not been transformed). To determine whether the test and target melodies were identical, participants needed to mentally transform the test melody to be in the same key or temporal order for comparison. Unsurprisingly, people were most accurate when presented with control melodies (between 76% and near 100% accuracy) and were less accurate when presented with transposed (69–90% accuracy) and reversed melodies (80% accuracy; Foster and Zatorre, 2010; Foster et al., 2013). These findings suggest that manipulations people make to their musical imagery can vary in complexity and difficulty.

Additionally, a survey measure—the Bucknell Auditory Imagery Scale (BAIS; Halpern, 2015)—has been used to assess the vividness and control of auditory imagery. In the vividness subscale, people are instructed to generate images of specific auditory experiences (e.g., a trumpet playing the beginning of "Happy Birthday") and rate the lifelikeness of the resulting image. To assess control, people perform changes to the established auditory images (e.g., the trumpet stops playing and a violin finishes the song), like the management component of the proposed model, and indicate the ease of performing these manipulations. Not all items involve musical imagery, however—several items involve manipulating auditory images of environmental sounds (e.g., waves crashing against rocks on a beach) or human voices (e.g., the sound of an elderly clerk assisting you over the phone).

Performance on the BAIS-Control subscale suggests there are individual differences in the self-reported ability to control auditory images and, in some cases, predicts performance on auditory imagery tasks. In several cases, higher self-reported imagery control predicted better accuracy (Gelding et al., 2015; Greenspon et al., 2017) on auditory imagery tasks involving pitch judgments, and people who are more accurate in singing specific pitches (Greenspon et al., 2017) or have more musical experience (Gelding et al., 2015) report better control abilities. Interestingly, people reporting better control abilities were better able to predict changing beat intervals (as opposed to reacting to changes in beat intervals) during a sensorimotor synchronization task requiring updating beat representations while listening to music (Colley et al., 2018). People with higher BAIS-Control subscale scores were also better able to synchronize with the music (Colley et al., 2018). In other cases, however, the BAIS-Control subscale was unrelated to tempo-related judgments, such as tapping to the beat of imagined or heard music (Jakubowski et al., 2016).

Limitations of the Auditory Imagery Approach to Musical Imagery

This work, however, has not explored the complexity of these experiences outside of the lab. In classic auditory imagery studies, the stimuli are single tones or chords or simple melodic lines (e.g., Farah and Smith, 1983; Hubbard and Stoeckig, 1988; Janata and Paroo, 2006) and more recent studies have used both simple (e.g., Foster et al., 2013; Gelding et al., 2015) and somewhat more complex stimuli (e.g., Bailes et al., 2012; Weir et al., 2015). But the considerable heterogeneity and idiosyncratic nature of everyday musical imagery contents has not been captured in the lab-based auditory literature. Often, everyday musical imagery contains familiar, recently heard songs (Liikkanen, 2008, 2011; Williamson and Jilka, 2014); other times, people use musical imagery as a tool to develop original compositions (Cowell, 1926; Mountain, 2001) and to rehearse for performances (Holmes, 2005; Bailes, 2007). Thus, a focus on only musical imagery experiences in controlled lab settings paints an incomplete picture of people's musical imagery experiences outside of the lab. Indeed, the mind wandering literature has documented both similarities and differences between lab and daily life mind wandering experiences (McVay et al., 2009; Kane et al., 2017).

When applying this mental control framework to daily life, it is necessary to recognize that initiation and management of musical imagery in daily life will not look identical to these components when examined in a lab. First, in lab studies participants initiate and manipulate musical imagery as specified by researchers. Although possible, it is unlikely that in daily life someone is playing the first few notes of the Bb major scale and requests that another person imagines the rest of that scale or for someone to be told to imagine a single tone and be asked, "Is this your note?" People have a variety of motives for deliberately initiating and managing musical imagery that are not captured in lab experiments. Additionally, the nature of lab-based auditory imagery tasks is predicated on people willfully initiating and managing specific musical images, making it difficult to study involuntary or uncontrolled instances of musical imagery (see

Hubbard, 2018); however, recent studies have begun to induce involuntarily initiated musical imagery experiences to better understand these processes (e.g., Hyman et al., 2013; Floridou et al., 2017; Moeck et al., 2018).

MAJOR APPROACHES TO MENTAL CONTROL IN EVERYDAY MUSICAL IMAGERY

Everyday musical imagery research can be grouped into three approaches: (1) the involuntary musical imagery approach; (2) the mental rehearsal and composition approach; and (3) the ecological musical imagery approach. Although each approach focuses on a different slice of musical imagery, all three provide support for the dual-component model.

Involuntary Musical Imagery Approach

Recent everyday musical imagery research has focused on involuntary musical imagery—experiences defined as being "spontaneous" and "uncontrolled" (e.g., Liikkanen, 2008, 2011; Floridou et al., 2015). Although there has been some recent debate surrounding what exactly involuntary musical imagery is (see Williams, 2015 for review, and Hubbard, 2018 for a more general commentary on terminology), the "earworm"—involuntary, repetitive musical imagery—is the classic case that has received the most attention.[2]

Hearing earworms is a nearly universal experience (Liikkanen, 2008; Floridou et al., 2015), but these experiences vary. In some instances, people enjoy it (Beaman and Williams, 2010; Williamson and Jilka, 2014; Filippidi and Timmers, 2017) but in others wish the music would disappear (Liikkanen, 2011; Williamson and Jilka, 2014). Some people have a seemingly never-ending stream of involuntary musical imagery (Brown, 2006; Lipson, 2006) whereas others experience brief episodes (Floridou et al., 2015). Involuntary musical imagery can be triggered in many ways, such as by hearing a song recently (Halpern and Bartlett, 2011; Williamson et al., 2011; Hyman et al., 2013) or by personal concerns or worries (Floridou et al., 2015), or for no apparent reason (Kvavilashvili and Mandler, 2004; Hyman et al., 2013; Floridou and Müllensiefen, 2015). The common denominator is that they are involuntary.

But what exactly is meant by "involuntary" is inconsistent in the literature. In a few definitions, the involuntariness refers to initiation—the music appeared spontaneously and without intention. For example, involuntary musical imagery has been described as a "short musical piece, which comes to the mind unintended" (Floridou et al., 2017, p. 2189) and "subjectively hearing music playing in one's mind without the individual actively retrieving it" (Filippidi and Timmers, 2017, p. 312) or as music that "intrudes into consciousness without deliberate effort" (Liikkanen, 2011, p. 237) and as "songs [that] often enter the mind without conscious volition" (Hyman et al., 2015, p. 14). Elsewhere, it appears that the focus is the inability to manage the imagery, with involuntary musical imagery being described as songs "that get stuck in your head even though you do not want them to stay there" (Beaman and Williams, 2013, p. 402) or "the experience of an inability to dislodge a song and prevent it from repeating itself in one's head" (Beaman and Williams, 2010, p. 637). Still other definitions state that both the initiation and management are involuntary, such as a "short section of music that comes to the mind spontaneously without effort and then goes on repeating itself without conscious control" (Floridou and Müllensiefen, 2015, p. 472) or "the spontaneous recall and repetition of a piece of music within the mind" (Jakubowski et al., 2018, p. 2). The only scale of involuntary musical imagery experiences defines it as when a "short section of music comes into the mind, spontaneously, without effort, and then repeats without conscious control" (Floridou et al., 2015, p. 28).

The same term is used, but how mental control is discussed lacks consistency. Williams (2015), in his review of this literature, echoed many of these terminology concerns and concluded that involuntary musical imagery is a superordinate category that contains experiences such as earworms, musical dreams, and musical synesthesia. To Williams (2015), the key feature is that these experiences must be involuntarily initiated. More recently, researchers have also induced involuntary musical imagery in the lab (e.g., Hyman et al., 2013; Floridou et al., 2017; Moeck et al., 2018), demonstrating the ability to also examine involuntarily initiated musical imagery in the lab setting.

Although management is not explicitly referenced as a separate aspect of mental control, the involuntary musical imagery literature does provide evidence for its existence. This literature often asks about people's ability to either change the content of their musical imagery or to end the experience. For example, in two separate studies participants were asked what activities they engaged in to get rid of their involuntary musical imagery (Beaman and Williams, 2010; Williamson et al., 2014)—people reported a variety of activities including imagining a different song, thinking of something other than the music, or engaging in an external task to end the experience (e.g., chewing gum; Beaman et al., 2015). Additionally, a small portion of people (3%) said that they never attempt to get rid of their involuntary musical imagery (Williamson et al., 2014). Other work also finds that people who find it more difficult to get rid of their involuntary musical imagery tend to have longer episodes of involuntary musical imagery and find them more worrying (Beaman and Williams, 2013). Although correlational, this suggests there are individual differences in management ability. Interestingly, findings pertaining to these types of items are not described as instances of control and sometimes episodes of involuntary musical imagery are described as malleable, involuntary experiences and that there are "many anecdotal descriptions that people successfully use active behaviors to manage their [involuntary musical imagery]" (e.g., Williamson et al., 2014, p. 2). Additionally, several involuntary musical imagery studies have examined the length of these experiences, further suggesting that this type of musical imagery can

[2]Involuntary musical imagery should not be confused with musical hallucinations, which are instances of musical imagery that are due to the presence of neurological or psychiatric disorders (Evers and Ellger, 2004; Hemming and Merrill, 2015). The literature on musical hallucinations are not reviewed here as the emphasis is on non-clinical forms of everyday musical imagery.

be sustained over time (e.g., Beaman and Williams, 2010; Floridou et al., 2015; Hyman et al., 2015).

One study has directly compared involuntary and voluntary musical imagery experiences using a Tempo Judgment paradigm (see **Table 1**; Jakubowski et al., 2018). They compared people's perceptions of tempo for involuntarily and voluntarily initiated musical imagery of the same song and found that representation of the tempo for the two episodes was not significantly different. Like the auditory imagery studies using a similar paradigm, this suggests people can sustain involuntary musical imagery episodes. Only a few studies have assessed management, but the inclusion of these types of items suggests multiple ways in which musical imagery can be involuntary and that just because a musical imagery experience begins spontaneously, it does not mean that it always remains uncontrolled.

Mental Rehearsal and Composition Approach

Unsurprisingly, musicians also report using imagery techniques to enhance their performances. To bolster their confidence, some performers report picturing themselves having won a role and performing on stage prior to an audition (Bowes, 2009); others rely on motor imagery to rehearse without fatigue (Bowes, 2009). Musicians use a range of mental imagery techniques, including musical imagery, as tools to improve upon their craft. Research examining musical imagery as part of the musical process—composition and rehearsal—implies that control is a key component of these uses of musical imagery. Although this work does not explicitly use control as a term, descriptions from musicians often imply they rely on controlled forms of musical imagery as a part of their craft.

Mental Rehearsal

Most work has focused on people's use of mental imagery as a rehearsal tool and the efficacy of imagery compared to other rehearsal techniques. In qualitative studies, musicians described the ways musical imagery factors into their rehearsal and performance practices. Musical imagery can be used to achieve several goals—a survey of music students and musicians revealed musical imagery is often used to achieve mastery of a piece, assess technical aspects of music, and rehearse whole pieces (Gregg et al., 2008). Additionally, musicians describe using musical imagery across all stages of musical performance, from their initial learning of a piece (Holmes, 2005) to rehearsals of their repertoire (Holmes, 2005; Bowes, 2009; Fine et al., 2015) and immediately before and during their performances (Holmes, 2005; Bowes, 2009; Keller, 2012; Saintilan, 2014; Fine et al., 2015).

Musicians allude to both initiating and managing their musical imagery experiences. Most frequently, musicians reported running through the piece of music and constructing an image of how a performance should sound (Bowes, 2009; Saintilan, 2014; Fine et al., 2015). For some, there are particular situations in which they employ musical imagery (e.g., "I use [imagery] most specifically in the wings before a performance, or the hallways before an audition," Bowes, 2009, p. 152). In other cases, musical imagery is used to achieve specific outcomes, from improving technical elements of a piece (e.g., "to locate the musical passages that have some kind of difficulty at the rhythmic level, melodic, technical and mentally seek a solution," Bailes, 2009, p. 74; Fine et al., 2015) to meeting stylistic and artistic goals (e.g., "I will hear in my head how I want the first note to sound and the mood I want to convey," Holmes, 2005, p. 225). The musicians do not directly say these experiences are controlled, but it is probable that to achieve these specific outcomes a portion of their musical imagery experiences are intentionally initiated (e.g., using imagery at a specified time) and managed (e.g., mentally working through technical components of a piece).

These studies examining mental rehearsal provide a limited amount of support for the use of initiation and management and any conclusions are largely speculative. These descriptions do, however, identify starting points for work emphasizing when and how musicians employ involuntary and voluntary musical imagery.

There are also quantitative studies examining similar questions that are largely concerned with the effectiveness of using musical imagery as a rehearsal technique as compared to other methods. Multiple studies manipulate the kind of feedback available to participants when they perform and assess impacts on performance quality. In one project, the efficacy of purely mental or physical practice of novel music was compared (Bernardi et al., 2013). Participants provided a baseline performance of unfamiliar piano music and then completed two sessions of either mental imagery or physical practice. The effects for physical practice were stronger, but mental practice did lead to multiple positive performance outcomes—fewer errors, better movement timing, and quicker wrist movements—suggesting purposefully initiated and maintained mental rehearsal does have benefits. Other work has manipulated the type of imagery people used—motor imagery (imagining only movement associated with performance) or non-motor musical imagery (Johnson, 2011). Like Temporal Accuracy tasks (see **Table 1**), participants indicated when they had mentally completed the musical excerpt. Although accuracy did not differ between the imagery conditions, using non-motor musical imagery resulted in greater confidence in tempo accuracy.

An early study assessed when using mental rehearsal is beneficial (Rubin-Rabson, 1941). While learning a new piece, musicians either (1) completed 5 physical practice trials, 4 min of mental rehearsal, and continued physical practice until completing one memorized trial; (2) physically practiced until completing one memorized trial then completed 4 min of mental rehearsal; or (3) physically practiced until completing one memorized trial and an additional 4 min of physical practice. The results indicated that the first method resulted in needing fewer physical practice trials to complete one fully memorized trial than the other methods, suggesting mental rehearsal is beneficial during initial learning of music.

In more complex paradigms, musicians perform pieces under a variety of feedback conditions. In one study, pianists were asked to perform memorized music under four different conditions: (1) normal playing conditions (baseline); (2) without auditory feedback (i.e., the volume on the keyboard was off); (3) without auditory or visual feedback (i.e., the volume on the keyboard was off and they could not see their hands); and (4) tapping

a single key to the beat without auditory or visual feedback (Wöllner and Williamon, 2007). Performances in Condition 2 (no auditory feedback) had timing and dynamic profiles most like baseline performances. A similar study that manipulated the availability of motor and auditory feedback found that depriving performers of auditory, but not motor, feedback impaired performance accuracy as compared to baseline; however, people with better auditory imagery abilities were less affected (Highben and Palmer, 2004). Interestingly, other work found that having motor, but not auditory feedback, did not significantly alter performance dynamics and articulation as compared to having normal auditory and motor feedback (Bishop et al., 2013b). In all studies, participants used imagery to compensate for the absent feedback.

In a related design, participants were presented with a musical score that had a well-known melody from classical music embedded within it, but this melody could not be identified through visual inspection of the score but could using musical imagery (Brodsky et al., 2008). Participants read the score silently, with rhythm distractions (i.e., participant tapping a steady beat while the researcher taps a different rhythm) or with phonatory distractions (i.e., participant singing traditional folk song using the syllable la) and then listened to a melody that was evaluated as being the same as or different from the melody embedded in the score. Participants were able to perform the task, and accuracy was worse than the control condition for both distractor conditions—the two distractor conditions did not differ in accuracy. In a second experiment using the same paradigm, participants were asked to perform finger movements as if they were playing the piece during the score reading period, which improved accuracy in the rhythm distraction condition.

These quantitative mental rehearsal studies are comparable to those from the lab-based auditory imagery approach—they use behavioral methods to assess imagery ability in the lab—so they can be interpreted similarly. In all tasks, people are instructed to imagine specific passages of music. Their ability to do so indicates people can initiate musical imagery. Likewise, these tasks require people to imagine an extended passage, not just a single tone. This means that to complete the task, people are sustaining their image, one form of management. These principles easily transfer from the lab-based auditory imagery research, but these studies differ in their aims. By using richer musical stimuli that more closely approximate music that may be mentally rehearsed (e.g., scores, music from participant's repertoire), these studies demonstrate the ability to control forms of complex musical imagery and that such techniques can be used to accomplish musical goals.

Mental Composition

A smaller literature has discussed the role of musical imagery in composition. Mental imagery has often been thought to be connected to the generation of creative ideas (see Daniels-McGhee and Davis, 1994), and musical imagery can play a role in the composition of original music. Perhaps the most striking example is Ludwig van Beethoven, who continued to compose remarkable music, such as his ninth symphony, after going deaf. Beethoven stated:

> I carry my thoughts about with me for a long time, often for a very long time before writing them down. I can. . .be sure that. . .I shall not forget [a theme] even years later. I change many things, discard others, and try again and again until I am satisfied; then, in my head, I begin to elaborate the work. . .the underlying idea never deserts me. It rises, it grows. I hear and see the image in front of me from every angle (Hamburger, 1952, p. 194).

Examination of documentation of other eminent composers' references to the use of musical imagery echoes the sentiments expressed by Beethoven—imagery is an important aspect of the composition process (Agnew, 1922). Beethoven's remarks and descriptions of Schumann's (Agnew, 1922) and Cowell's (Cowell, 1926) composing strategies suggest that active management of musical imagery also occurs when composing. Additionally, composers report that inspiration often strikes in the form of spontaneous musical imagery (Agnew, 1922; Cowell, 1926; Bennett, 1976). Thus, it appears that while developing a composition sounds like an intentional act, there may also be involuntary, spontaneous bouts of progress.

Within the contemporary scientific literature, there has been very little discussion of musical imagery's role in the composition process, and what does exist relies on theoretical musings, anecdotes, or interviews with a few composers (e.g., Bennett, 1976; Mountain, 2001; Bailes, 2009; Floridou, 2015). These reports, however, do align with the accounts of historical composers. Because musical imagery is free from the physical limitations of the composer (e.g., technical proficiency on an instrument; inability to play multiple parts simultaneously), imagery provides the composer a measure of flexibility (Bailes, 2009; Bailes and Bishop, 2012), and composers are free to experiment and tinker with the music to get closer to the final piece (Mountain, 2001; Bailes, 2009; Bailes and Bishop, 2012). Additionally, composers also report involuntarily initiated episodes of novel musical imagery that they may subsequently use in their own compositions (Floridou, 2015). Based on the limited evidence, there are reports describing both the initiation and management of musical imagery related to composition. But because investigations of musical imagery during the composition process are few and far between and purely descriptive, additional research with broader samples must be done to draw generalizable conclusions.

Ecological Musical Imagery Approach

The final approach uses ecological momentary assessment techniques to measure everyday musical imagery experiences. Researchers tend to take a descriptive, exploratory approach: they seek to describe people's everyday musical imagery experiences. Experience sampling, the most frequently used technique, collects probe-caught musical imagery experiences as they are happening via completion of multiple surveys per day across several days at random time intervals. This method provides researchers with a measure of control over data collection in people's everyday environments (e.g., when people can complete surveys, how frequently people are probed). All studies discussed used experience sampling methods. This approach

preserves differences between episodes that can be obscured when using retrospective survey or interview measures that require respondents to pool their musical imagery experiences (see Cotter and Silvia, 2017 for additional details).

This small collection of studies captures involuntary, voluntary, and creative musical imagery experiences and discuss musical imagery as a general phenomenon experienced by musicians and non-musicians alike.[3] This research has found that musical imagery is frequent (Beaty et al., 2013; Bailes, 2015; Cotter et al., 2018), usually pleasant (Beaty et al., 2013; Cotter et al., 2018), and contain both familiar and self-generated, original music (Beaty et al., 2013; Bailes, 2015). Additionally, the subjective qualities of these experiences, such as valence or vividness, vary between episodes (Cotter et al., 2018).

Much like the other approaches, however, mental control has not been a prominent focus. Most studies in this approach have not differentiated between involuntary and voluntary instances of musical imagery, but some studies have asked questions, like the involuntary musical imagery approach, alluding to people's ability to exert control over their musical imagery. In daily life, people do not frequently initiate musical imagery (Beaty et al., 2013; Bailes, 2015; Cotter et al., 2018)—when asked if they started an episode of musical imagery on purpose, people report doing so approximately 25% of the time (Cotter et al., 2018). Interestingly, when people are asked to initiate an episode of musical imagery in everyday life, both musicians and non-musicians report being able to do so most of the time (61%; Cotter and Silvia, 2018), and all participants were able to initiate musical imagery at least once during the study. Even though not the dominant way musical imagery begins, both musicians and non-musicians do report intentionally initiating musical imagery occasionally in their everyday life and are generally capable of initiating musical imagery when instructed to do so.

Researchers have also assessed people's management of their musical imagery. Like the involuntary musical imagery approach, many of these items involved wanting to get rid of or alter the content of an episode. For instance, some work has asked if people wish the imagery contained different music (Bailes, 2007, 2015) or if they wanted the imagery episode to end (Bailes, 2007, 2015; Beaty et al., 2013). These items do not directly assess management, but endorsement of these statements indirectly implies management failure. Although the reporting of these responses was limited, people did not strongly endorse these items (Bailes, 2007; Beaty et al., 2013), implying that management failure is not the norm. Indeed, when people are asked whether they perceive control over their imagery, people report moderate levels of perceived control (Cotter et al., 2018).

One study has also investigated self-reported management ability (Cotter and Silvia, 2018). In this study, participants were asked to perform five manipulations to their musical imagery—changing the tempo, key, vocalist's gender, primary instrument, and entire song. Participants reported being able to perform the various manipulations between 47 and 72% of the time (see **Figure 1**)—the most difficult manipulation was changing the key of the music whereas the easiest was changing the song. Unsurprisingly, people with greater musical expertise reported a greater ability to perform all manipulations. Consistent with the findings from the auditory imagery literature, people were able to

[3]Some studies within the involuntary musical imagery approach (e.g., Beaman and Williams, 2010; Jakubowski et al., 2018) have also used ecological momentary assessment techniques; however, the ecological musical imagery approach is defined both by its methodology *and* its emphasis on musical imagery in a general sense (i.e., not emphasizing a particular type of experience), these involuntary musical imagery studies are not also reviewed in this section.

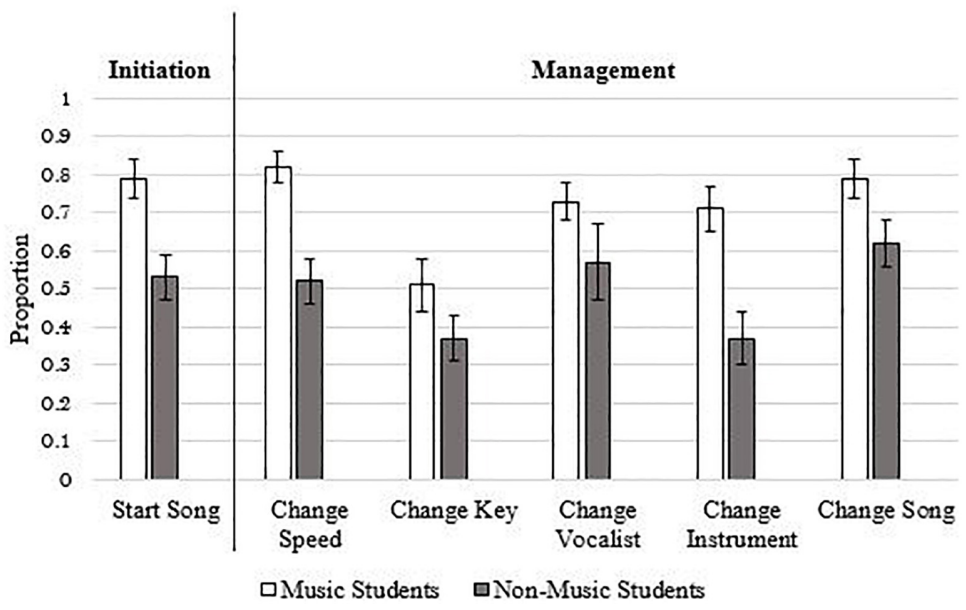

FIGURE 1 | Ability to initiate and manage musical imagery. Errors bars indicate 1 SE. *N* participants = 58, *N* episodes = 1,409. Figure is adapted from Cotter and Silvia (2018).

manage their everyday musical imagery, but there were instances when they failed.

MENTAL CONTROL IN EVERYDAY MUSICAL IMAGERY

Mental control is complex and multi-faceted. In the literature, the concept of mental control has not been explicitly developed—if directly discussed at all—and many studies treat mental control as a unitary construct. But there is a tacit understanding of its multi-faceted nature, based on how researchers describe musical imagery and measure it in practice. Thus, it is necessary to develop and recognize an explicit model of mental control in everyday musical imagery, such as the dual-component model discussed here.

A Dual-Component Model: Initiation and Management

Of the two components, initiation—whether a musical imagery episode begins spontaneously or intentionally—has received the most interest. Because experiencing musical imagery in everyday life is common, a natural question is why we have these experiences. In the literature, this often takes the form of evaluating what triggers these experiences. In several involuntary musical imagery (Hyman et al., 2013, 2015; Floridou et al., 2015) and ecological (Bailes, 2007, 2015) studies of musical imagery, researchers have asked people why they were hearing musical imagery. Frequent responses included hearing the song recently (Hyman et al., 2013, 2015), preparing for a performance (Bailes, 2007), or not knowing exactly why (Bailes, 2007, 2015). But people do also report intentionally initiating their musical imagery. Collectively, the four literatures reviewed support initiation as one component of mental control of musical imagery.

Management, on the other hand, has not been thoroughly discussed or developed as an aspect of mental control, but it has been present in the literature. In many ways, this component is more complex than initiation because there are multiple ways in which musical imagery can be managed—altering features of the music, sustaining the experience, or stopping the episode altogether. Although these examples have not been referred to as ways to control musical imagery, several researchers assessed people's abilities and propensities to manage their musical imagery, through evaluating different mental rehearsal techniques (e.g., Johnson, 2011) or asking people to identify manipulations to a musical excerpt (e.g., Foster and Zatorre, 2010). Overall, these literatures support management as one component of mental control of musical imagery.

But this is not the only phenomena whose underlying processes have been parsed in this manner—the initiation and management distinction presented here has its antecedents in discourse of related phenomena. In the memory literature, we can view the distinction between memories that are retrieved directly through automated activation of a memory from environmental cues and retrieved generatively through actively accessing a specific memory (e.g., Addis et al., 2012; Anderson et al., 2017) as initiation-related distinctions. Similarly, we can discuss rehearsal of memory (e.g., Craik and Watkins, 1973) as a management-related process. In the physical movement literature, research distinguishes between voluntary and involuntary actions and shows that actions that begin involuntarily can be brought under control (De Havas et al., 2016).[4] In the more closely related visual imagery and mind wandering fields, there are also similar distinctions. There exist separate self-report measures of the ability to generate and manipulate visual images (e.g., Gordon, 1949; Sheehan, 1967; Marks, 1973; Halpern, 2015). In the mind-wandering literature, Smallwood (2013) introduced the process-occurrence model that also differentiates between how an instance of mind-wandering begins and how it unfolds. The proposed dual-component model of mental control of musical imagery is grounded in these prior conceptualizations of control. This similarity demonstrates that distinguishing between control processes is fruitful for better understanding each phenomenon and can be a guiding force for further development of the field.

LOOKING BACK AND LOOKING FORWARD: THE UTILITY OF A DUAL-COMPONENT MODEL

What Can a Dual-Component Model Tell Us About Past Research?

Past research has not emphasized mental control, yet there is still valuable information about these processes in past research. With the development of this model of mental control, we can re-examine the literature with an eye toward this mental control distinction. Specifically, differentiating between initiation and management in this dual-component model will help researchers interpret and organize the large amount of prior work in seemingly disparate literatures. Past research's assessments of initiation or management tend to be a few items given only a passing mention in articles (Beaman and Williams, 2010, 2013; Liikkanen, 2011; Williamson et al., 2014). But by re-examining the literature through the lens of the proposed model of mental control, we can better understand and interpret prior work, such as identifying relationships between the two components of mental control or recognizing limitations that were not readily apparent (see **Table 2**).

For example, in the involuntary musical imagery approach emphasizing involuntarily initiated experiences, there are several items (e.g., whether people attempted to stop or change the experiences) that can be used to better divide and understand this class of experience. Based on existing data, it is possible to further differentiate cases of involuntary musical imagery that persist in being uncontrolled from cases in which people manage the experience. This additional specificity allows for

[4]Although physical movement is not solely an internal cognitive process, the inhibition of thoughts can be modeled similarly to the inhibition of actions (e.g., Logan, 1983). Additionally, with the neurological connections between motor imagery and action (Berna et al., 2012) and co-occurrence of motor and musical imagery (Lotze, 2013), these distinctions provide further support for differentiating between control processes in musical imagery.

more refined examination of whether these experiences differ on other dimensions of musical imagery. But this also suggests that current work on involuntary musical imagery is limited because it obscures potential differences between involuntarily initiated musical imagery that remains involuntary and episodes that are deliberately managed. Further, the proposed model describes multiple ways in which a single episode of musical imagery can be involuntary, showing that the label of "involuntary musical imagery" does not convey the same specificity it once did when the field of musical imagery research was less mature.

Additionally, the four literatures have evolved independently with few bridges between them. Researchers commonly review work within their own approach and provide limited, if any, consideration of findings from the other approaches. This is especially true of the mental rehearsal and composition approach, rooted in music education, which is almost completely isolated from the others. But in providing a common language regarding mental control, this model can illuminate how this literature fits alongside the other three. Although this conceptual analysis focuses on one piece of musical imagery experiences, it demonstrates these approaches have similarities.

For instance, musicians reference having music pop into their heads that is then applied to compositions (Agnew, 1922; Cowell, 1926; Hamburger, 1952) or having music they are rehearsing repeating in their minds (e.g., Holmes, 2005), suggesting that involuntary musical imagery processes—a different everyday musical imagery approach—may also play a role in the creation and rehearsal of music. But we can also identify links between lab-based auditory imagery research and musicians' applications of imagery. Musicians report sustaining and mentally playing through music in their repertoire (e.g., Holmes, 2005; Bowes, 2009) similar to the paradigms used in several Pitch Discrimination, Timing Judgment, Tempo Accuracy, Lyric Comparison, and Loudness Profile tasks used to assess management abilities in the auditory imagery literature. Without the terminology and conceptual framework introduced here, drawing such parallels is not as straightforward.

TABLE 2 | Summary of implications of the dual-component model.

How does a dual-component model shape our perspective on existing work?
Re-examining and analyzing existing data
• Fully analyzing items related to initiation or management processes
• Revising interpretations of past work through the perspective of the dual-component model
Identifying weaknesses and limitations of past work
• Lack of precision in currently used terminology (e.g., involuntary musical imagery)
• Recognize limitations of work treating control as a unitary construct and identify ways to clarify existing findings through future work
Drawing parallels between approaches to musical imagery
• Identify ways in which mental control operates and is assessed similarly across different literatures and experiences
• Extend analyses of similarity to other dimensions of musical imagery experiences
How does a dual-component model shape future research?
Combine aspects of different research approaches
• Identify complementary strengths and weaknesses of the different approaches to create new paradigms for future research
• Expand upon initial research blending these approaches to examine musicological features that potentially influence mental control processes
Foundation for further refinement of the model
• Empirically evaluate candidate sub-components of management (e.g., sustention, manipulation, termination)
• Further develop theory regarding cognitive mechanisms involved in initiation and management

How Can a Dual-Component Model Guide Future Research?

Since both initiation and management are evident in the four approaches, a natural step is to apply the lessons from one approach to the others. For example, the strengths of the lab-based auditory imagery approach include its behavioral measurement and emphasis on the cognitive processes underlying imagery. But it often lacks the complexity of musical imagery in everyday life and has limited ecological validity. The ecological approach has the opposite character—research assesses musical imagery in people's daily lives, but its descriptive and self-report nature does not provide the same clarity and validity as the lab-based studies (see Hubbard, 2013, 2018; **Table 2**).

Borrowing techniques would benefit both literatures without compromising their respective focuses. Future auditory imagery work could use more complex stimuli, such as music similar to what is heard in everyday life (e.g., pop songs; Bailes, 2015), to evaluate people's control abilities. Researchers have begun using realistic stimuli in lab-based work (e.g., Godøy et al., 2006; Bishop et al., 2013a; Jakubowski et al., 2015; Weir et al., 2015) and found that people are able to generate relatively accurate musical images of the stimuli. To build upon these studies, additional work should examine how realism of stimuli and related factors (e.g., stimulus complexity, familiarity, instrumental vs. vocal) relate to mental control. Given the considerable heterogeneity of everyday musical imagery contents (e.g., Bailes, 2015; Jakubowski et al., 2016), examination of how musicological factors (e.g., presence of lyrics, complexity of composition, musical genre) influence mental control abilities is a top candidate for future research.

Conversely, future ecological studies should work to adapt the behavioral approaches used in lab-based research to increase the validity of reports. Indeed, there are a few studies that have begun to integrate behavioral and ecological assessment (e.g., singing involuntary musical imagery episodes into a recorder, McNally-Gagnon, 2016; recording tempo of voluntary and involuntary musical imagery via tapping the beat, Jakubowski et al., 2018). With the widespread use of smartphones, future research could, for example, have participants complete Pitch Discrimination or Timing Judgment tasks (see **Table 1**) by listening to musical excerpts and completing specific management tasks that can be used to evaluate the accuracy of their imagery. In this way, the ability to perform these tasks could be assessed across multiple environments and compared to the lab-based findings. This is only one example of how borrowing from other approaches to musical imagery can enrich the field.

Finally, the introduction of this model represents a starting point for formal investigations into the role of mental control in everyday musical imagery and allows researcher to ask many more research questions that otherwise would have remained non-obvious. How do management behaviors differ between voluntarily and involuntarily initiated imagery? Are purposefully initiated episodes easier to manage than involuntary initiated ones? Which personal or environmental factors (e.g., mood, mental fatigue) most closely relate to attempts to control musical imagery? Do these factors differ for initiation and management? These are a few examples of research that can emerge through differentiating between the initiation and management.

Importantly, future research must also investigate these components of mental control of musical imagery concurrently across all approaches to further substantiate the distinction between initiation and management. Since research has yet to examine initiation and management within the same study, the association between these two components and any differential relations with related concepts (e.g., affective valence of the experience, Cotter et al., 2018) are still an open issue. The first step would be to include measures of both initiation and management within the same study to understand the relationship between the two components. This conceptual analysis represents the starting point for such investigations and provides a theoretical basis grounded in four approaches to musical imagery and models of related phenomena (e.g., mind wandering, Smallwood, 2013).

One limitation of this model that should be addressed by future research is that sustaining, altering, and stopping musical imagery are considered examples of management processes but may instead represent sub-components of management or entirely separate components. As past work has not differentiated between ways of controlling musical imagery, the proposed model takes a more general approach through distinguishing between control of the start and evolution of an episode. But it is possible that these examples of management rely on differing, but related, cognitive processes or have different implications for people's musical imagery. For instance, deliberately sustained episodes may have more positive valence than episodes that are altered or stopped. Research could also explore the relation between voluntarily and involuntarily managed episodes of musical imagery (e.g., Is it easier to manipulate an episode that is being voluntarily sustained than one that continues involuntarily? Are involuntarily sustained episodes more difficult to stop?). To date, no research has examined sustention, manipulation, and termination of musical imagery episodes individually and thus a parsimonious approach to mental control of musical imagery was adopted. Further work is necessary to better understand how these dimensions of management relate to one another and whether there are additional components of mental control of musical imagery.

CONCLUDING REMARKS

People have rich internal worlds. Musical imagery is one complex, idiosyncratic internal experience the vast majority of people report regularly having in their everyday lives (e.g., Liikkanen, 2011; Cotter et al., 2018). We exhibit considerable variety in the contents of our musical imagery (e.g., Bailes, 2015), and from episode to episode our imagery differs in richness and multimodality (e.g., Bailes, 2007; Bowes, 2009). Research has examined a multitude of qualities of musical imagery, such as valence, length, and vividness (e.g., Cotter et al., 2018), but less attention has been given to the processes underlying these complex experiences.

Mental control, an important element of musical imagery experiences, is a complex, multi-faceted process that has not been a focal point of past research. Examining four diverse approaches to musical imagery—lab-based auditory imagery, involuntary musical imagery, mental rehearsal and composition, and ecological musical imagery—demonstrates that mental control is not a singular, unitary construct and can be broken down into two overarching components: initiation and management.

Recognizing a dual-component model of mental control advocates for a thoughtful re-examination of past work and generates new directions for future research. By re-examining the literature, we can identify its limitations and what prior research already can tell us about initiation and management and where there are paths for growth. But more importantly, this dual-component model can spark new lines of research to develop our understanding of the underlying processes of musical imagery.

AUTHOR CONTRIBUTIONS

KC is the sole author and is responsible for all manuscript contents.

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Effect of Meditative Movement on Affect and Flow in Qigong Practitioners

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Qigong is a Meditative Movement exercise that consists of mindful movements, regulation of breathing and attentional control. In this study we investigated whether Qigong practice might be associated with the affect and flow of its practitioners during the exercise. Although practitioners of Meditative Movement anecdotally describe flow-like experiences and strong effects on affect there are only a few empirical studies that focus on acute effects of Qigong practice on affect, and to our knowledge none on flow. Understanding these phenomena could shed new light on the interrelationship between body movement and the embodied mind. Self-reported affect and flow of qigong practitioners (N = 19) was probed in four qigong sessions, 1 week apart, each lasting about an hour. We used the PANAS (Positive And Negative Affect Schedule) to measure self-reported affect pre- and post-session. Additionally, open-ended questions were used to further inquire the specific quality of the post-session affect. Flow was measured using the Flow Short Scale, twice during each Qigong session and once after it. Our results confirm previous studies that Qigong practice shifts affect toward positive valence. Content analysis of the open-ended questions further revealed that the resulting experience can be described as restful, relaxed, happy, balanced, and clear. Although the lack of a control group/condition preclude drawing firm causal conclusions, our results indicate that Qigong practice produced flow already 20 min into the session, and that flow state intensified at 40 and 60 min. Future directions for studying affect and flow in meditative exercise are discussed.

Keywords: exercise, meditative movement, flow experience, affect, Qigong

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INTRODUCTION

The last few decades have seen an increasing interest in western culture toward oriental physical and mental practices such as meditation, Yoga and Martial Arts. Yoga can be considered part of mainstream culture with over 20 million practitioners in the United States alone (Schmalzl et al., 2015), and in the past years many different forms of "mindfulness" techniques have become increasingly popular. But while the positive effects on health and well-being from both physical exercise and meditative exercises are commonly accepted, forms of practice where these two are

combined are still little researched and poorly understood (Payne and Crane-Godreau, 2013). Perhaps it is because of methodological challenges that meditative techniques based on executing large, coordinated movements – such as Qigong or Taijiquan – have had rather limited academic research done on them (Schmalzl et al., 2014).

This type of research would, however, be important for understanding human performance, well-being and the body–mind relationship from both applied and theoretical points of view. On the practical side it would be useful to have a clearer picture of the physiological and emotional effects of different types of exercise including those beyond traditional western forms. This would for example aid in assessing their potential benefits (or risks) for physical and mental health for particular individuals. Also, as performance in many fields (e.g., athletic performance) depends inseparably on both the physical and mental state of the performer, understanding the neural and psychological mechanisms involved in techniques explicitly combining body and mind could lead to novel methods of training and evaluation.

On a more fundamental level meditative techniques – and in particular movement-based meditative techniques involving the sensation and control of body movements – produce complex subjective experiences that may have unique features distinct those found in most everyday activities. These are interesting phenomena in their own right. This is particularly so if they can deepen our theoretical understanding emotion, as traditional emotion theories may need to be extended to incorporate new types of affect, or to describe the interplay of controlled body movement, somatic sensations and conscious attention in the generation of feelings and regulation of emotional state. Concerning this last point, "embodied mind" exercises also speak to a wider shift in cognitive science from paradigms that analyze cognitive processes and their sensory "inputs" and motor "outputs" separately, toward models of active perception (Ballard, 1991) and embodied cognition (Clark, 1999; Barsalou et al., 2003; Barsalou, 2008). In this framework, the motor system and the bodily mechanisms it controls directly contributes to cognitive processing, by actively shaping the sensory inputs and grounding explicit and abstract conceptual content in tacit, concrete sensorimotor processes. The upshot is that it is not possible to understand cognitive mechanisms in isolation of their bodily coupling with the body and the world.

Finally, on a phenomenological level our experience is, arguably, essentially that of an embodied agent in the world. We experience ourselves situated in a perpetual space with motor-specific affordances, we feel our emotions in the body, we frequently use bodily-spatial metaphors for describing social or abstract reality etc. Understanding how our sense of being-in-the-world arises from body and brain function – across the levels from detailed neurophysiology through basic psychological mechanisms to phenomenology of experience – would perhaps shed significant new light on some of the old mind–body problems.

Meditative movement practices, such as Yoga or Qigong combine specific movement patterns with mental techniques for reaching a meditative state of mind. The purpose of this study was to better understand the self-reported state of mind achieved in one such practice – Qigong – and in particular the possible elicitation of positive affect and flow-like experiences by the meditative movement training. Specifically, we investigated the effect of Qigong on the self-reported affective state measured by a standardly used self-report scale for positive and negative affect (Watson et al., 1988) and flow experience measured through a self-report questionnaire commonly used, e.g., to study flow in sports (Rheinberg et al., 2003). Also, to classify the language used by the participants to describe their affective state after the training we performed qualitative content analysis on verbal self-reports. These qualitative and exploratory methods are appropriate at this stage of research to shed light on the phenomenology of the mental state achieved in Qigong training.

As there are no well-established, precise definitions of meditative movement, positive affect or flow in the academic literature, we will next elaborate the meaning of these concepts in the context of this study.

The terminology and definitions used to describe meditative movement in the scientific literature vary (Payne and Crane-Godreau, 2013). Cardosoa et al. (2004) define *meditation* as practices with following features: (M1) Clearly defined techniques; (M2) Psychophysical relaxation, that leads to muscular relaxation; (M3) "logic relaxation" i.e., reduction of logical thought (need for evaluation, expectation, and explanation); (M4) The state is self-initiated and self-sustained; (M5) Attention is focused by anchoring concentration into a mental image, breathing, body state or some other target (Note: there exist two meditation styles, with respect to focusing of attention and awareness: focused attention and open awareness. M5 only applies to focused attention style meditation). Payne and Crane-Godreau (2013) use the term Meditative Movement for forms of physical exercise where such meditative attention is directed toward bodily sensations, including proprioceptive, interoceptive, and kinesthetic sensations. They include traditional Chinese methods such as Qigong and Taijiquan, as well as certain styles of Yoga and other oriental practices such as Aikido and Sufi Dance, but also certain western somatic practice forms such as Alexander Technique and Feldenkrais. On the other hand, in their study on Qigong, Johansson and Hassmén (2013) use the term mind-body therapies for Qigong, Taijiquan, meditation and Yoga. Schmalzl et al. (2014) use the term Movement-based embodied contemplative practices for traditional oriental forms such as Yoga, Qigong, Taijiquan, and modern western somatic methods such as the Alexander technique and Feldenkrais-method.

Larkey et al. (2009) propose *Meditative Movement* as designation for a category of forms of exercise, such as Taijiquan and Qigong, that combine (MM1) some form of movement or body positioning, (MM2) a focus on breathing, and (MM3) a cleared or calm state of mind with a goal of (MM4) deep states of relaxation. They consider meditative movement a class mind–body or body–mind exercises that is different from traditional (western) exercise forms in that the focus is on bodily sensations and breathing, and achievement of a state of relaxation (This is in contrast to focus on external targets and performance goals, and achieving certain performance measures.) Meditative Movement

in this sense can be considered as a superordinate class of exercise forms analogous to aerobic exercise.

We adopt the term Meditative Movement, and use it in the sense proposed by Larkey et al. (2009). We leave at the moment open whether the lists (M1–M5 and MM1–MM4) should be augmented to exclude sports with, arguably, similar features but very different techniques to traditional meditation – such as long-distance running or free diving – or whether indeed these fields should be considered as forms of meditative movement. Even in this case we take it, however, that under any reasonable further restrictions into the definition, traditional movement based meditative techniques are to be included in the definition of Meditative Movement. This includes Qigong which is a meditative movement form comprising of movements, static poses, regulation of breathing as well as various cognitive techniques such as somatic awareness, mental imagery, and focusing of attention (Cohen, 1999; Jahnke et al., 2010; Klein et al., 2016; Osypiuk et al., 2018). Overall the general purpose of Qigong practice is to increase vitality, balance circulation and to harmonize body–mind relationship.

Affect, emotion and feeling are used, sometimes interchangeably, to designate those episodes of our experience that have some emotional component. Emotion is often considered to comprise of physiological (e.g., hormonal), bodily (e.g., facial expression, pose) and mental (e.g., attentional or memory-retrieval) components, not all of which are accessible to consciousness. That is, there are processes involved in an emotion other than the *feelings* arising from emotional processes which we can report.

Here, we use the term affect in a broad sense. We consider the term affect to denote episodes of emotional life with a time scale of some minutes, and which can be brought into awareness and explicitly reported (This in contrast to, e.g., mood which can persist for hours or days.) Affect can be investigated by both self-report measures as well as psychophysiology. Only self-report measures were used in this study. However, we do not pre-theoretically commit to the notion that affect always has, by definition, a positive or negative *valence*. Although some theorists define affect thus, we consider it would be pre-judging the issue to assume all affect must contain such evaluative component (This is particularly pertinent when considering meditative states of mind, where a neutral affect, yet distinct from boredom, tiredness or other typical forms of "flat affect" might be prevalent.) Also, we do not commit to the notion that the affective episodes in Meditative Movement should be categorizable into traditional *basic emotions* (as in categorical emotion theories), or constructed from arousal, valence (and possibly a "cognitive" evaluation). Meditative movement elicits complex emotional-cognitive-bodily experiences, and to what extent they conform to, and are captured by traditional emotion-concepts is an open issue. Therefore, we consider "affect" to be the most neutral term to adopt.

Many emotion theories regard affect as "the experiential component of all valenced (i.e., 'good' or 'bad') responses, including emotions and moods" (Scherer, 1984; Lazarus, 1991; Frijda, 1993; Gross, 1998, 1999) in Ekkekakis and Petruzzello (2000, p. 77). We do not, on two counts. Firstly, we do not restrict the term affect to the consciously reportable feeling, and in particular a good/bad evaluation (valence). There are two reasons. One is that, affective neuroscience or models of affective processes can involve aspects of affective states that are not reportable, and affect can be studied in non-human species where the issue of reportability is problematic. The other is that, especially in regard to meditation, we think it is not a good idea to paint oneself into a theoretical corner by defining affect as including an evaluative component of positive vs. negative. Leaving the definition open means that meditative states can conceivably involve affect, even powerful affect, in the absence of a good/bad evaluation. Secondly: we do distinguish affect and mood – by duration, although there need not be a hard cut-off for when an affective episode has lasted long enough to become mood. This is more out of convenience, rather than a conviction of differences in underlying mechanisms. However, in terms of response to psychological or pharmacological manipulations, and experimental operationalization, there is a difference in rapidly shifting affective episodes and more persisting emotional-motivational state, the latter of which we would call mood.

Flow (Csikszentmihalyi, 1975; Nakamura and Csikszentmihalyi, 2002) is a complex psychological construct, developed to describe phenomenologically the enjoyment people get from activities that they engage with, often with no apparent external reason or incentive. The flow state is sometimes achieved during challenging task performance ("deep flow") or more mundane activities like watching television ("microflow episodes"). It is characterized by the following features: (F1) total immersion and attentional focus in what one is doing; (F2) merging of action and awareness (being 'one' with the task and/or the environment); (F3) loss of reflective self-consciousness, and/or a sense of effortlessness and automaticity; (F4) a sense of control and confidence; (F5) an experience of the activity as highly enjoyable; (F6) sustained motivation (if given the choice, you choose to continue doing the task rather than to discontinue); (F7) a distortion of temporal experience (time may seem to go slower or faster than normal). Tasks which elicit flow have an autotelic quality, i.e., people will want to do Flow-producing activities again and again, regardless of external reward. Although the flow state is a multidimensional phenomenon as described above [F1–F7 combines *cognitive* (e.g., attention, automaticity), *affective* (enjoyment), *behavioral* (self-reinforcing or "autotelic") aspects as well as subjective experience (emotional quality of enjoyment, awareness of self, time, and space)] typically flow is studied through self-report questionnaires. Here we, too, concern ourselves with the self-reported *flow experience*. Note that enjoyment (F5) does not necessary imply pleasure or positive hedonic experience or positive valence – consider, e.g., mountaineering in challenging conditions, or a long-distance runner enduring pain.

To better understand the complex experiences during Qigong practice, and to operationally disentangle flow and affective valence, we used both standard flow and standard affective valence questionnaires. Previous work on Qigong has shown Qigong training to have an overall positive effect on the affective state of participants (e.g., Payne and Crane-Godreau, 2013; acute

effects of single Qigong sessions, e.g., Lee et al., 2004; Johansson et al., 2008; Johansson and Hassmén, 2013; for reviews see Jahnke et al., 2010; Wang et al., 2010; Chi et al., 2013; Wang et al., 2013). We set out to study acute affective effects of Qigong training and the presence of Flow in a longitudinal design with four sessions. Previous work using self-report questionnaires had indicated positive affective state is elicited by many forms of exercise, including Meditative Movement, and we set to replicate this finding. To the best of our knowledge, Qigong has not been previously investigated with standard Flow self-report instruments.

Additionally, we wanted to explore further into the *quality* of the experienced affect, which may go beyond simply positive vs. negative valence or the presence/absence of flow. For this purpose we decided to collect open ended self-report data of the participants' descriptions of their emotional experience in their own words for qualitative content analysis.

In sum: by combining widely used measuring tools with open self-reports gives us a more nuanced picture of the complex affective experience of participants. This is a similar approach than what, e.g., Rose and Parfitt (2007) and Johansson and Hassmén (2013) have used. While positive affect during Qigong has been reported in the literature, there are to the best of our knowledge no studies relating this form of Meditative Movement practice to flow. Given that there are parallels between the elicit conditions and experience of flow and the meditative state, we expected qigong exercises to be conducive to the experience and to probe this hypothesis we also administered a widely used questionnaire for self-reported flow.

MATERIALS AND METHODS

The experiment had a longitudinal design where the participants (N = 19) participated in four weekly 90 min group training sessions (see **Figure 1**). In each session three different Qigong exercise sets were performed. A 5 min reflection period followed each exercise set, during which the participants were encouraged to probe their own mental state introspectively for a few minutes, after which they proceeded to fill in the Flow Short Scale (FSS) self-report questionnaire. Participants also filled in the Positive And Negative Affect Schedule (PANAS) self-report questionnaire before and after each session. These responses were used in the statistical analyses. At the end of sessions 2,3 and 4 the participants filled in an open verbal-self report of their affective states. This data was analyzed using qualitative content analysis.

Participants

The participants (7F, 14M) were recruited from among the Finnish Qigong community by email. There were no explicit exclusion criteria, but all participants were healthy adult meditative movement practitioners who had experience with this type of exercise. Following Jahnke's (review Jahnke et al., 2010) recommendation using Qigong as main category all previous training experience whether it was any form of Qigong or any form of Chinese Internal Martial Arts such as Taijiquan or Yiquan, was categorized as Qigong experience.

Participants gave informed written consent to partake in the experiment and the use of the data for scientific purposes in accordance with the Declaration of Helsinki. The data collection procedure does not contain aspects that according to the Finnish Advisory Board on Research Integrity[1] would require ethical pre-evaluation. The data were collected as part of an undergraduate thesis project, which is exempt from ethical pre-evaluation to be conducted by the University ethical review board. However, we have submitted the procedure to the University of Helsinki Ethical review board in humanities and social and behavioral sciences for a series of follow-up experiments with identical procedure but using slightly different questionnaires. It has been declared ethically acceptable (Statement 27/2019).

Background information was collected with a form that asked for their age, sex, and training experience. The participants were aware they were participating in a scientific study, but were naïve with respect to the research questions. The participants were informed that it was desirable that they participate in all four sessions, but that missing one session would not invalidate their data.

Nine participants took part in all four sessions, and 10 in 3 sessions. Two participants only took part in two sessions and their data was disregarded from the study. The age of the participants that took part in at least three sessions (N = 19, 7F 12M) ranged from 26 to 78 year (mean: 50 year, *SD*: 15 year). Prior experience in Qigong ranged from 3 months to 20 year (mean: 6.5 year, *SD:* 6.7 year). Weekly training ranged from 0 to 8 sessions (mean: 3.5, *SD:* 2.7). It was not controlled what kinds of practices participants did between sessions (if any).

Session Protocol

During each Qigong session, the participants performed three Qigong exercise sets, each lasting about 20 min. This was done in a group, led by the first author (PP), who has taught Qigong and Chinese Internal Martial Arts for more that 20 years. The exercises were based on the Dynamis-qigong style developed by him. Filling out the questionnaires took altogether about 30 min. The entire session lasted about 1.5 h.

The aim was to make all the sessions as similar to one another as possible in terms of ordering of the exercises and the duration of the phases, so that longitudinal effects would not be introduced by differences in session content, and also to minimize the effects of a participant missing one session. Thus, each session followed the same pattern, as follows:

(1) Beginning of session. Participants fill in the PANAS self-report questionnaire.
(2) First Qigong exercise: "Body opening and relaxing exercises," comprising of a variety of slowly performed waving, shaking, stretching and circling movements, while focusing attention to different bodily sensations (video link: https://www.youtube.com/watch?v=2lYm_z8SlUk).
(3) First reflection moment. Participants fill in the FSS self-report questionnaire.

[1] http://www.tenk.fi

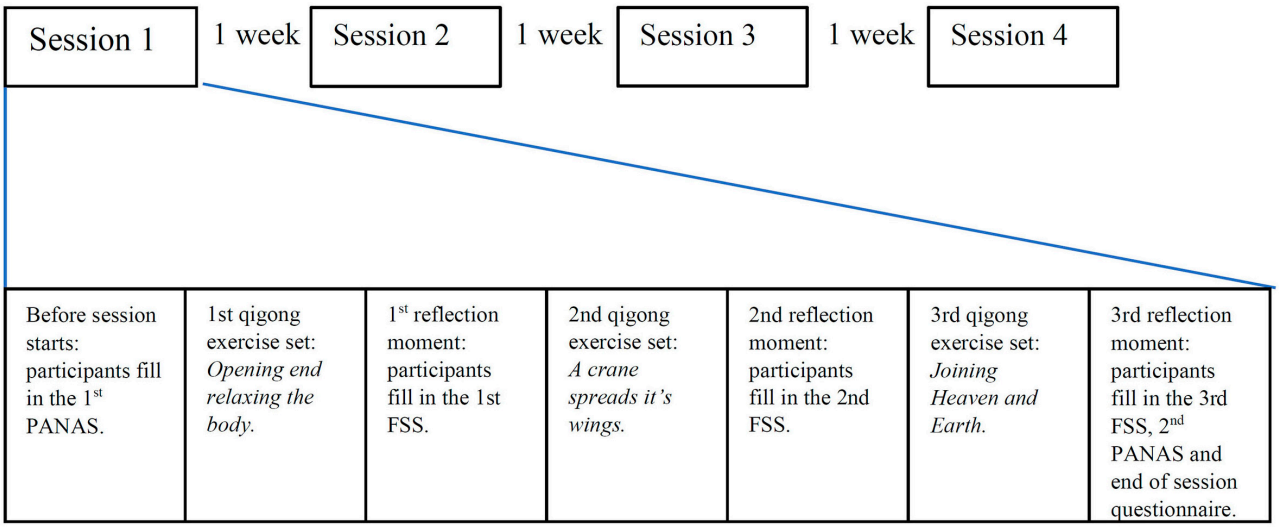

FIGURE 1 | The longitudinal design of the study, and the structure of each Qigong session.

(4) Second Qigong exercise: "A crane spreads its wings," combining motion, breathing, and directing attention to harmonizing movement and breathing (video link: https://www.youtube.com/watch?time_continue=37&v=a_BleyXFsig).
(5) Second reflection moment. Participants fill in the FSS.
(6) Third Qigong exercise: "Joining heaven and earth," where movement, breathing and different mental images, such as imagining warmth or light flowing through the body, in coordination with movement and breathing, are integrated using attentional focus (video link: https://www.youtube.com/watch?v=wqb66SuL-HE).
(7) Third reflection period. Participants fill in the FSS, PANAS, and end-of-session debriefing questionnaire. End of session.

This structure follows the common training methodology in Qigong of moving from temporally extended and "external" large scale movements to ever smaller and subtler "inner movement," which in the tradition is regarded as the most powerful but also demanding form of exercise (Cohen, 1999; Schmalzl et al., 2014). Also, a consideration in developing the protocol was that the FSS questionnaires between exercises should not disrupt the state of meditative focus, and they were hence introduced into the sessions as part of a "reflection moment."

Instruments

The PANAS and FSS self-report questionnaires were used to assess affective effects and the elicitation of flow, respectively.

Positive And Negative Affect Schedule is a paper and pencil questionnaire designed to measure positive and negative affect (valence). It consists of twenty items, 10 with adjectives describing positive and 10 describing negative affect. Watson et al. (1988) demonstrated internal consistency for the PANAS ranged between 0.86 and 0.90 for positive affect and 0.84–0.87 for negative affect. Test–retest reliability for the PANAS (1 week) were reported as 0.79 for positive affect and 0.81 for negative affect (Watson et al., 1988).

Pre-session, the participants answered the question "How have you felt during the past few hours overall" and after the session "How do you feel right now" on a five-step Likert scale anchored at 1 = not at all or very little to 5 = very much. Total PANAS score was calculated by subtracting the sum of negative items from the sum of positive items (i.e., sign of the deviation from zero indicates the overall positive valence). Subtracting the pre-session total PANAS score from the post-session PANAS score yielded a measure for the change in affect during the session.

Flow Short Scale is a paper and pencil questionnaire designed to measure the experience of flow (Rheinberg et al., 2003). It consists of 10 Likert scale questions anchored at 1 = Not at all and 7 = Very much. There are two scales, fluency of performance (six questions), and absorption by activity (four questions). The fluency and absorption scores were averaged, and then summed to give the total flow score as per Rheinberg et al. (2003). Cronbach alpha for fluency and absorption was (0.92). There are no standard Finnish translations of PANAS or FSS. The version used here is based on an existing PANAS translation which was slightly modified by PP and MT. The FSS used was the translation used in Cowley et al. (2019) with some slight edits.

Post-session Debriefing

Additionally, at the end of each session the participants filled in a debriefing questionnaire, containing further questions about the achievement of flow, open-ended questions for self-reporting their current affective state, as well as questions pertaining to the organization of the experiment. At the end of each four sessions, the participants filled a self-report questionnaire asking them about the session as a whole. There were three items based on the FSS perceived importance scale, another three based on the FSS skills and demands scale (both answered

1–7 Likert scale anchored 1 = not at all, 4 = partly, 7 = very much), and four questions concerning the practical arrangements of the experiment.

Note that unlike Rheinberg et al. (2003), the three FSS perceived importance scale items and three FSS skills and demands items were only presented to the participants at the end of the session, and the participants were instructed to answer on the basis of how they experienced the session as a whole. The main reason was to keep the breaks between the Qigong exercise sets short, in order not to disrupt the meditative frame of mind.

Positive And Negative Affect Schedule scores measure total positive vs. negative affective state (valence), but do not give further insight into the quality of the experience. For this purpose, the participants were asked (at the end of sessions 2–4) to describe their feelings by answering in their own words "What words or sentences would best describe your emotional state right now after the session?"

Also, participants were asked whether they felt the reflection periods and questionnaire-filling were disruptive to the maintenance of a meditative focus. The aim was to make the self-report questionnaires as naturally a part of the normal course of a Qigong session as possible, and this question was used to evaluate how well this succeeded. The final item in the debriefing questionnaire was open space, where participants could write whatever comment they had (if any) concerning the session.

Content Analysis of the Open-Ended Responses

The participants gave written open-ended answers to the question "what words or sentences would best describe your emotional state right now after the session?" Words/expressions describing the respondent's affective state in the open-ended responses were classified into categories by an iterative process as follows. The first author (PP) first went through all the material, identifying 64 meaning units, with a total of 117 occurrences, and grouping them into classes of units judged to have similar meanings based on synonymy using a thesaurus. The principle was to classify each meaning unit to exactly one class.

From this, nine classes emerged, labeled peaceful, cheerful, energized, relaxed, drowsy, balanced, tense, present, ambiguous (word meaning was unclear). Based on these labels alone, the second author (OL) then independently classified the meaning units into those nine classes. Discrepancies between the authors' classifications were identified, and the differences in interpretation discussed. On the basis of this, the category labels were slightly revised, and each category was given a short verbal description of the intended interpretation of the category label.

This augmented categorization was then given to three naive classifiers, who were not involved in the preceding discussions, nor experienced in Meditative Movement (but did have some experience of survey and self-report questionnaire research). They were independently given written instructions to classify each word into exact one category, and use the category "unclassified" if the meaning unit does not clearly fit any of the other categories. Based on the naive respondents' classifications, and feedback from debriefing them on how they interpreted the category labels and descriptions, the categorization was refined still, yielding the nine classes used to categorize the respondents self-reported affective state in this study. Finally, this classification scheme and instructions was given to 14 classifiers who independently classified each word to one of the nine categories.

English translations for the category labels with examples, and the class descriptions provided to the classifiers are given in **Table 1**.

The classifications of the meaning units by the 14 naïve classifiers was used to calculate each meaning unit a semantic consensus rating as to how well the meaning unit conveys the meaning of the category. This consensus rating represents each word occurring in the responses as a vector of nine dimensions, each ranging from 0 (i.e., no naive classifier classified the word as belonging to category) to 1 (i.e., all classifiers classify the word as belonging to the category), summing to one (so for example, if all classifiers considered a particular word to belong to class 3, the word would be represented as [0,0,1,0,0,0,0,0,0], for another word the consensus might be marginally less, with one respondent classifying the word into class nine, giving [0,0,0.929,0,0,0,0,0,0.071], another word might be more ambiguous still, yielding, e.g., [0.143,0,0.716,0,0,0,0.71,0,0.071] etc.). The semantic consensus ratings of all meaning units are given in **Supplementary Table S1**.

RESULTS

This section first describes the quantitative results of the effects of the Qigong exercises on self-reported affect and flow-experience, as measured by the PANAS and FSS scales. Then, the qualitative results of the content analysis of open verbal questions are given.

Statistical Analysis of PANAS and FSS

The data was analyzed using IBM SPSS 25.0. Preliminary analyses were done to plan the final statistical analysis. Namely, the participants were grouped according to whether they had prior experience specifically of the Dynamis-qigong style or not. No statistically significant differences in PANAS or FSS results were found using Mann–Whitney test (PANAS: $Z = -0.575$, $p = 0.565$, FSS: $Z = -0.868$, $p = 0.391$) and in the rest of the analyses all participants were treated as one group. Group comparison analysis were also performed with sex, age, frequency of weekly practice and years of experience with PANAS and FSS scores, but no statistically significant effects were found. Therefore, in the statistical analyses reported below all participants are treated as a single group, and sex, age or experience effects were not investigated further.

PANAS Results

Affective state was measured by PANAS at the beginning and end of the session (**Figure 2**). There was an increase in positive affect and decrease in negative affect during sessions (**Table 2**). Total change in PANAS score can be seen in **Figure 3**. The range of the PANAS scale is [−40, 40], and comparing the pre- and post-session scores within subjects the average change is + 8.85

TABLE 1 | The nine categories of affective quality that emerged from the analysis of the open-ended self-report questionnaires.

Class number	Class name	Class description
1	Restful	Sedation of body/mind; relaxed body, feeling drowsy (note: tiredness nevertheless a separate class). *Examples: restful, relaxed*
2	Energized	Lightness and ease of bodily movement, sense of empowerment in body or mind (opposite of drowsy). *Examples: vital, energized*
3	Tired	Heaviness/slowness of physical movement, sense of fatigue in mind/body (opposite of energized). *Examples: slowed, tired*
4	Lucid, clear	Mind is calm and clear "like a calm sea/lake." *Examples: cleared, clear, and calm*
5	Balanced	Words related to balance and stability. *Examples: balanced, tranquility, and balance*
6	Positive affect	Any positively colored "mental" (rather than physical) experience not fitting the above categories. *Examples: cheerful, happy*
7	Negative affect	Opposite of positive affect. *Examples: painful, tense*
8	Present	Conscious, mental awareness (mindfulness). *Examples: awake, present*
9	Other (unclassified)	Note: if the word does not CLEARLY fit any of the above classes, classify it here. *Example: healed, a bit empty*

(over 10% of the range), which may be considered substantial. Both negative and positive affect changes reached significance on the non-parametric Wilcoxon test (**Table 3**). The results support the hypothesis that, as found in prior studies, qigong exercises can induce a more positively valenced affective state. A Friedman test revealed no significant differences in PANAS scores between sessions 1–4 [df (3), $p = 0.95$].

TABLE 2 | Pre- and post-session PANAS scores, averaged across the four weekly sessions.

	Mean	*SD*
PANAS pre: negative	15.20	6.29
PANAS post: negative	10.77	2.64
PANAS pre: positive	25.67	8.51
PANAS post: positive	30.09	9.71
PANAS pre: total	10.47	9.95
PANAS post: total	19.32	9.36

FSS Results

A match between skill and task demand is generally considered a precondition of flow. This was probed by explicitly asking the participants to rate the task difficulty of the session on a scale of 1–7, with anchors 1 = "too low," 4 = "just right," and 7 = "too high." As shown in **Table 4**, the majority (86.4%) of the answers indicated an appropriate level of task difficulty, which a good fit between task demand and capability.

The experience of flow itself was measured with the FSS. The average flow (averaged across participants and sessions) was mean = 5.66, *SD* = 0.63 (see **Figure 4**). The scale range is [1.00, 7.00]. **Figure 5** shows a box plot of Z-normalized flow scores of the four sessions. The FSS scores of the qigong exercise sets 1–3 (averaged over the four weekly sessions) are shown in **Table 5**. The FSS scores of the four weekly sessions (averaged across exercise sets) are shown in **Table 6**.

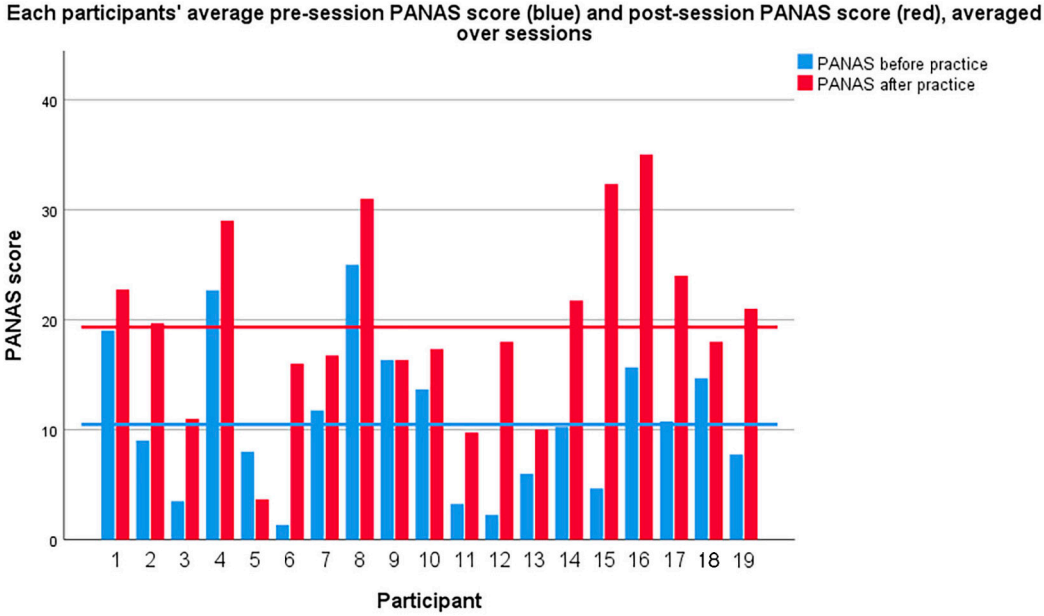

FIGURE 2 | Each participants' pre-session (blue) and post-session (red) PANAS score averaged across sessions. Horizontal lines indicate group pre- and post-means. X axis: Individual participants. Y axis PANAS score.

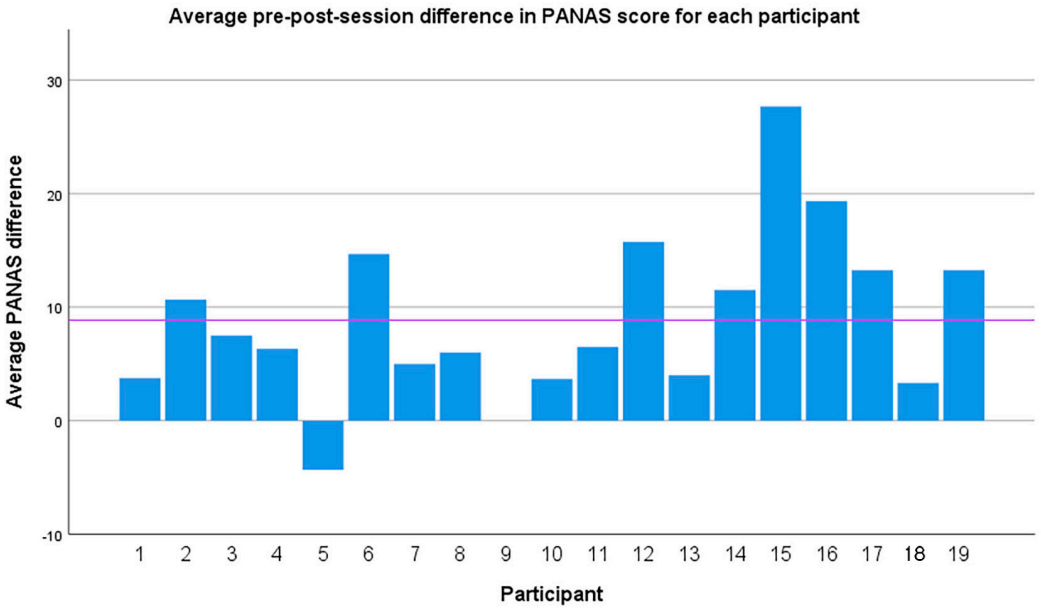

FIGURE 3 | Mean pre-post-session change in PANAS score for each individual participant. Horizontal line indicates group mean. Note: participant 9 has identical pre- and post-PANAS scores. X axis: Individual participants. Y axis: PANAS score.

Friedman test revealed the mean FSS scores of the exercise sets 1–3 different significantly df(2), $p < 0.001$. Pairwise comparison with Wilcoxon test indicate a difference between the first and second exercise sets ($Z = -3.027$, $p = 0.002$) and between first and third exercise sets ($Z = -3.743$, $p < 0.001$). I.e., the second and third exercise sets FSS scores were statistically significantly higher than those of the first.

Content Analysis

Our use of semantic classification of each meaning unit into nine categories of experience allowed us to study the occurrence of each *category* in the response data, as opposed to merely counting frequencies of individual *meaning units* (most of which were used only once). For this, we simply multiplied the frequency of occurrence of each meaning unit with the weightings given by that meaning unit's semantic consensus ratings, yielding a table of weighted occurrences of each category. In other words, the participants' use of a particular meaning unit contributes to the occurrence of each semantic class through the scalar product of word frequency and semantic consensus vector. The weighted occurrence of the class is then simply the component-wise sum of each meaning unit's weighted contribution to the class. The meaning unit frequencies and weighted contributions to class occurrence are given in **Supplementary Table S1**. The weighted occurrence of each semantic class is shown in **Figure 6**.

By far the highest occurring semantic category was 1 Restful category followed by 6, Positive affect and 5, Balanced and 4 Lucid, clear. These four categories covered 74.36% of our classification. Interestingly, both category 2 Energized, and its polar opposite 3 Tired, were about equally represented. 8 Presence/mindfulness, 7 Negative affect and 9 Unclassified were only weakly expressed in the material. The predominant affective states that qigong practitioners reported in our study can be summarized as feeling restful, relaxed, happy, balanced and clear.

TABLE 3 | Wilcoxon test on PANAS scores.

	Negative affect change	Positive affect change	Total affect change
Z	−5.98	−4.22	−5.57
Asymp. Sig. (two-tailed)	<0.001	<0.001	<0.001

TABLE 4 | Match between skill and task demand.

The degree of difficulty of this session was	1 too low	2	3	4 just right	5	6	7 too high	Total
N	1	3	5	57	0	0	0	66
%	1.5	4.5	7.6	86.4	0	0	0	100

Other Results

Participants were asked whether they felt the reflection periods and questionnaire-filling were disruptive to the maintenance of a meditative focus. Out of 60 answers only three subjects reported disruptions (9.67% of all answers). Majority of subjects (67.74% of all answers) felt that reflection periods were positive and enhancing. The rest of the answers (22.58%) were neutral.

DISCUSSION

In this study we investigated whether Qigong practice might be associated with the affect and flow of its practitioners during the exercise. Using a repeated measurements paradigm and both

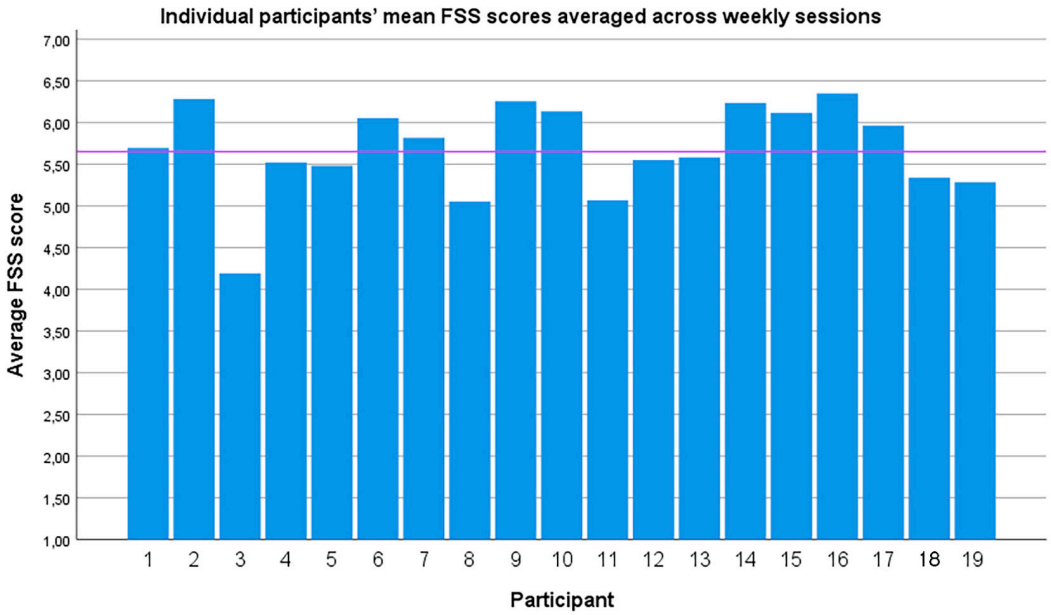

FIGURE 4 | Individual participants' mean FSS scores averaged across weekly sessions. Horizontal line indicates group average. X axis: Individual participants. Y axis FSS score.

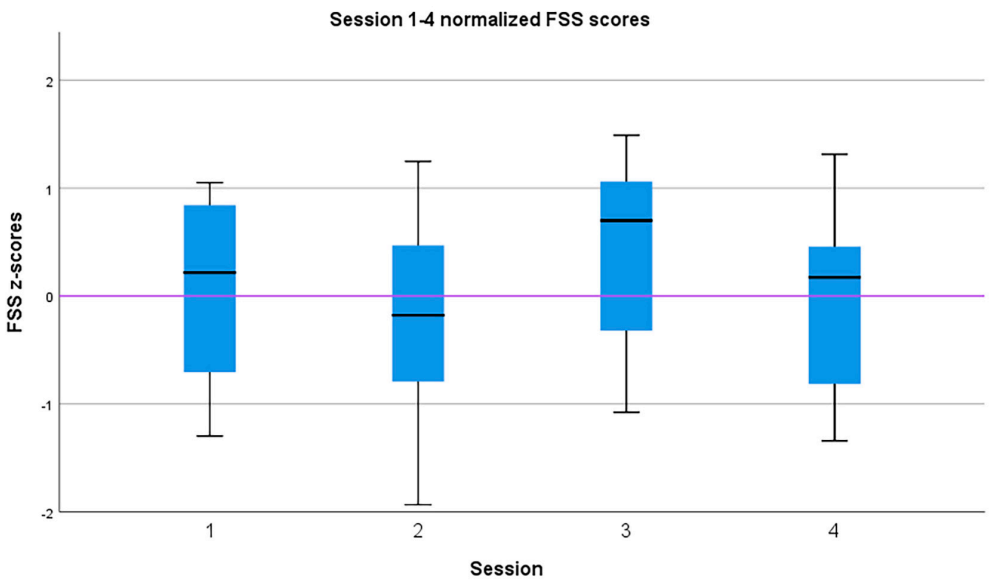

FIGURE 5 | Session 1–4 normalized FSS scores. X axis: sessions 1–4. Y axis: normalized FSS score.

standard questionnaire and open-ended self-report methods, we were able to determine the effects of Qigong on affect and the experience of flow. Affective valence changed toward positive, as measured with PANAS pre- and post- session, in a timeframe of about 1 h. [It is of course possible that affective change happens much faster, as suggested study done by Johansson and Hassmén (2013), affective change happened in 20 min.] Our open questions suggest most prominent affective state experienced during Qigong can be characterized as restful, relaxed, happy, balanced and clear. Note that for the most part these affective qualities did not have much overlap with PANAS items. We interpret that there is room to develop a more fine-grained picture of the possibly multidimensional affective changes in meditative movement.

Flow was measured with FSS, and measurements suggest that flow was achieved by the first 20 min measurement point and it increased further in 40 and 60 min measurement points. Since there was no counterbalancing of the three Qigong exercise sets

TABLE 5 | Flow Short Scale scores after exercise sets 1–3, averaged across sessions.

	N	Minimum	Maximum	Mean	*SD*
1st exercise set: *Opening and relaxing the body*	66	3.63	6.75	5.45	0.77
2nd exercise set: *A crane spreads it's wings*	66	3.33	6.79	5.70	0.70
3rd exercise set: *Joining Heaven and Earth*	66	2.83	6.83	5.82	0.81

TABLE 6 | FSS scores of sessions 1–4.

	N	Minimum	Maximum	Mean	*SD*
Session 1 FSS	19	4.83	6.32	5.69	0.51
Session 2 FSS	19	4.43	6.44	5.54	0.57
Session 3 FSS	19	4.08	6.60	5.84	0.65
Session 4 FSS	9	3.42	6.49	5.43	0.90

we cannot say if this increase is as result of different types Qigong exercises, or if flow experience increased simply as a function of time. In the open-ended responses, some subjects described their Qigong experience in a way that resembles the way that flow is described, such as: "Today I felt a bit tired, although also concentrated and calm. Training session woke me up and brought very enjoyable concentration in to the body, even flow-like experience where my body moved automatically." These results are accordance with Csikszentmihalyi's view that oriental meditative movement arts and Martial Arts are designed to produce flow (Csikszentmihalyi, 1990).

The amount of previous Meditative Movement practise, sex or age did not appear to affect PANAS or FSS results in our small sample, and so we did not investigate these in more detail. All participants of this study had at least several months of previous Meditative Movement experience and it seems that was enough time to obtain adequate skill to gain positive effects of this practice.

There was lot of variance between different subjects and between subjects in different sessions in regards PANAS and FSS.

Limitations and Future Directions

Meditative Movement is as-yet quite little studied, and the appropriate methods to understand it are still in developmental stages. Two questionnaires from more established lines of research (affect and flow) were used here for better comparability into existing research. It is likely that gleaning more accurate and nuanced information about Meditative Movement will require dedicated self-report instruments that take into account the special features of Meditative Movement as an exercise form. Such methods are indeed under development, such as the Meditative Movement Inventory (Larkey et al., 2009). This is a 17-item questionnaire aiming to capture in descriptions different aspects of meditative movement, such as the meditative state of mind, breathing, flow of movement and affective quality.

Cross-cultural commensurability is always an issue in questionnaire based research, due to linguistic and cultural differences that need to be reconciled in translating questionnaire items. There are no generally accepted Finnish translations for PANAS and FSS. The version of PANAS used here was an existing translation. Some items such as "excited" and "enthusiastic" have subtle differences that are difficult to convey in standard Finnish. It is however unlikely that this would have seriously affected the results. The vocabulary used in PANAS is generic and measures

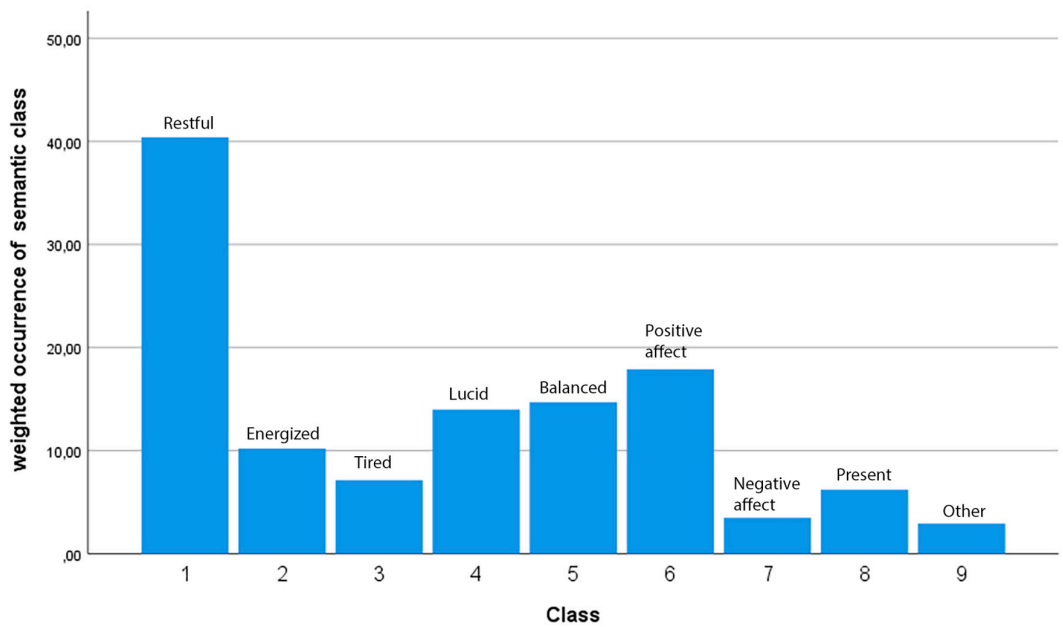

FIGURE 6 | Weighted occurrence of each semantic class in the open response data.

wide range of emotional states. In our open-ended questionnaire only in four instances out of 64 classified answers the same words as in PANAS questionnaire were used (alert once, nervous once, and active twice). Thus, our analysis of open-ended self-report questions allow us to capture more subtle differences in the emotional state meditative movement was experienced in our participants. A dedicated questionnaire designed specifically for self-report of affective states in meditative movement might have higher validity and reliability, and could prove useful for probing in more detail the emotional effects of other forms of exercise as well.

Regarding FSS questionnaire, it is not clear how well two of the perceived importance items "I must not make any mistakes here" and "I am worried about failing" fit Qigong – especially the Dynamis-qigong approach used here. The participants were explicitly told before the session to find their individual way to perform the exercises, so there was no normative way to "fail" or to define "error," as such.

Flow was probed with FSS after three 20-min Qigong exercise sets. Such after-the-fact reports cannot tell about the fluctuation of flow during the exercises, or, indeed, whether the emotional experience corresponding to the items was at all present during performance or only emerged after completion of the exercise. This is a fundamental limitation of all after-the-fact self-reporting. It is particularly vexing in the case of studying flow, because flow is by definition a state of reduced self-consciousness and therefore external probes to report one's flow might themselves disrupt the very phenomenon. After-the-fact vs. concurrent report of flow is an issue that needs serious methodological work in the field of flow research.

The results suggest that already after the first exercise, a state of flow was achieved. It would be interesting both from a practical and theoretical points of view to know how quickly experienced practitioners of Meditative Movement can "enter into flow."

One limitation of the study is that the majority (89%) of the participants had previously participated in Meditative Movement training led by the first author. Thus, if the participants interpreted the aim of the sessions to induce positive feelings or elicit flow, experimenter bias could be introduced to the PANAS and FSS scores. Care was taken to present all oral and written instructions in as neutral and non-leading way as possible, but ultimately there is no way to determine the magnitude of the issue, or ascertain how well it was mitigated. In meditation research this problem of bias might be seen as especially worrying. However, in their Meta-Analysis on meditation Sedlmeier et al. (2012) did not find experimenter bias, participants' expectation or personal relationship effects to have a strong effect on results.

The three different Qigong exercise sets were repeated in the same order in each session in order to follow the common Qigong progression from large- to small-scale movement. This introduces systematic within session differences in exercise type before each FSS report. However, because this type of ordering corresponds to the "natural" ordering of the exercises for Qigong, it was judged that ecological validity of the session structure was more important than counterbalancing the exercise types, which would have allowed us to probe the question of whether specific individual types of exercises are particularly conducive to flow, or associated with positive affect.

More research is also needed to understand the effects of Meditative Movement on flow, such as how fast can an experienced practitioner reach a flow-state. Another interesting avenue would be to combine flow questionnaires with psychophysiological measurements such as EEG (Electroencephalography), HRV (Heart rate variability), or EDA (Electrodermal activity). However, a problem with psychophysiological measurements are their sensitivity to movement-induced errors in signal, which can be major problem in Meditative Movement research. Still, wearable sensor technology is rapidly evolving that might alleviate this problem. Also, there exist several forms of Meditative Movement practices were physical movement is very small, such as Yiquan ("intention boxing") were the practitioner stands still for long periods of time in certain postures (such as "hugging the tree" -posture) and uses mental (motor) imagery that produces only small micromovements in the body. Since the movements in this kind of practice are very small, recording psychophysiological signals would likely be easier than in most forms of Meditative Movement (or exercise generally), in terms of avoiding signal corruption from motor artifacts.

Also, to get a clearer view of the underlying principles specific to Meditative Movement, its effects on flow and affect should be systematically compared to forms of sitting meditation, regular relaxation techniques, or regular physical exercise. Later on, systematic comparative studies even with other activities known to be associated with mood regulation and flow experience, such as dance or music listening or sports, should be conducted. Large-scale empirical efforts along those lines would highlight commonalities and differences between different meditation methods and, in a broader framework, between different types of mood regulation and management of stress. Yet, it needs to be acknowledged that such controlled experiments remain a challenge for future studies, as it is first necessary to identify the (theoretically) most significant aspects of Meditative Movement/qigong in order to determine relevant independent variables and controls. Additionally, it is necessary, to identify the (theoretically) most significant effects in order to determine meaningful dependent variables. In parallel, as already pointed out earlier, we need to work to determine the most sensitive and reliable methodological choices. Thus, at the present state of research on psychological concomitants of meditative movement, in our judgment, exploratory groundwork like the work presented here is an important starting point.

CONCLUSION

Meditative movement practices combine specific movement patterns, breathing and mental attention focusing techniques to achieve cognitive and emotional changes in the human, understanding of which could shed new light on the interrelationship between the body and the embodied mind. Although self-report data has limitations, and can usually only be collected after-the-fact, they are nevertheless the

only way more subtle questions about the quality of affective experience or the phenomenon of Flow experience can be experimentally posed. Established questionnaires and more qualitative techniques of analyzing the way participants describe their inner feelings in their own words can hopefully pave the way for the development of psychometrically validated questionnaires designed specifically for the study of Meditative Movement, and even psychophysiological measurements. Such complementary techniques should allow us to better understand the mental and physical changes produced by sustained practice of Meditative Movement, and, further, to lead to theoretical advancements in understanding the complex interplay of body movement, breathing, and attention in the generation of human experience.

DATA AVAILABILITY STATEMENT

The datasets analyzed for this study can be found on figshare: https://doi.org/10.6084/m9.figshare.9638024.v1.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

PP conceived the study and ran the experiment. PP, OL, and MT designed the experiment, wrote the manuscript, first draft, and approved the manuscript for submission. PP and OL analyzed the data.

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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.2019.02375/full#supplementary-material

The files are available on Figshare, here is the link: https://doi.org/10.6084/m9.figshare.9638024.v1

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Conflict of Interest: PP has been teaching professionally different Meditative Movement methods (including Dynamis-qigong that were used in this study) over 20 years, and the majority of subjects had participated at least once in his classes.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Influence of Positive and Threatened Awe on the Attitude Toward Norm Violations

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Awe is an emotional response to vast stimuli needing for accommodation. Although several studies have revealed that awe led to more ethical attitudes toward one's own behavior and to generosity toward people in general, it is unclear whether and how the two types of awe—positive and threatened—influence one's attitude toward others' social norm violations. In the current study, we examined the influence of these types of awe on tolerance toward deviators' behavior by using a pre-post design and a scenario task within the Japanese population. The findings indicated that positive awe increased the tolerance of others' norm violations, while threatening awe did not.

Keywords: positive awe, threatened awe, norm violation, tolerance, attitude

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INTRODUCTION

Social norms have an important role in maintaining the society and interpersonal relationships in the interaction with ecological and historical threats (e.g., natural disasters and conflicts). Countries and regions which have been exposed to such threats have tight cultures (strong norms and intolerance toward deviators) (Gelfand et al., 2011; Harrington and Gelfand, 2014). Conversely, given that cultural tightness is associated with lower levels of happiness (Harrington et al., 2015) and that disgust for norm violations can sometimes turn into aggression (Bondü and Richter, 2016), the importance of liberalizing attitudes toward norm violations was postulated. Therefore, in this study, we pay attention to awe as the factor of tolerance toward norm violations and investigate this effect in East Asia, specifically Japan, which is thought to be a tight culture (Gelfand et al., 2011; Mrazek et al., 2013).

Awe is an emotional response to stimuli characterized by perceived vastness and need for accommodation (Keltner and Haidt, 2003). Positive awe induces a feeling of being trivial in a vast world, that is "small self" (e.g., Shiota et al., 2007; Piff et al., 2015; Bai et al., 2017; Gordon et al., 2017), decreases aggression (Yang et al., 2016), and facilitates generosity and prosocial behavior toward people in general (Rudd et al., 2012; Piff et al., 2015; Guan et al., 2019; Li et al., 2019). Interestingly, awe-prone participants reported a high score on the openness-to-experience personality trait (Shiota et al., 2006), and high openness is associated with looseness in culture (weak social norms and tolerance toward norm violation) (Harrington and Gelfand, 2014). This implies that positive awe had a receptive effect on norm violation. However, while positive awe experience increased temporally measured tolerance for uncertainty (Valdesolo and Graham, 2014), dispositional awe correlated with the need for closure cognition (Shiota et al., 2006). The relationship between trait-awe and psychological attitude cannot predict the relationship between state-awe and psychological attitude, and little is known about the

influence of state-awe on norm violation. Additionally, many previous studies examining the effect of awe on generosity and prosocial tendencies have been conducted within the context of ethical judgment of one's own selfish behavior and tolerance of people in general (not deviators). Thus, it remains unclear how awe influences attitude toward others' norm violations in a daily context.

Awe is roughly classified into two types based on valence: positive awe, which is a positive emotion and often induced by the beauty of nature (e.g., the Grand Canyon and aurora) and great people (e.g., Gandhi), and threatened awe, which is awe with a flavor of fear and often induced by the natural disasters (e.g., tsunami and tornado) or notorious dictators such as Adolf Hitler (Gordon et al., 2017). Awe, then, has general and specific effects depending on its valence (Piff et al., 2015; Gordon et al., 2017; Guan et al., 2019). The influence of awe on tolerance toward others' norm violations may differ depending on the types of awe, as threatened awe does not enhance a sense of connection to everything unlike positive awe (Krenzer, 2018). In line with these findings, the purpose of this paper is to investigate the influence of awe on the attitude toward others' norm violations using both positive awe and threatened awe.

Positive awe enhances a sense of connection to a particular person (e.g., a friend) or to people in general (Shiota et al., 2007; Van Cappellen and Saroglou, 2012; Krause and Hayward, 2015; Stellar et al., 2017; Nelson-Coffey et al., 2019). In an American sample, positive awe was found to decrease self-focused attention and strengthen the feeling of being included in a community (Bai et al., 2017). Moreover, given that induction of positive awe decreases participants' social dominance orientation and promotes environmentalism (Zhao et al., 2018), positive awe releases people from their social hierarchy, and connects them not only with one another but also with non-human objects such as the environment. A previous study that has developed the awe state scale has also revealed that "connectedness" and/or "liberation/connection" is an important factor in positive awe-experiences, which includes items such as "connected to everything" (Krenzer, 2018; Yaden et al., 2019). Positive awe liberates people's attention from the existing self and references, and enhances a sense of connectedness to everything, perhaps depending on the context. Thus, positive awe may promote a tolerant attitude toward social norm violations, in the context of connectedness to deviators. Therefore, we hypothesize that induction of positive awe encourages participants to tolerate norm violation.

While positive awe strengthens a sense of being connected to everything, threatened awe does not (Krenzer, 2018). If positive awe enhances a sense of connection to other people and even deviators, independently of social hierarchy, it is postulated that threatened awe promotes neither a tolerant attitude nor an intolerant attitude toward others' norm violations; as suggested by previous research, threatened awe may enhance strict attitudes toward norm violations (Gelfand et al., 2011; Gelfand and Lun, 2013; Kastenmüller et al., 2013; Mrazek et al., 2013). Furthermore, cross cultural surveys and experiments indicate that ecological, historical, and societal threats (e.g., natural disaster, terrorism, war) promote tightness and intolerant attitudes toward norm violation (Gelfand et al., 2011; Gelfand and Lun, 2013; Mrazek et al., 2013). Also, the priming of a natural disaster enhances sensitivity to justice against perpetrators (Kastenmüller et al., 2013). However, these studies did not check whether participants felt awe toward the ecological threat nor investigate the effect of threatened awe directly. Considering that natural disasters and the 9.11 attack are typical of stimuli that induce threatened awe (Gordon et al., 2017), threatened awe may encourage participants to be intolerant of norm violations.

Positive awe may be related to the socio-political factors in the tightness-looseness model (e.g., government, education, religion and spirituality), because awe is often induced by great leaders, scientific knowledge, and religion (e.g., Keltner and Haidt, 2003; Gordon et al., 2017; Valdesolo et al., 2017). Previous studies have proposed a systems model of tightness-looseness and investigated the factors of the cultural tightness-looseness from the perspective of temporal behavior and culture (e.g., Gelfand et al., 2011; Gelfand and Lun, 2013), but most of them have focused on the promotors of tightness, and the socio-political factor is one of them. In this study, we examine the temporal influence of positive awe as the promotor of looseness.

Current Study

The purpose of this study is to examine whether and how two types of awe (positive awe/threatened awe) influence attitudes toward others' norm violations. As norms differ across countries, regions, and societies, it may be difficult to generalize the study. Therefore, we measure attitudes toward norm violations by using the social norm violation scenario task (Mu et al., 2015), which comprehensively depicts norm violations in various situations and has been validated between tight and loose cultures. We tested the hypothesis that positive awe encourages participants to decrease the ratings of "inappropriateness" in norm violation scenarios, while threatened awe does not, or not otherwise encourages intolerance of norm violations.

MATERIALS AND METHODS

Participants

The participants of this study comprised 50 Japanese-speaking students from Kyoto University (22 women; mean age = 21.32, *SD* = 2.04). This study was approved by the Ethical Review Board of Kyoto University. All participants provided written informed consent. For ethical considerations, it was explained that they might watch a video depicting natural disasters and had the right to exit the experiment at any time. We also checked whether the ratings of each of the measures were reliable, based on the criterion of Mean $\pm$ 3 *SD*. As a result, two participants were excluded from analysis. Finally, 48 participants (20 women; mean age = 21.29, *SD* = 2.04) in the final sample were analyzed.

Procedures

First, all participants watched a 2 min neutral clip, in which a narrator described an automobile factory. Participants were inside an experiment room. The videos were presented on computer and it was listened to by speakers. After watching a neutral video, participants completed measures of their emotional states, perceived self-size (Bai et al., 2017), sense of connection with their community (Mashek et al., 2007), attitude toward social norm violations (Mu et al., 2015), openness-to-experience (Costa and McCrae, 1992), conscientiousness (Costa and McCrae, 1992) and other scales (pretest). Then, they were randomly assigned to watch one of two videos: a 2 min positive awe-eliciting clip, consisting of a montage of beautiful nature clips, composed of glaciers, forests, mountains, and stars; a 2 min threatened awe-eliciting clip, consisting of a montage of threat-based nature clips, specifically tsunamis and floods. After watching an awe video, they completed the same measures of their emotional states, perceived self-size, sense of connectedness with their community, attitude toward social norm violation, openness-to-experience, conscientiousness and other scales (posttest). After this experiment, participants in a threatened awe condition were asked whether they or their family had experienced a natural disaster, and none reported having had such an experience. The neutral and positive awe-eliciting clips used in this study were the same clips used in a previous study (Takano and Nomura, 2018). We used this threatened awe-eliciting clips without measuring its validity by preparatory experiment, but ratings of "ifu," "ike," and "perceived self-size" provided us with the validity of this video and manipulation. Participants responded to emotion, perceived self-size, sense of connectedness with their community in writing and the rest using Qualtrics[1]. Screenshots of each conditions were shown in **Supplementary Figure S1**.

Materials

Emotions

As a manipulation check, we used these emotion reports to confirm that participants felt awe while watching the awe-inducing video more so than while watching a neutral video. All participants reported the extent to which they were feeling: "ike," "ifu" (awe is referred to as "*ike*" and/or "*ifu*" in Japan; Muto, 2014), wonder, fear, anxiety, amazement, annoyance, compassion, moved, nervous, respect, sadness, curious, amusement, happiness, and appreciation, measured on a 7-point Likert scale from 1(*not at all*) to 7(*extremely*). This measure is widely used to check the validity of awe induction (see Gordon et al., 2017).

Perceived Self-Size

Perceived self-size was measured with one item, symbolic self-circle, taken from Bai et al. (2017). Participants checked the circle that best represented how big or small they feel themselves to be on a 7-point Likert scale rating from 1 (*a smallest circle*) to 7 (*a biggest circle*). This scale consists of one pictorial item and is insusceptible to translation issue. Also, it has been validated across cultures (Bai et al., 2017).

A Sense of Connection With the Community and Society

In the same way as a previous study (Bai et al., 2017), we measured participants' sense of connection with their community and society using the Inclusion of Community in the Self scale (Mashek et al., 2007), a single-item pictorial measure consisting of six pairs of overlapping circles, with each pair of same-sized circles overlapping slightly more than the preceding pair. In each pair, the left circle was labeled as "self" and the right as "community at large." Participants checked the pair of circles that best represented their relationship with their community on a 6-point Likert scale from 1 (*not at all overlapping*) to 6 (*mostly overlapping*).

Openness to Experience and Conscientiousness

We measured participants' openness to experience and conscientiousness at the state level to examine the pre-post effects of presentation of positive and threatened awe for each, using the Japanese version (Shimonaka et al., 1999) of the NEO-FFI (Costa and McCrae, 1992). The NEO-FFI-Openness to Experience ($\alpha = 0.58$) and NEP-FFI-Conscientiousness ($\alpha = 0.78$) consisted of 12 items, respectively. Participants were asked to rate the extent to which they agreed with each statement, from 0 (strongly disagree) to 4 (strongly agree) to twenty-four items.

Attitude Toward Norm Violation

We measured participants' attitudes toward others' social norm violations by using a scenario task, the Social Norm Violation Task (Mu et al., 2015). This task has been validated across cultures in a previous study, controlling for social norm differences between cultures. Participants were asked to judge whether certain behaviors were appropriate or not in different situations. Subjects were presented with forty-five scenarios (fifteen scenarios × three conditions): fifteen "appropriate" scenarios each describing a stranger behaving appropriately in a situation (e.g., Jacob is in the bike lane. He is cycling.); fifteen "weak violation" scenarios each describing a stranger behaving weakly inappropriately in a situation (e.g., Jacob is on the city sidewalk. He is cycling.); fifteen "strong violation" scenarios each describing a stranger behaving strongly inappropriately in a situation (e.g., Jacob is on the highway. He is cycling.). Participants were asked to judge the level of inappropriateness for all scenarios on a 6-point Likert scale from 1 (very appropriate) to 6 (very inappropriate). In previous studies (Mu et al., 2015), participants were asked to rate appropriateness from 1 (*very appropriate*) to 4 (*very inappropriate*). We added two points ("*appropriate*" and "*inappropriate*") to the four points ("*very appropriate*," "*slightly appropriate*," "*slightly inappropriate*," and "*very appropriate*") used in the previous study (Mu et al., 2015) to analyze the ratings serially and quantitatively. We translated this tool into Japanese and used it. The mean ratings of "inappropriateness" for each condition in fifteen scenarios in each condition were analyzed as dependent variables.

[1] https://www.qualtrics.com/jp/

RESULTS

Emotion (Manipulation Check)

Emotion reports confirmed that participants in a positive awe condition experienced stronger feelings of both of "*ike*" and "*ifu*" in the posttest (i.e., after watching positive awe clips) ("*ike*": $M = 4.92$, $SD = 1.86$; "*ifu*": $M = 4.25$, $SD = 1.77$) than in the pretest (i.e., after watching neutral clips) ("*ike*": $M = 2.42$, $SD = 1.42$; "*ifu*": $M = 1.38$, $SD = 0.64$) ["*ike*": $F(1,23) = 35.20$, $p < 0.001$, $\eta_p^2 = 0.61$; "*ifu*": $F(1,23) = 68.42$, $p < 0.001$, $\eta_p^2 = 0.75$] (see **Table 1**). Participants in threatened awe conditions experienced stronger feelings of both of "*ifu*" and "*ike*" in the posttest (i.e., after watching threatened awe clips) ("*ifu*": $M = 5.54$, $SD = 1.25$; "*ike*": $M = 3.75$, $SD = 2.17$) than in the pretest ("*ifu*": $M = 1.17$, $SD = 0.48$; "*ike*": $M = 1.75$, $SD = 1.36$), ["*ifu*": $F(1,23) = 296.69$, $p < 0.001$, $\eta_p^2 = 0.93$; "*ike*": $F(1,23) = 13.80$, $p < 0.001$, $\eta_p^2 = 0.38$] (see **Table 1**). Participants in threatened awe conditions experienced stronger feelings of "*ifu*" than did participants in positive awe conditions in the posttest minus pretest, $F(1,46) = 12.51$, $p < 0.001$, $\eta_p^2 = 0.21$. The difference in "*ike*" rating (posttest minus pretest) between positive awe condition and threatened awe condition was not significant, $F(1,46) = 0.54$, $\eta_p^2 = 0.01$. These analyses were performed by an ANOVA. Other emotional state reports were shown in **Supplementary Table S1**.

Perceived Self-Size

Perceived self-size reports confirmed that participants in positive awe conditions perceived smaller self-sizes in the posttest ($M = 3.42$, $SD = 1.61$) than in the pretest ($M = 3.96$, $SD = 1.23$), $F(1,23) = 6.76$, $p = 0.016$, $\eta_p^2 = 0.23$. Participants in threatened awe conditions perceived smaller self-sizes in the posttest (M = 3.21, $SD = 1.47$) than in the pretest ($M = 4.00$, $SD = 1.29$), $F(1,23) = 7.24$, $p = 0.013$, $\eta_p^2 = 0.24$. These analyses were performed by an ANOVA. Accordingly, for both awe conditions, ratings of "*ifu*" and "*ike*" in the posttest increased compared to the pretest, and ratings of "perceived self-size" in the posttest decreased from the pretest.

Openness to Experience and Conscientiousness

Ratings for openness to experience and conscientiousness did not differ between pretest and posttest for either awe condition, $Fs < 0.66$, η_p^2s < 0.03 (see **Supplementary Table S2**).

A Sense of Connection With Community and Society

Ratings for inclusion of community did not differ between pretest and posttest for either awe condition, $Fs < 0.52$, $\eta_p^2 s < 0.02$ (see **Supplementary Table S2**).

Attitude Toward Norm Violation

Testing our hypothesis that positive awe encourages tolerance toward norm violations, we performed an ANOVA on the ratings of inappropriateness for scenarios depicting strong violations, which revealed the predicted positive awe effect, $F(1,23) = 6.92$, $p = 0.015$, $\eta_p^2 = 0.23$. Participants in positive awe conditions reported the more tolerant attitudes toward strong violations in the posttest ($M = 4.83$, $SD = 0.38$) than in pretest ($M = 4.95$, $SD = 0.33$). Ratings for appropriate and weak violation scenarios in positive awe conditions did not differ between pretest and posttest, $Fs < 0.50$. In turn, to test whether inducing threatened awe influenced attitudes toward norm violations, an ANOVA on the rating of for inappropriateness for scenarios depicting strong violations revealed an insignificant effect, $F(1,23) = 0.02$, $\eta_p^2 = 0.00$. This result supported the hypothesis that threatened awe did not encourage a tolerant attitude toward violators, unlike positive awe. Ratings of appropriate and weak violation scenarios in threatened awe conditions did not differ between pretest and posttest, $Fs < 1.14$, $\eta_p^2 s < 0.05$. Moreover, we performed an ANOVA on the changed rating (posttest minus pretest) of inappropriateness for strong violation scenarios, which revealed marginally significant condition effects, $F(1,46) = 3.25$, $p = 0.078$, $\eta_p^2 = 0.07$, 95%CI [0.000,0.230] (see **Figure 1**). This result remained when controlling the changed rating of openness to experience and conscientiousness as covariates, $F(1,44) = 3.27$, $p = 0.084$, $\eta_p^2 = 0.078$, 95%CI [0.000,0.231].

TABLE 1 | Mean differences in awe emotion, perceived self-size, A sense of connecting with community and society, attitude toward norm violation across conditions.

	Positive awe ($N = 24$)				Threatened awe ($N = 24$)				Comparison of two types of awe (posttest-pretest)	
Variable	**Pre**	**Post**	***F***	η_p^2	**Pre**	**Post**	***F***	η_p^2	**Interaction *F***	η_p^2
Awe emotion										
Ifu	1.38 (0.64)	4.25 (1.77)	68.42**	0.75	1.17 (0.48)	5.54 (1.25)	296.69**	0.93	12.15	0.21
Ike	2.42 (1.42)	4.92 (1.86)	35.20**	0.61	1.75 (1.36)	3.75 (2.17)	13.80**	0.38	0.54	0.01
Perceived self-size										
Symbolic self-circle	3.96 (1.23)	3.42 (1.61)	6.76*	0.23	4.00 (1.29)	3.21 (1.47)	7.24**	0.24	0.48	0.01
Attitude for norm violation										
Appropriate	1.73 (0.36)	1.72 (0.41)	0.02	0.00	1.67 (0.41)	1.72 (0.54)	1.05	0.04	0.64	0.01
Weak violation	4.02 (0.50)	4.00 (0.48)	0.50	0.02	3.98 (0.50)	4.03 (0.52)	1.14	0.05	1.65	0.03
Strong violation	4.95 (0.33)	4.83 (0.38)	6.92*	0.23	4.94 (0.45)	4.94 (0.48)	0.02	0.00	3.25^{+}	0.07

*Each mean is followed by the corresponding SD in parentheses. Awe is called "ifu" or "ike" in Japan. $^{+}P < 0.10$; *P < 0.05; **P < 0.01.*

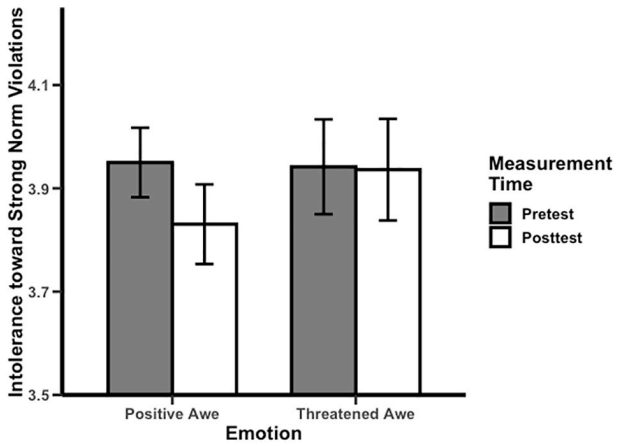

FIGURE 1 | Influences of positive awe and threatened awe on the intolerance toward strong norm violations. Error bars represent ±1 SE.

DISCUSSION

The purpose of this study was to examine the influence of two types of awe (positive awe and threatened awe) on attitudes toward others' norm violations. To the best of our knowledge, this study is the first that shows different effects of two types of awe on tolerant attitudes toward others' norm violation: positive awe encouraged people to tolerate others' strong norm violations, but threatened awe did not.

Positive Awe and Attitude Toward Norm Violation

Induction of both positive and threatened awe increased ratings of awe ("*ifu*" and "*ike*"), and decreased the rating of "perceived self-size." Manipulation checks allowed for the validation of awe induction based on the experimental stimulus. Additionally, the rating of "inappropriate" for strong norm violations decreased after viewing positive awe clips. This result corresponds with previous studies that found that positive awe enhances tolerance of people in general by using the money donation task, helping time task, and dictator game (Rudd et al., 2012; Piff et al., 2015; Guan et al., 2019).

On the other hand, interestingly, positive awe did not significantly change the Inclusion of Community in the Self (a measurement of a sense of belonging to society and community). As effects of positive awe on the social networks vary cultually (Bai et al., 2017), the present finding differs from that of the various ethnic samples recruited through Amazon MTurk in the United States (Bai et al., 2017). However, it corresponds with the findings within Chinese population, showing that positive awe did not significantly change the sense of social network size among Chinese people (Bai et al., 2017), who live in a collectivist culture like the Japanese. It is also noteworthy that positive awe led to a closer distance between the self and others in the Chinese sample (Bai et al., 2017). Given that a closer connection to society and community leads to more intolerance of others disturbing order, as typical of collectivism and tightness of culture (Gelfand et al., 2011), the present result in which attitudes toward others' norm violations become tolerant may be consistent with the result that a feeling of connection with society and community is not changeable.

Our findings also contribute toward furthering the theory in the domain. Previous research has mainly focused on the factors of tightness, but this study focused on positive awe as a promotor of looseness and found that positive awe encouraged participants to hold loose attitudes. Further, positive awe is induced mainly by nature, another person, self, religious experiences, art, music, and architecture (Gordon et al., 2017). Although, according to previous studies, religiosity is associated with tightness (Gelfand et al., 2011), our results suggest that certain religions (e.g., a religion which has a loving God) are associated with looseness. We may need to consider how people perceive God within religion, in the tightness-looseness model. This argument corresponds recent findings that conflicts increase support for cultural tightness, which in turn increases the importance of punitive God (Caluori et al., 2020).

Difference Between the Two Types of Awe

Participants in a threatened awe condition reported higher changed rating of "*ifu*" than participants in a positive awe condition, while in regard to changed rating of "*ike*," there was no significant difference. This may be because the letter "怖" in "*ifu* (畏怖)" means fear in Japanese, while the letter "敬" in "*ike* (畏敬)" means respect.

In contrast to positive awe, threatened awe did not have a significant influence on the attitudes toward others' norm violations. The interaction, although it was marginally significant, indicated that positive awe and threatened awe have, at least, a different influence on the generosity at the least. Furthermore, the present result corresponds to the previous hypothesis that effects on connection would differ between the types of awe (e.g., eliciter, valence) (Van Cappellen and Saroglou, 2012; Krenzer, 2018), suggesting that positive awe may promote the generosity toward norm violation by emphasizing connection to others with various attributes, while threatened awe does not, because it does not emphasize connection. On the other hand, threatened awe often leads to the enhancement of connections between people and other-focused behavior and culture, alleviating feelings of loss in the face of threatened-awe inducing events (Nomura et al., in press). Moreover, as norms have an important role in maintaining the society, tolerance toward deviators may not be adaptive in such a situation. In sum, positive awe enhances connectedness to everything/everyone, whereas threatened awe may lead to connection with a particular something/someone, which does not include deviators, probably because connection to deviators generally does not become a buffer against threats. This explanation corresponds to the result that threatened awe encourages participants to be generous toward people in general (Piff et al., 2015). Since few studies have examined which layer of "connectedness" is affected by experience of awe, investigation of the influence of two types of awe on the feeling of connectedness is of interest.

LIMITATIONS AND FUTURE DIRECTIONS

While our study contributes to furthering the theory in understanding attitudes toward norm violation, certain limitations of the current study should be noted, along with some future directions. First, the sample size is relatively small for a behavioral study. This may have contributed to the marginally significant condition effects (positive awe vs. threatened awe) observed in our study.

Second, as the influence of awe on the attitudes toward norm violation may vary between cultures, it is of interest to see whether the effect of positive awe on generosity toward norm violations is reproduced in Western samples.

Third, details of the psychological processes underlying enhancement of tolerance toward norm violations by inducing positive awe remains unclear. Investigations into the nature and effect of awe on individuals and society are in nascent stages and researchers have a great deal yet to explore; for example, the effect of elicitor of awe on social cognition and time perception. Time perception has also been mentioned as an effect that differs between positive and threatened awe (Guan et al., 2019). Social norm violation is disorderly behavior, and ethnical judgment of such behavior may tolerate it in states liberated from time pressure.

Fourth, in this study, a neutral video was shown before positive or threatened awe video in a fixed order, so it is possible to interpret the results as participants being primed to experience something more interesting in general after watching the neutral clips. However, considering awe experiences themselves consist of interesting and wonderous things (e.g., Gordon et al., 2017), it is likely that the present results revealed awe-specific effects under the comparison of two types of awe. It is also of interest to see whether neutral states preceding awe experience would affect attitude toward norm violations.

The forms of connections induced by awe should be investigated in future studies as a function of collectivist vs. individualistic cultures that the participants belong to, as well as within culture differences examining how individuals view their own cultures. Since there is little awe-related research to examine the forms and layers of connection (except for Van Cappellen and Saroglou, 2012), we investigated the influence of awe on general connectedness from the perspective of norm violation. In this study, however, the results for the Inclusion of Community in the Self scale were not significant. This may be because the meaning of "community" in the ICS varies between participants, and some of them might have friends in mind while other may think about family members. Different measures than the ICS may be more appropriate for collectivist cultures. Also, as religiosity and spirituality regulated the influence of awe on feelings of connectedness, religiosity may be related to the cultural differences in the influence of awe on connection (Nomura et al., in press).

Finally, the homogeneity of the sample population may be considered a weakness, particularly since students' data may not generalize to the wider population. Future studies should explore additional populations to improve our understanding of this phenomenon.

CONCLUSION

In summary, we investigated the influence of two types of awe on attitude toward others' norm violations. The results indicated that positive awe led to tolerant attitudes toward others' norm violations, while threatened awe did not, suggesting that the influence of awe on attitude toward others' norm violations differs with the types of awe.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethical Review Board of Kyoto University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

Both authors designed the current study, analyzed the date, interpreted the funding and reviewed the manuscript. KS recruited the participants, collected the data and wrote the main 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.2020.00148/full#supplementary-material

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METHODS
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Providing Psychological and Emotional Support After Perinatal Loss: Protocol for a Virtual Reality-Based Intervention

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The loss of an infant during the perinatal period has been recognized as a complex and potentially traumatic life event and can have a significant impact on women's mental health. However, often times, psychological aftercare is typically not offered, and manualized interventions are rarely used in clinical care practice and have seldom been evaluated. In recent years, a growing number of studies have demonstrated the efficacy of virtual reality (VR) interventions to facilitate the expression and coping with emotions linked to a traumatic event. The objective of the proposed paper is to present the protocol of a randomized control trial aimed to assess a novel VR-based intervention for mothers who experienced a perinatal loss. We hypothesize that the VR-based intervention group will show significantly reduced symptoms related to grief, postnatal depression and general psychopathology after treatment relative to a treatment-as-usual (TAU) group. Participants would be randomly assigned to the TAU + VR or to the VR + TAU condition. The TAU condition as well as the VR-based intervention will last 3 weeks, after which women will complete a post-assessment. The proposed VR-based intervention will consist in three weekly sessions focused, respectively on: (1) collect information about the loss and psychoeducation about perinatal grief, and introduction to the virtual environment; (2) through the use of the virtual environment, women will be assisted in the elaboration and acceptation of loss; (3) recreate, using the specific features of the virtual environment a positive metaphor representing woman's future life. VR has proved to be a valid intervention tool in clinical psychology, and in the last years VR technologies have become more affordable to be used in clinical practice. With the present study we propose to answer to the unquestionable need for interventions addressed to ameliorate the emotional effects in women who experienced perinatal loss, by exploiting also the therapeutic opportunities offered by a new technology as VR.

Keywords: perinatal loss and grief, intervention, virtual reality, women mental health, psychological intervention

INTRODUCTION

The perinatal period is a complex time in women's lives. It is a transitional time which requires important changes and challenges as searching for a new identity as an individual, a partner in a couple, and a member of a society (Bibring, 1959; Barclay et al., 1997). The complexity of this period can dramatically increase if women experience perinatal loss. The loss of an infant during the perinatal period has been recognized as complex emotional experience and a potentially traumatic life event for women who experienced it, no matter how and at what gestational stage it occurred (e.g., Berman, 2001; Klier et al., 2002; Bennett et al., 2012). Indeed, although mothers have few or no direct life experiences with their infant, grief in a context of the loss of a child in the perinatal period does not vary significantly in terms of intensity from other type of loss (Kersting and Wagner, 2012). In this paper we use the term perinatal loss to refer to the experiences of women who lost a child during the perinatal period (i.e., loss due to miscarriage, stillbirth, termination due to medical indications, and neonatal death). Miscarriage, stillbirth, and neonatal death continue to be significant topics of concern in the twenty-first century. In Québec (a province of Canada) it is estimated that each year 20,000 pregnancies do not terminate in a live birth (Agence de la santé publique du Canada, 2008).

Research and clinical reports have shown that the loss of a child can cause a multitude of emotions and psychological distress in many women (de Montigny et al., 2017b). Grief is a natural, non-pathological phenomenon and a deeply personal process (Kersting and Wagner, 2012). Reactions to the loss of a significant one can involve transient impairment of daily functioning, elusion of social activities, presence of recurrent and intrusive thoughts, feelings of deep longing and incapability of feeling sensations and emotions (Kersting and Wagner, 2012). The severity of psychological distress generally tends to wane over the first year after the loss (e.g., Bennett et al., 2012). Nonetheless about 20% of women continue to suffer from clinically significant symptoms 1 year after their loss (Boyle et al., 1996; Leon, 2001). Perinatal losses have been shown to have detrimental effects on both mothers' and fathers' psychological well-being, on the other members of their families, and are also associated with post-traumatic stress, depression, anxiety, and sleep disturbances (Boyle et al., 1996; Hughes and Riches, 2003). Hughes et al. (2002) reported that approximately 20% of women who experienced a perinatal loss can manifest depression or posttraumatic stress symptomatology. Furthermore, losing a child during the perinatal period has been identified as a complex and potential threatful life experience, which can, in some cases, further develop in complicated grief reactions, characterized by more disruptive, pervasive, or stable symptoms than in a normal grief response. Persistent complex bereavement disorder, also known as complicated grief disorder, has been included in the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5; American Psychiatric Association, 2013).

Despite the increasing recognition that perinatal loss can lead to significant consequences on women's mental health, often times, few of the women affected receive emotional and psychological support (de Montigny et al., 2017b). The necessity of psychological interventions supporting women after a pregnancy loss is unquestioned in the scientific literature. Nevertheless, psychological aftercare is typically not offered, and manualized interventions are hardly applied in clinical care practice (e.g., Kersting and Wagner, 2012; de Montigny et al., 2017b). The lack of manualized interventions mirrors the corresponding lack in the scientific literature. Indeed, in an attempt to systematically review the scientific literature for psychological and support interventions to reduce levels of stress, anxiety or depression on women who experienced a miscarriage, Campillo et al. (2017) did not find any randomized controlled trials.

In recent years, new technologies have been increasingly used for the assessment, treatment and better understanding of mental health related problems. For instance, Internet- and computer-based interventions are increasingly popular, ranging from pure psychoeducation websites to online self-help groups, self-help interventions, counseling, and even psychotherapy for all sorts of mental health problems (e.g., Andersson and Titov, 2014; Ebert et al., 2018; Moshe et al., 2020), including for parents who experiences perinatal loss (e.g., Kersting et al., 2011a,b). Virtual reality (VR) is another technology that saw an exponential increasing in its popularity in clinical and health psychology. VR embodied the unique opportunity to create (and recreate) simulated environments "where the testing, training, teaching, and treatment of cognitive, emotional, and sensorimotor processes can take place under stimulus conditions that are not easily deliverable and controllable in the physical world" (Rizzo and Bouchard, 2019, p. 6). More specifically, numerous studies have demonstrated the efficacy of VR-based interventions to facilitate the expression and coping with emotions (e.g., Rizzo and Bouchard, 2019). Most of the virtual environments created and used as toll to treat potentially traumatic events are realistic in the sense that their aim is to virtually replicate, in a safe and controlled situation, a real life aversive situation (e.g., war environments, Peskin et al., 2019; sexual assault, Loranger and Bouchard, 2017). The virtual environment "EMMA World" was developed as a tool to facilitate the expression and coping with emotions in stress-related disorders (posttraumatic stress disorder, complicated grief, and adjustment disorders) (Baños et al., 2009, 2011). EMMA's World objective is not to realistically reproduce the physical features of a threatening or traumatic event, but rather to employ symbols and personalized elements that can evoke emotional reactions and can facilitate the expression of patients' emotional state in a symbolic way that will be used by the therapist. To achieve therapeutic objectives, different virtual landscapes and symbols are customized to be personally meaningful for the patient; those virtual elements are used to recreate, in a safe and controlled environment, emotions and situations that are difficult for the person to confront and process (Baños et al., 2011). The possibility to use personalized stimuli in EMMA World could be particularly relevant to support women in coping with their perinatal loss and the multitude of emotions that they can

experience in this critical period of their life. It is expected that such a focus intervention would be more effective than services routinely provided and referred-to as treatment-as-usual (TAU).

The objective of the proposed paper is to describe the protocol of a randomized control trial aimed to assess a VR-based intervention for mothers who are experiencing perinatal loss. We hypothesize that: (a) when administered before TAU, the VR-based intervention will lead to a greater reduction in symptoms related to grief, postnatal depression and general psychopathology, compared to participants receiving TAU; (b) when administered after TAU, the participants will show a significant pre/post-VR-based intervention improvement in symptoms related to grief, postnatal depression and general psychopathology.

MATERIALS AND METHODS

Inclusion/Exclusion Criteria

The intervention program will be offered to mothers who had recently experienced a perinatal death, including: having lost a child during pregnancy because of miscarriage (i.e., embryo or fetus death prior the 28th week of gestation); termination due to medical indications; stillbirth (i.e., fetus death after 28 completed weeks of gestation); or neonatal death (i.e., infant death within the first 7 days of life). Women who have experienced perinatal death while pregnant within no more than 1 year before the enrollment will be invited to participate to the study. Exclusion criteria include significant vision impairments despite wearing corrective glasses or lenses, presence of a diagnosed mental disorder, and being under psychological treatment. The target sample will be composed of 40 women. To evaluate the size of the involved samples, we used a Sample Size Calculation (Power Analysis) using the software GPower*3. We based the power-analysis on a recent study assessing efficacy of an EMMA's World-based intervention for the treatment of stress-related disorders. We estimated a minimum of 40 women to be included in the trial, in order to achieve a minimum power of 90%, considering a medium effect size of $f = 0.25$, and a significance level of 0.05.

Measures and Data Analysis

Personal Information Sheet

Women will be asked about their age, nationality, relationship status, religion, education level, occupation, French proficiency, presence of psychiatric and/or physical problems (i.e., mobility and sight problems), being under psychological treatment and use of drugs. In addition, women will be asked to provide information about their perinatal loss: date of perinatal death, type of perinatal death (i.e., miscarriage, termination due to medical indications, voluntary termination of pregnancy, stillbirth, or neonatal death), gestation weeks, previous pregnancy, planned pregnancy, previous children.

Outcome Measures

Perinatal grief will be measured with the Perinatal Grief Scale (PGS; Potvin et al., 1989; Toedter et al., 2001; French validation: Paris et al., 2017). The PGS is composed by 33 statements divided into three subscales: Active Grief, which includes 11 items that refers to the normal emotional reactions to the loss (i.e., sorrow, missing the child, or crying); Difficulty Coping, which includes 11 items that refers to more complex emotional reactions (e.g., difficulty with normal life activities, lack of support, problems in marital relationships); and Despair, which refers to long-term effects of the loss (e.g., existential feelings of helplessness and hopelessness) and relevant coping strategies. The PGS uses a Likert type scale with five response options ranging from 1 (i.e., "strongly disagree") to 5 (i.e., "strongly agree"). The total score varies between 33 and 165 points, with values above 91 points represent potential psychiatric morbidity. Complicated grief will be measured with the Inventory of Complicated Grief (IDC; Prigerson et al., 1995; French adaptation: Zech, 2006). This instrument consists of 19 items concerning the immediate bereavement-related thoughts and behaviors of the respondent, who is asked to report the frequency (from "0 = never" to "4 = always") with which he/she currently underwent each of the emotional, cognitive, and behavioral states detailed in the instrument. Individuals with an ICG total scores > 25 reported to have significantly worse general, mental and physical health, social functioning, and bodily pain, as well as depression. Thus, the authors concluded that this score should be the criterion for distinguishing between uncomplicated and complicated grief reactions. Depressed mood will be assessed using the Beck Depression Inventory-II (BDI-II; Beck et al., 1996; Validated in French by Édition du centre de psychologie appliquée, 1996). The BDI-II is one of the most widely used instruments to assess depressive symptoms and their severity following the criteria of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; American Psychiatric Association, 2000). The BDI-II consists in 21 symptoms assessed with multiple-choice responses rated on a scale value of 0–3. The maximum total score is 63, with the following standardized cutoffs: 0–13: associated to normal minimal range, 14–19: associated to mild depression, 20–28: associated to moderate depression, and 29–63: associated to severe depression. Postnatal depression will be assessed through the 10-item Edinburgh Postnatal Depression Scale (EDPE; Cox et al., 1987). The EPDS is the most commonly used screening tool to determine women's clinically significant signs of depression during the perinatal period (e.g., McCabe-Beane et al., 2016). Since many symptoms of depression overlap with normal states in women during the perinatal period (e.g., sleep disturbance), EPDS items were planned to evaluate only the mood components of depressive symptoms. The 10 items are rated on a scale from 0 to 3, and are reflecting the mood during in the last 7 days. EPDS score of 10 and 13 are proposed as cut-off scores indicative of potential minor or major depression, respectively (Cox et al., 1987; see McCabe-Beane et al., 2016 for other cut-off scores). Anxiety will be assessed using the State and Trait Anxiety Inventory-form Y (STAI-Y; Spielberger, 1983; French validation: Gauthier and Bouchard, 1993). It consists of a self-report instrument conceived to evaluate trait (a stable personality trait) and state (a temporary and fluctuating condition) anxiety. The STAI-Y

consists of two subscales (trait and state anxiety) with 20 items each rated on a 4-point scale. Higher scores indicate greater anxiety. Affect will be measured with the Positive and Negative Affect Scale (PANAS; Watson et al., 1988; French validation: Gaudreau et al., 2006). The PANAS is a widely used scale which consists of two subscales, one measuring positive affect and the other assessing negative affect. Each subscale is composed of 10 items, scored on a 5-point Likert scale ranging from 1 (i.e., "very slightly or not at all") to 5 (i.e., "extremely"). Clinical global impression assessed by the therapist will be assessed at pretest and post-test using the Clinical Global Impression rated by the therapist (CGI; Guy, 1976). It consists in a 3-item observer-rated scale that measures illness severity (CGIS), global improvement or change (CGIC) and therapeutic response. The CGI is rated on a 7-point scale, with the CGIS characterized by a range of responses from 1 (i.e., "normal") to 7 (i.e., "amongst the most severely ill patients"). CGI-C scores range from 1 (i.e., "very much improved") to 7 (i.e., "very much worse"). Treatment response ratings should consider both treatment-related negative events and therapeutic efficacy, ranging from 0 (i.e., "marked improvement and no side-effects") to 4 (i.e., "unchanged or worse and side-effects outweigh the therapeutic effects"). Each CGI's component is rated separately, and this instrument does not provide a global score.

Satisfaction With the Intervention

Women's satisfaction with the intervention will be rated at post-test using the Client Satisfaction Questionnaire (CSQ-8; Attkisson and Zwick, 1982). The CSQ-8 is a self-report measure designed to assess clients' satisfaction with mental health services. The 8-items versions has eight question-items (quality of service, kind of service, met needs, recommend to a friend, amount of help, deal with problems, overall satisfaction, and come back), rated using a 4-point Likert scale, with a possible total scores can vary from 8 to 32. Higher scores indicate greater satisfaction with the service.

In order to test our hypothesis, we will perform repeated measures (Mixed Model) ANOVA with 3 Times (Pre, Post-test 1, Post-test 2) and 2 Conditions (VR-based intervention first, followed by TAU, i.e., VR+TAU; TAU first, followed by VR-based intervention, i.e., TAU+VR). For ethical reasons, the study is a randomized control crossover design, where all participants receive an intervention. The Pretest to Post-test 1 allows the comparison of VR-based treatment versus TAU, and the Post-test 1 to Post-test 2 allows to test the added value of the VR-Based intervention to TAU.

Virtual Reality Setting

Devices

The following devices will be used: two computers, one projector, a wireless pad and a speaker system. One computer will have the graphical outputs from its graphic card connected to one projector (resolution of 1024_768 pixels and power of 2000 lumens). The projector will project the virtual environment on a screen of 4 × 1.5 m placed on a wall. Women will use the wireless pad in order to navigate and interact with the virtual environment. The second computer will permit to the therapist to adapt the virtual environment following the instruction of the participant (see Baños et al., 2009, 2011 for more detailed descriptions).

EMMA's World Virtual Environment

Women will be able to choose between five different landscapes (i.e., beach/island, desert, meadow, dark forest, and snow-capped natural landscape) the one that better represent their emotional state related to the loss of their child (see **Figure 1**). These landscapes have been specifically designed to represent, in a metaphoric way, different emotions (e.g., joy, sadness, anxiety; Baños et al., 2009, 2011). Women will be able also to select some personalized virtual elements (e.g., three-dimensional objects, sound, images, and texts) which have been designed to help patients to express, confront and manage emotions and difficult life experiences (for a more detailed description please refer to Baños et al., 2009, 2011). At the center of each landscape there is a virtual temple (**Figure 2**), where women can have access to the "Book of Life," a virtual book in which women will be able to reflect and write their feelings and thoughts related to their loss. Patients are not only able to write, but also to insert personal pictures, three-dimensional symbols, videos, and sounds, in their Book of Life. This book has different chapters that can define the progresses of the intervention and/or can represent the different chapters of the women's life. Finally, the time of the day in the virtual environment can also be customized. The therapist can control all of these elements from a single interface.

VR Intervention

The proposed intervention will consist in three weekly sessions of 2 h focused, respectively, on: (1) gathering information about the loss and psychoeducation about perinatal grief, and introduction to EMMA World; (2) through the use of EMMA World, women will be assisted in the elaboration and acceptation of loss; (3) recreate, using the features of EMMA World (i.e., a series of different virtual landscapes and symbolic elements personalized to each participant as personal pictures, sounds or videos) a new and positive metaphor representing the woman's future life.

Procedure

Women will be recruited at Université du Québec en Outaouais (UQO) as well as at the Centre d'études et de recherché en intervention familiale (CERIF) and at the Association Parents Orphelins[1]. In a first screening session, mothers will be informed about the study, asked to agree and sign a consent form and will be also asked to answer to a battery of questionnaires (i.e., "Assessment for eligibility, **Figure 3**). Information about the history of participant's pregnancy and perinatal loss will also be collected during this first in-person meeting.

Women will be randomly assigned to the VR+TAU or to the TAU + VR condition. Randomization will be performed using a true random number service[2], and will be not stratified

[1]https://parentsorphelins.org/

[2]http://www.random.org

FIGURE 1 | Examples of EMMA's World landscapes.

FIGURE 2 | EMMA's World temple.

based on participant's characteristics. The TAU condition is a homogenous standard program proposed by the CERIF at UQO based on group counseling offered to women and men who experienced a perinatal loss. The TAU condition as well as the VR-based intervention will last 3 weeks, after which women will complete a post-assessment (see **Figure 3**). The VR-based intervention will be conducted at the Cyberpsychology Laboratory of UQO; the TAU group counseling will take place at the CERIF of UQO.

DISCUSSION

The aim of the proposed study is to assess a VR-based intervention for mothers after pregnancy loss in a randomized controlled trial. In order to test our hypotheses, we will compare the innovative VR-based intervention presented in this paper, with a TAU condition. Specifically, we hypothesize that the VR-based intervention group will show significantly reduced symptoms related to grief, postnatal

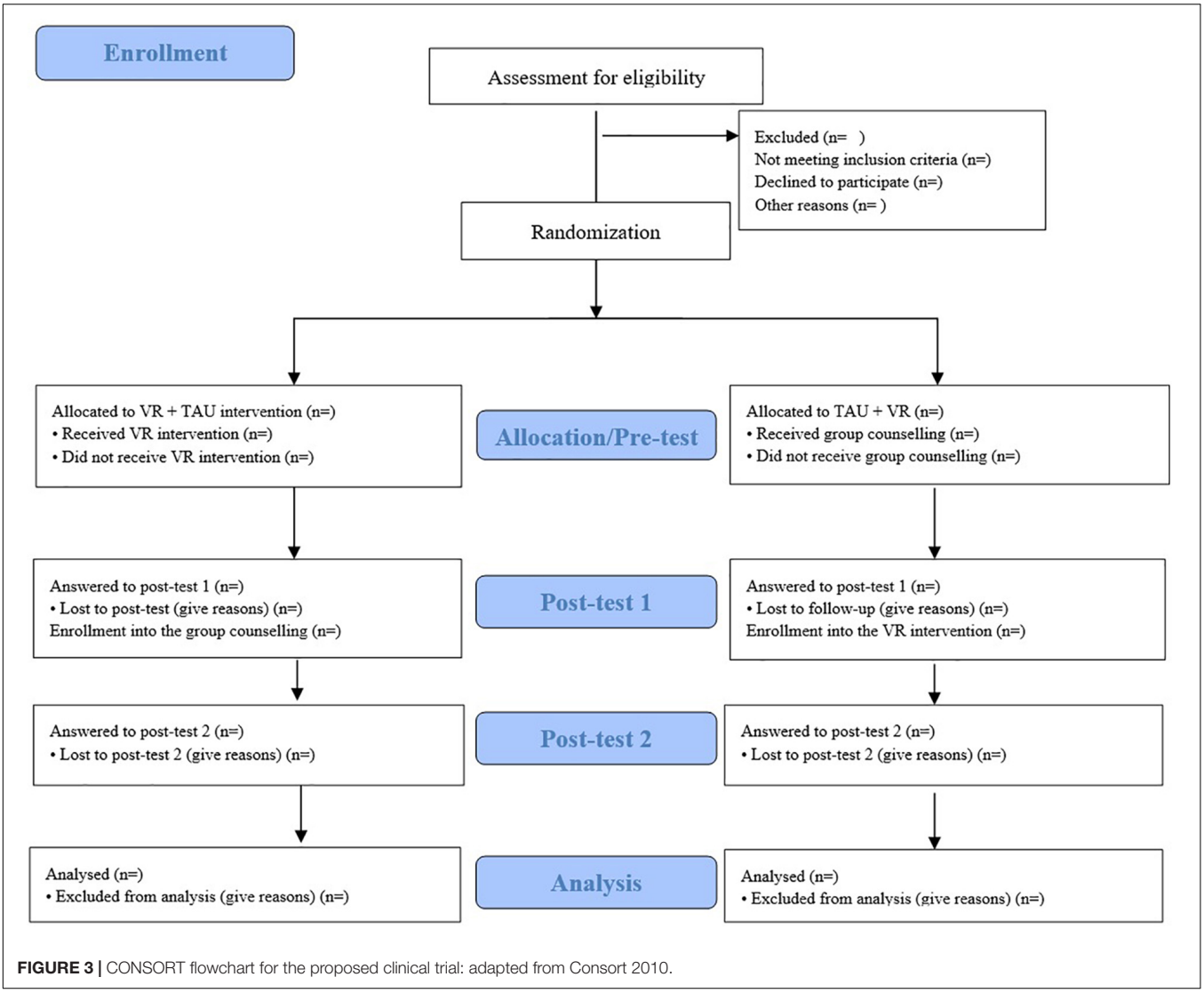

FIGURE 3 | CONSORT flowchart for the proposed clinical trial: adapted from Consort 2010.

depression and general psychopathology after treatment relative to a TAU group.

Despite the potential emotional impact and significant prevalence of loss during pregnancy, in Québec there are no specific protocols for providing psychological and emotional support to those mothers (de Montigny et al., 2017b). VR has proved to be a valid intervention tool in clinical psychology, and in the last years VR technologies have become more affordable to be used in clinical practice (Rizzo and Bouchard, 2019). The present study proposes to answer to the need for interventions designed for women who experienced a complex experience as a perinatal loss and make good use of the therapeutic opportunities offered by VR. If effective, the proposed VR-based intervention could be implemented in clinical care practice, giving the opportunity to women who experienced a perinatal death to access to well-established effective psychological intervention. In order to maintain a homogeneous sample for this first study, the intervention will be provided only to woman who have experience perinatal death. This excludes men and other people who might have been closely involved in the pregnancy (e.g., a female spouse). Future studies should also take in consideration men's experiences and non-traditional parenthood. Indeed, the loss of a child can cause a multitude of complex emotions and psychological distress in mothers as well as in fathers. However, fathers' experiences of perinatal loss have been less investigated comparing to the mother's ones (de Montigny et al., 2017a). Since in this study we have focused on women's experience of perinatal loss, future studies should also investigate to applying this VR-based intervention to men who are dealing with the loss of their baby during the perinatal period.

ETHICS STATEMENT

The proposed study was approved by the Ethical Committee of UQO, and will be conducted in accordance with the CONSORT

2010 Statement and the Helsinki Declaration of 1975, as revised in 2018.

AUTHOR CONTRIBUTIONS

GC, SB, and FM conceived and designed the protocol. RB participated in the design and developed the virtual environment. GC wrote the first draft. SB, FM, RB, and CV provided the required revisions. SB, FM, RB, and CV were GC supervisors. All authors revised and approved the final version of the manuscript.

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Awe and the Experience of the Sublime: A Complex Relationship

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Awe seems to be a complex emotion or emotional construct characterized by a mix of positive (contentment, happiness), and negative affective components (fear and a sense of being smaller, humbler or insignificant). It is striking that the elicitors of awe correspond closely to what philosophical aesthetics, and especially Burke and Kant, have called "the sublime." As a matter of fact, awe is almost absent from the philosophical agenda, while there are very few studies on the experience of the sublime as such in the psychological literature. The aim of this paper is to throw light on the complex relationship between awe (as understood by psychologists) and the experience of the sublime (as discussed by philosophers). We distinguish seven ways of conceiving this relationship and highlight those that seem more promising to us. Once we have a clearer picture of how awe and the experience of the sublime are related, we can use it to enhance collaboration between these domains. We would be able to use empirical results about awe in a philosophical analysis of the experience of the sublime, which in turn can help us to design novel experimental hypotheses about the contexts in which we experience awe.

Keywords: awe, positive awe, threat-based awe, sublime, aesthetic experience, fear, admiration

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INTRODUCTION

Since Keltner and Haidt (2003)'s seminal paper, psychologists have become increasingly interested in *awe*, an affective experience which is difficult to explain within the traditional dichotomy between positive and negative emotions.[1] It is widely acknowledged that experiences of awe produce in general positive outcomes contributing to mental health (increased pro-social behavior, life-satisfaction and meaning of life – see, e.g., Rudd et al., 2012; Piff et al., 2015), and indeed most psychological studies have investigated awe as a positive emotion (see, e.g., Griskevicius et al., 2010; Campos et al., 2013; Shiota et al., 2017). However, although awe can be seen as having an *overall* positive valence, it has a negative flavor (Chirico et al., 2016, 2017). Awe seems to be a complex emotion or emotional construct characterized by a mix of positive (contentment, happiness), and negative affective components (fear and a sense of being smaller, humbler or insignificant). It is

Abbreviations: ES, experience of the sublime.

[1] Awe is almost always considered to be an emotion or an emotional construct. Whether it represents a single construct referred to by all researchers is of course debatable. We suspect that clarifying its relationship to the experience of the sublime will also clarify its nature. Another issue concerns the relationship between emotion and cognition. When we consider awe as an emotion, we leave it open whether it also involves cognitive elements.

interesting to notice that beyond English "awe" is often captured by a combination of positive and negative terms meaning something like "fear mixed with admiration" ("timore reverenziale," "effroi mêlé d'admiration," "*Ehrfurcht*", "敬畏").

Despite the protean nature of awe, it has been suggested that it is a *basic emotion* (Ekman, 1992), even having a distinctive facial expression which involves a particular pattern combining the gaze looking upward, the mouth open slightly, and slightly oblique eyebrows (Shiota et al., 2003). There is currently no consensus about these claims in the psychological literature, which, however, has found convergence points. Most studies, influenced by Keltner and Haidt (2003), have taken vastness and need for accommodation to be the prototypical appraisal themes of awe, which is thus defined as a strong emotional response to (physical or metaphorical) grand stimuli needing new conceptual/perceptual resources.

Interestingly, the description of awe in psychology matches well an aesthetic experience widely discussed in the philosophical literature, which has to do with the sublime. Here is a telling excerpt by Thomas Mann's *The Magic Mountain* describing this kind of experience:

> But if there was something roguish and fantastic about the immediate vicinity through which you laboriously made your way, the towering statues of snow-clad Alps, gazing down from the distance, awakened in you feelings of the sublime and holy (Mann, 1924/1996, p. 462).

Huge and steep mountains, starry night skies, waterfalls, grand canyons, deserts, thunderstorms are all examples of grand stimuli triggering experiences of the sublime. This type of experience arises when we are confronted with an overwhelming vastness or power and nature offers paradigmatic examples of such a grandeur.

Like awe, the experience of the sublime has an ambivalent valence (Brady, 2013). As an aesthetic experience, the experience of the sublime has an overall positive valence (Arcangeli et al., 2019), even though it also involves a negative affective evaluation of the world, something like terror (Burke, 1759), fear (Kant, 1790/2000) or a feeling of self-negation (Cochrane, 2012). Keltner and Haidt (2003) explicitly tie the concept of awe to the philosophical concept of the sublime, and see an analogy between the aspects they take awe to have (i.e., vastness and need for accommodation) and power and obscurity (as being difficult to grasp by intellect) in Burke's seminal analysis of the sublime.

These considerations suggest that what psychologists call "awe" is what philosophers call "experience of the sublime." Do we really have here one type of experience (multifaceted though it is) only, which has simply been labeled differently in different disciplines?

As a matter of fact, it is striking that awe is almost absent from the philosophical agenda, while there are very few studies on the experience of the sublime as such in the psychological literature (see, e.g., Eskine et al., 2012; Ishizu and Zeki, 2014; Hur et al., 2018). The aim of this paper is to throw light on the relationship between awe (as understood by psychologists) and the experience of the sublime (as discussed by philosophers). Once we have a clearer picture of how awe and the experience of the sublime are related, we can use it to enhance collaboration between these domains. We would be able to use empirical results about awe in a philosophical analysis of the experience of the sublime, which in turn can help us to design novel experimental hypotheses about the contexts in which we experience awe.

Although a terminological equivalence might recommend itself as the simplest, our goal is to show that alternative explanations of the relationship between awe and the experience of the sublime are worth exploring, opening up new paths of interdisciplinary enquiry. More precisely, through a careful analysis of the extant philosophical and psychological literature, we will sort out seven possible ways in which awe and the experience of the sublime connect. Some of them are less plausible than others and have been simply hinted at in passing by some authors. Accordingly, we will give more space to the most plausible views. In conclusion, we will briefly indicate what is in our view the most promising path to understand the complex relationship between awe and the experience of the sublime (henceforth ES).

SEVEN VIEWS ON AWE AND THE EXPERIENCE OF THE SUBLIME

At least seven views of the relationship between awe and the ES can be envisaged:

A. Awe and ES are the same type of experience.
B. Awe is an ingredient of ES.
C. ES is an ingredient of awe.
D. ES is a species of awe.
E. Awe is a species of ES.
F. Awe and ES share only a proper part.
G. Awe and ES are unrelated to each other.

Let us expand on each of these views in turn.

The Equivalence Between Awe and the Experience of the Sublime

Option A is the equivalence view suggested by Keltner and Haidt (2003), although their more detailed view is that ES is awe with some additional "peripheral or flavoring" features, such as (experience of) beauty (see option D below). They seem to be followed by Fingerhut and Prinz (2018), who picture awe as intense wonder, and thus the sublime as a species of beauty. Some philosophers too seem to opt for option A. For instance, Brady (2013) writes: "It might be argued that the sublime is a relic best left alone, perhaps better replaced with a concept carrying less weighty historical and metaphysical baggage, such as 'awe' or 'grandeur'" (p. 2). In a similar vein, McShane (2013) notes: "The concept of the sublime as it has been discussed in philosophy (though not in literary criticism) from about the mid-eighteenth century onward I take to be the same concept as awe. Many other commentators seem to agree on this point; Burke's and Kant's analyses of the sublime are often discussed in analyses of the nature of awe" (p. 756, fn 34).

Option A entails that all the objects of ES are awe-inspiring. The latter claim is certainly plausible, which already enables us to

exclude option G (i.e., that awe and ES have nothing in common). However, it is not clear that all awe-inspiring objects are also objects of ES or, for that matter, of any aesthetic experience at all. For instance, our awe of Mother Teresa's compassion is arguably not aesthetic (McShane, 2013). Therefore, option A does not seem to be sustainable.

Is Awe an Ingredient of the Experience of the Sublime or Vice-Versa?

Option B pictures awe as being an ingredient (either a causal determinant or a proper part) of ES. Brady (2013) herself gives voice to this option when she describes ES as a mixed feeling, "with certain negative feelings (*awe*, terror, etc.) felt alongside positive ones (exaltation, admiration)" (p. 40, our italics). She suggests that both Kant and Herder hold this view. Commenting on Herder, Zuckert (2003) writes: "[T]he viewer of sublime architecture such as St. Peter's has a progressive experience: she approaches with a feeling of awe, enters and appreciates the decoration and elaboration, and then absorbs and is absorbed by the whole" (p. 220).

These philosophical observations hint at the idea that awe somehow captures the negative component of ES. This seems to be in contrast with what most psychologists advance, namely that awe is a positive emotion (see the Introduction). It should be noted, however, that some studies suggest the existence of two sorts of awe experiences, a positive and a negative one, that can be distinguished along several dimensions (subjective experience, physiological correlates and consequences on well-being).

A study by Piff et al. (2015) investigated two awe conditions, a positive and a negative one (elicited by videos about either non-threatening or threatening natural phenomena). They reported that both awe conditions, compared to the control condition, equally produced higher level of awe, and an increased sense of being diminished in the presence of something greater than us. By contrast, only negative awe produced increased negative emotions (e.g., anxiety, fear, and nervousness). Similar results were reported by Rivera et al. (2019). In the same vein, Sawada and Nomura (2020) showed that positive and negative awe-eliciting videos were rated more awe-inspiring, compared to a control condition, and increased happiness and anxiety ratings, respectively. This distinction is supported by a further work asking participants to describe a memorable awe experience and to report the elicitors, emotions and appraisals related to it (Gordon et al., 2017). Participants describing positive and threat-based awe experiences reported comparable levels of awe, but greater levels of fear were associated with the second kind of experience only.

Therefore, option B might be supported by claiming that, at least, negative (or threat-based) awe is an ingredient of ES. This view seems to be suggested in the psychological literature by Ishizu and Zeki (2014), who claim that ES "is a distinct cognitive-emotional complex" involving many components, awe included (which they associate with fear and horror), "but is distinct from each individually, i.e., that the whole is other than the parts" (p. 6).

Distinguishing between a positive and a negative type of awe can also be used in support of option C – i.e., the view that ES should be seen as an ingredient of awe. In philosophy this option has been suggested for instance by Kearney (1988) who, commenting on Kant, writes that "the sublime experience of overwhelming super-abundance produces a sense of 'awe'" (p. 175). Some psychologists, based on philosophical theories assigning a pivotal role to fear and terror in ES such that of Kant (see the Introduction), draw a parallel between the negative species of awe and ES (Gordon et al., 2017), which suggests that the latter is the negative ingredient (either a causal determinant or a proper part) of awe. This view, however, is based on the assumption that ES is mainly associated with strong negative emotions, especially fear. Few empirical studies have tried to investigate this subject. Eskine et al. (2012) reported that fear induction, but not induction of happiness or of general physiological arousal, can increase sublime ratings of pictorial abstract artworks. In another study sublimity ratings of photographs depicting natural scenarios were correlated with ratings of fear, but not with ratings of happiness (Hur et al., 2018). These data seem to suggest that ES is associated with fear (see also Chirico and Yaden, 2018), yet this is a questionable hypothesis, which has been nuanced by other works. It should be noted that Hur et al. (2018) themselves did not find any physiological evidence (from facial electromyography) linking sublimity ratings with physiological markers of fear. In one neuroimaging study on ES, Ishizu and Zeki (2014) reported that sublimity ratings of pictures of nature positively correlated with ratings of pleasantness. Moreover, although in line with philosophical treatment of ES they expected to find activation in brain areas classically associated with the experience of fear and threat such as the amygdala and the insula, their results did not show any such activity. Pelowski et al. (2019) investigated the cognitive-affective profile of ES in a large sample. They reported that the vast majority of reports (90.8%) could be classified under one category associated with positive emotions (e.g., pleasure). They also found a second statistically significant cluster associated with higher level of negative emotions, but this class was quite rare and was also associated with lower ratings of sublimity. It seems, thus, that the prototypical ES would be rather a positive experience (as suggested see the Introduction).

Taken together these findings show that there is not a clear-cut association between ES and either positive or negative emotions, and that probably, following Pelowski et al. (2019)'s suggestion, a positive and a negative variant of ES might exist. This would weaken the idea that the sublime is the dark side of awe, and more generally it puts pressure on option C (as well as on a specific reading of option D, as it will be made clear shortly).

Is the Experience of the Sublime a Species of Awe or Vice-Versa?

The distinction made within the experimental literature between two sorts of awe can motivate a more ontologically demanding view than C, namely option D. While according to the former ES is an ingredient of awe, the latter claims that ES is a *species* of awe. Therefore, depending on how we interpret what sets apart positive and negative awe (i.e., whether they are two aspects of the same species or two species, possibly belonging to the same

genus), we can end up with the view that ES coincides with the negative species of awe. This view, however, is open to the same worries raised against option C, since it also hinges on the alleged idea that ES is mostly a negative experience.

Option D can be supported by other means, pivoting on different ways of sorting out awe species. In the philosophical literature, Quinn (1997), for instance, distinguishes aesthetic and religious awe (see also Clewis, 2019). On this suggestion, option D is then the additional view that ES coincides with the former species of awe. Indeed, Quinn argues that ES is awe in the absence of religious belief. Among psychologists, Konečni (2011) seems to hold a similar view. Indeed, his aesthetic theory, which posits aesthetic awe as the peak aesthetic experience, treats the latter "as the prototypical subjective reaction to a *sublime stimulus-in-context*, (. . .) one aspect of aesthetic awe, which distinguishes it from awe that is induced by fear, is *existential security* of the experiencing person" (p. 65). There are no *prima facie* reasons against this reading of option D, which remains a workable option.

As far as we know, option E, according to which awe is a species of ES, has not been pursued in the psychological literature. In philosophy, it seems that only Burke (1759) has explicitly endorsed it. According to him, the "highest degree" of ES is *astonishment* and its "subordinate degrees" are *awe*, *reverence*, and *respect* (p. 123). One way of supporting E is to appeal to a distinction drawn by Shapshay (2013a,b) between two varieties of ES: while the "thin sublime" is a largely non-cognitive, affective arousal, the "thick sublime" also involves a cognitive play of ideas (especially about the place of human beings within the environment). On the hypothesis that awe is a purely non-cognitive, emotional response (but see fn1), it might be suggested that it coincides with a species of ES, namely the "thin sublime."

The question is not settled, however, since the idea that awe is an emotion can also lead to option D. If awe is a basic emotion and the sublime is a culturally specific category (as suggested in the classic study by Nicolson, 1963), then awe may very well be an ingredient of ES, but it would unlikely be the other way around.

Only a Common Denominator Between Awe and the Experience of the Sublime

Finally, according to option F, there is a common denominator between awe and ES, although they differ from each other in all other respects. Building on our previous discussion, a plausible suggestion is that they involve the same kind of *negative* affective appraisal. Both experiences involve being overwhelmed by a stimulus too vast (big, powerful, etc.) for our ordinary cognitive ways of apprehending and coping with the world. Option F goes further, and states that awe and ES do not have anything else in common. In particular, they involve different kinds of *positive* affective evaluation (or only ES has an overall positive valence after all).

DISCUSSION

What should we conclude from the foregoing critical comments on the complex relationship between awe and ES? Let's start by taking on board the plausible suggestion just made, that they involve at least the same kind of negative affective appraisal. Now both awe and ES also involve a positive evaluation. They are the kind of experience that we seek for and want to reproduce. The next question is then whether we should consider the positive evaluation involved in awe to be also involved in ES, and how.

Suppose, as is sometimes claimed (see Brady's quotation in the previous section), that the positive evaluation in awe is *admiration*. If this positive evaluation is also involved in ES, it follows that in having the latter, aesthetic experience, we experience admiration. Now what would be the object of our admiration? In the case of religious awe, it is obvious what the object of admiration is, namely God (or some divinity). In contrast (although the point is certainly controversial), it is not all obvious that admiration is the key concept involved in ES, or more generally in aesthetic experience.

An interesting proposal, put forward by McShane (2013), is that awe involves an evaluation of the *importance* of the awe-inspiring object, which *impresses* us in some respect. This might lead to a defense of option D: ES would be a species of awe, namely aesthetic awe. This defense would go like this. The concept of importance is relatively formal, and there are different types of importance. Thus, if all cases of awe involve the same *kind* of positive evaluation (the object of awe is subjectively evaluated as being of great importance), different cases of awe concern different *species* of importance. One of these species is aesthetic importance, or importance from an aesthetic point of view. Of course, such a defense should make clear what aesthetic importance is precisely, but it would be a way of reconciling two (apparently conflicting) intuitions we might have about awe and ES, that they are very close experiences, and that awe need not be an aesthetic experience.

We suspect that any psychological study of awe, whatever its valence (positive or negative) and the domain it concerns (aesthetic, religious, social, etc.) should take a stance on its relationship with ES. At the same time, though, philosophers should get more interested in awe itself and its role in the determination of the overall valence of ES. What we have offered here is of course only an exercise in conceptual geography, and further interdisciplinary studies should go deeper in the specification of, and comparison among, the more promising options we have delineated here.

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MA, MS, AJ, PP, and JD have contributed equally to the analysis of the literature and to the finalization of the manuscript. MA proposed the structure of the presentation (with JD) and has been the main redactor.

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Testing If Primal World Beliefs Reflect Experiences—Or at Least Some Experiences Identified *ad hoc*

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Do negative primal world beliefs reflect experiences such as trauma, crime, or low socio-economic status? Clifton and colleagues recently suggested that primals—defined as beliefs about the general character of the world as a whole, such as the belief that the world is safe (vs. dangerous) and abundant (vs. barren)—may shape many of the most-studied variables in psychology. Yet researchers do not yet know why individuals adopt their primals nor the role of experience in shaping primals. Many theories can be called *retrospective theories*; these theories suggest that past experiences lead to the adoption of primals that reflect those experiences. For example, trauma increases the belief that the world is dangerous and growing up poor increases the belief that the world is barren. Alternatively, *interpretive theories* hold that primals function primarily as lenses on experiences while being themselves largely unaffected by them. This article identifies twelve empirical tests where each theory makes different predictions and hypothesizes that retrospective theories are typically less accurate than interpretive theories. I end noting that, even if retrospective theories are typically inaccurate, that does not imply experiences do not shape primals. I end by offering a conceptual architecture—the Cube Framework—for exploring the full range of human experience and suggest that, though psychologists have historically focused on negative, externally imposed experiences of short-duration (e.g., trauma), positive, internally driven, and longer-term experiences are also worth considering.

Keywords: experiences, primal world beliefs, trauma, socio-economic status, family income, gender, crime

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INTRODUCTION

After psychologists introduce new constructs, such as learned helplessness or grit (Abramson et al., 1978; Duckworth et al., 2007), many researchers eventually ask an important question: *Which experiences influence (or are influenced by) my construct?* Having recently introduced a construct (Clifton et al., 2019), I turned to this question, beginning with a literature search for a tool that would enable systematic theorizing about a broad range of experiences in relation to my construct. What I found instead were a few organizing frameworks unsuited to this particular task of general theorizing (e.g., Duerden et al., 2018) and a handful of largely overlapping clinically oriented checklists dominated by a particular type of involuntary, negative experiences of quick duration, such as injury or death of a family member (e.g., the Social Readjustment Rating Scale by Holmes and Rahe, 1967; the Life Experiences Survey by Sarason et al., 1978).

Moreover, despite positive psychology's promising departure from psychology's historical focus on negative experiences (Seligman and Csikszentmihalyi, 2000), the positive psychology literature has yet to produce commensurate checklists of positive experiences. Thus, absent the tool I sought, I conducted the sort of *ad hoc* process that is common among researchers. In this process, hypotheses emerge concerning those experiences the researcher happens to think of, often ones already examined in relevant literatures or ones intersecting personal experience. This process has weaknesses. Chief among them is that research programs can never support a reasonably adequate understanding of the role of experience if no reasonably comprehensive range of *things one personally encounters, undergoes, or lives through*—Merriam-Webster's definition of *experiences*—is ever considered. Thus, after discussing a newly introduced construct and engaging in a typical process of *ad hoc* literature-driven hypothesis generation, I conclude this article with an atypical offering: a simple yet comprehensive conceptual framework for considering the full range of human experiences called the *Cube Framework*.

THE NEW(ISH) CONSTRUCT: PRIMAL WORLD BELIEFS

For decades various literatures have independently examined the possibility that particular dependent variables, such as political ideology and recovery from trauma, may stem from individual differences in generalized beliefs about the sort of world this is (Janoff-Bulman, 1989; Perry et al., 2013). The most studied is belief in a *Just* world, which is the belief that the world is a place where one gets what one deserves and deserves what one gets. Originally identified by Lerner (1965, 1980) to study the roots of blame and racism, *Just* has since been tied to dozens of variables that *Just* is thought to causally influence. In sum, those higher in *Just* tend to be kinder (presumably because the world rewards kindness); more hard-working (presumably because the world rewards hard work); more successful (because they've worked harder, were nicer, and are motivated to *post hoc* justify success); and blame victims like the sick and poor (presumably because they probably got what they deserved). Clifton et al. (2019) recently pulled these literatures together, calling beliefs about the basic character of the world *primals* or *primal world beliefs*, and engaged in an extensive empirical process to map all major primals. We found that *Just* was one of 26 different primals most of which had never been studied (see **Figure 1**), and many of the new primals are more predictive of human behavior than *Just*, such as the belief that the world is *Beautiful* (vs. ugly) and *Pleasurable* (vs. miserable).

This suggests the plausibility of a truly remarkable scenario described by Clifton and Kim (2020, p. 1). In sum, understanding the behavior of any creature requires observations of that creature in multiple environments. But humans can only ever observe each other in one environment: the world. Not realizing we profoundly disagree about this world along many dimensions, human efforts to understand each other's behavior should lead inevitably to a specific type of failure: overexaggerating the importance of dispositional differences (i.e., the fundamental attribution error). Thus, it is theoretically possible that psychologists have overlooked a major source of variation in most of the most-studied variables in psychology. Clifton et al. (2019) identify dozens of variables, such as BIG 5 personality traits and subjective well-being, that are likely impacted.

As research exploring the causal role of primals continues, it is worth asking a related but separate question: Where do primals come from? Specifically, which experiences shape (and are shaped by) primal world beliefs? The former question is broad and requires, among other things, a deep discussion of genetics and the ontology of personality traits, which is out of scope. This article concerns the more specific latter question about identifying relevant experiences.

RETROSPECTIVE AND INTERPRETIVE THEORIES OF HOW PRIMALS RELATE TO EXPERIENCES

Theories of how experiences shape primal world beliefs often fall into two broad types: *retrospective theories* and *interpretive theories*. Retrospective theories suggest that experiences play a key role in shaping primals such that primals often reflect the content of the individual's background. In this view, for example, the rich are likely to see the world as more *Abundant*, the poor are likely to see the world as more barren (i.e., low *Abundant* scores), and experiencing dangerous environments locally should cause one to see the world as more dangerous globally. This is consistent with an intuitively appealing theory animating much of the pre-existing literature on primals originally posed by traumatologist Janoff-Bulman (1989) and adopted by several others (Foa and Rothbaum, 1998; Foa et al., 1999; Kauffman, 2002; Boelen et al., 2006). This theory holds that traumatic events dramatically increases the belief that the world is dangerous (i.e., low *Safe* scores on the Primals Inventory). Since our (Clifton et al., 2019) identification of several previously unidentified primals, I have observed anecdotally at talks and conferences that similar retrospective intuitions emerge to explain primals' origins. For example, many researchers intuit that the rich will see the world as a *Good* place and privileged racial majorities will see the world as more *Just* and *Abundant* than minorities. What all these retrospective theories and intuitions have in common is the notion that past experiences characterized by *X* quality pushes the individual toward seeing the world as characterized by *X* quality to such an extent that the individual's primals reveal not just one's beliefs but also one's demographics.

Interpretive theories posit that, rather than a mirror reflecting one's experiences, a primal functions as a lens used to interpret experiences while being itself largely uninfluenced by them. For example, an interpretive theory of how the primal *Abundant* relates to personal wealth would predict that being rich (or poor) would have little to no impact on the belief that the world is *Abundant*. Likewise, experiencing dangerous environments or trauma (or safe environments) would have little to no impact on the belief that the world is *Safe*. Though such interpretive theories are reasonable, it's fair to say that they are typically not as intuitively appealing as their retrospective counterparts.

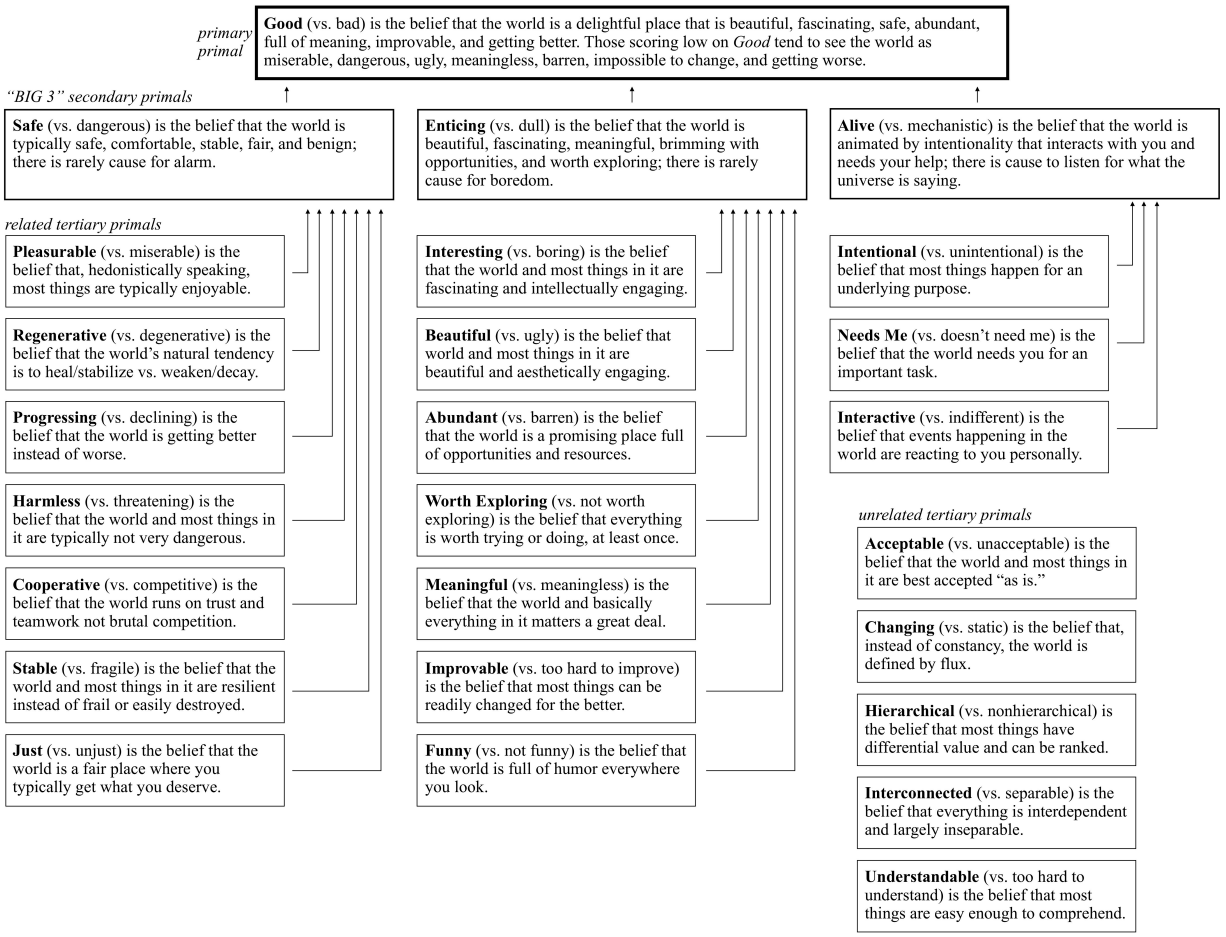

FIGURE 1 | Definitions and structure of the 26 primal world beliefs (22 tertiary, three secondary, and one primary) as identified by Clifton et al. (2019). Reproduced from Clifton and Kim (2020).

Nevertheless, I hypothesize that interpretive theories are generally more accurate than retrospective theories, though likely with some moderate exceptions such as childhood trauma and chronic pain. My rationale stems from the central point of Janoff-Bulman's (1989) original article, subtitled *Applications of the Schema Construct*, where she suggests that world beliefs likely operate as *schemas*.

Though definitions of *schema* vary (Van der Veer, 2000), the paradigm has been central to belief research for decades (e.g., Beck, 1963, 1964, 1967, 2005; Crum, 2013; Dweck, 2017). The term usually refers to pre-existing mental models about an object used to generate expectations, assist interpretation and memory reconstruction, and guide interaction (e.g., Piaget, 1926; Rumelhart, 1980; Janoff-Bulman, 1989; Bernstein et al., 1991; Brewer, 2000; Nash, 2013). For example, Davis (1991) found that a schema for an *egg* involves at least 45 different modifiers such as *nutritious*, *delicate*, and *laid in nests*.

In addition to introducing the idea of schemas (1926), Piaget (1971) theorized how schemas would typically relate to experiences. When facing evidence of a schema violation, Piaget posits two options—accommodation (revising one's schema) or assimilation (reinterpreting the new information to minimize its importance)—and assimilation would be overwhelmingly favored. Decades of research confirms this. When facing schema-inconsistent information, individuals tend to ignore it, reject it, reinterpret it, or adopt other rejection-seeking behavior (e.g., Ross et al., 1975; Hastie, 1981; Janoff-Bulman, 1989; Brewer, 2000). As schema's influence perceptions, the new information will often serve as "evidence" for the veracity of the original schema (e.g., Vernon, 1955; Labianca et al., 2000), thus creating a *self-supporting* feedback loop. In addition to altering percepts directly, a schema's influence on behavior can also lead to actual outcomes that provide further "evidence" of the original schema, creating a *self-fulfilling* feedback cycle (e.g., Labianca et al., 2000). In this way, schemas contribute to the phenomenon termed *confirmation bias* (e.g., Merton, 1948; Jussim, 1986; Nickerson, 1998).

Though Janoff-Bulman (1989) acknowledged that "the tendency is toward assimilation rather than accommodation," she thought trauma would be an exception that would reliably and dramatically alter world assumptions, including what we (Clifton et al., 2019) call *primal world beleifs*. Janoff-Bulman (1992) book on trauma was entitled *Shattered Assumptions* and her theory is sometimes called *shattered assumptions theory*. Yet

Kaler et al. (2008) found that in only about a quarter of those recently traumatized was there any reliable change in world beliefs and—moreover—these were equally divided between those coming to see the world more negatively and those coming to see the world more positively. Indeed, as Mancini et al. (2011) note, despite the popularity of shattered assumptions theory, there is little evidence much shattering happens. This is partly due to the absence of control groups, but also the smallness of observed effects which, when it is observed at all, is typically small, even among Holocaust survivors (e.g., Prager and Solomon, 1995). Indeed, if those who experienced first-hand the mass systematic internment, deprivation, torture, and slaughter during the Holocaust—arguably one of the most traumatic events in history—do not see the world as that much worse than those who escaped the experience, then retrospective explanations of how negative primals arise probably has less to offer than intuition suggests.

Yet, as Mancini et al. (2011) point out, shattered assumptions theory remains popular among researchers and clinicians—even lay people—likely in part because of its intuitive appeal. Indeed, after encountering similar patterns of retrospective intuitions in connection to newly identified primals, I have come to suspect several biases are at play, including an actor-observer bias wherein individuals tend to condescendingly imagine that other people cannot help but believe the things they do because of their backgrounds while our own primal world beliefs stem from something more objective and clear-eyed (Clifton, in press). Others are on a journey; I have arrived.

It may be that, rather than experiences influencing primals in a straightforward way, individuals use past experiences to justify whatever primal they already hold. For example, if one sees the world as a dangerous place and gets into a car accident, perhaps on average he will eventually frame that experience as evidence of what he knew all along. Likewise, if one sees the world as a safe place and gets into a car accident, perhaps on average she will eventually frame this experience as exceptional, having occurred for local, particular, and temporary reasons. Indeed, because the world is a giant dataset, there is much information that can be garnered in support of any primal. And if primals direct attention and resist assimilation as the schema literature suggests, researchers should expect such garnering to occur, and thus retrospective theories to be generally inaccurate.

Could a theory explaining how experiences relate to primals be both non-retrospective and non-interpretive? Perhaps. However, whereas retrospective theories could be completely false without fundamentally altering current assumptions about primals and their nature, the same is not true of interpretive theories. Fundamental to our (Janoff-Bulman, 1989; Clifton et al., 2019; Clifton and Kim, 2020; Clifton, in press) understanding of primals is the same assumption underlying researcher's conceptions of beliefs generally (e.g., Beck, 1963, 1964, 1967, 2005; Crum, 2013; Dweck, 2017). Namely, that beliefs influence thought and behavior largely via ambiguity interpretation. If primals were found to exert no influence on the interpretation of one's personal experiences, then primals are either (a) exclusively symptoms rather than causes of primals' numerous personality and well-being correlates; (b) primals' impact on these outcomes is unmediated by interpretation; or (c) primals do influence the interpretation of some new information but, for some reason, not new personal experiences. Given current research, these options seem unlikely.

TWELVE HYPOTHESES

To determine whether retrospective or interpretive theories are typically more accurate across different primals and different experiences, ideally multiple hypotheses in which each theory makes diverging predictions should be examined. **Table 1** specifies twelve hypotheses which were selected according to three criteria.

- The measurability of the relevant life experience.
- The involuntariness of the experience (to avoid confounding causal relationships).
- The clarity of alternative retrospective and interpretive predictions.

Multiple hypotheses are necessary because some involve disputable assumptions that others do not. For example, perhaps the most dubious assumption underlies hypotheses #4: Is the world really more dangerous for women than men when men are more likely to be killed violently and die on average 5 years sooner (e.g., Rochelle et al., 2015)? Perhaps, but among a variety of threats that disproportionately impact women, it is indisputable that most women spend life surrounded by biologically stronger, faster, more aggressive individuals who are motivated to assault them, often do, and whose denials are traditionally more likely to be believed over women's accusations (e.g., Lassek and Gaulin, 2009). Thus, if researchers were to find that nevertheless women and men see the world as equally *Safe*, that can be considered inconsistent with a retrospective theory of how *Safe* develops, though not compelling unless other hypotheses relying on different assumptions are also examined.

All twelve hypotheses can be determined by interpreting correlational effect sizes, with thresholds for interpretation varying depending on the hypotheses. However, based on commonly used thresholds (e.g., Cohen, 1992), the threshold of $r > 0.30$ that Kaler et al. (2008) used to examine a retrospective theory, and my own research experience, I suggest the following admittedly arbitrary thresholds for pairwise relationships:

- $r > 0.30$ can be considered *clearly consistent* with the retrospective prediction and *clearly inconsistent* with the interpretive prediction.
- $0.295 > r > 0.20$ can be considered *weakly consistent* with the retrospective prediction and *weakly inconsistent* with the interpretative prediction.
- $0.195 > r > 0.10$ can be considered *weakly inconsistent* with the retrospective prediction and *weakly consistent* with the interpretive prediction.
- $0.095 > r > -0.095$ can be considered *clearly inconsistent* with the retrospective prediction and *clearly consistent* with the interpretive prediction.

Because the twelve hypotheses seek to derive conclusions from orthogonality, I would remind the reader that, while

correlation does not indicate causation, under certain assumptions orthogonality does suggest causality's absence or triviality. Of course, researchers should check those assumptions, particularly curvilinearity, possible third variable confounds, indirect pathways, and counterbalancing effects. For example, Mancini et al. (2016) found that the negative psychological impact of the Virginia Tech shootings was mitigated by the countervailing effects of increased social support which may influence, among other things, beliefs about the world (Mancini, 2019). Nevertheless, if primals do not reflect backgrounds in a straightforward manner as evidenced by bivariate analysis, this would suggest that retrospective theories are inaccurate even if further analysis reveals confounds, indirect pathways, or counterbalancing effects. Retrospective theories are by definition not nuanced in this way.

Previous research sheds light on several of these hypotheses, especially trauma research. For example, converting Prager and Solomon's (1995) results to a Pearson's *r* suggests that that subjects who experienced the Holocaust see the world

TABLE 1 | Alternative retrospective and interpretive predictions of twelve correlational relationships between primals and experiences.

	Primal	Experience	Retrospective prediction	Interpretive prediction
1	*Safe* (vs. dangerous)	Childhood trauma	Trauma often increases the belief that the world is dangerous. Therefore, increased trauma should correlate substantially with lower *Safe* scores.	The primal *Safe* is used to interpret trauma while being itself little affected by it. Therefore, increased trauma should be marginally related or orthogonal to *Safe* scores.
2		Adulthood trauma		
3		Neighborhood crime rates	Living in dangerous places increases the belief that the world is dangerous. Therefore, living in a more dangerous zip code based on crime statistics should correlate with lower *Safe* scores.	The primal *Safe* is used to interpret dangerous situations while being itself marginally affected by them. Therefore, living in a dangerous zip code should be marginally related or orthogonal to *Safe* scores.
4		Sex	Being physically weaker than many around you—especially people motivated to assault people like you and often do—leads to seeing the world as more dangerous. Therefore, being female should correlate with low *Safe* scores.	The primal *Safe* is used to interpret situations in which one is susceptible to dangers while being itself marginally affected by them. Therefore, being female should be marginally related or orthogonal to *Safe* scores.
5	*Abundant* (vs. barren)	Childhood SES	Growing up poor often results in seeing the world as a more barren place with fewer resources and opportunities. Therefore, low childhood socio-economic status (SES) should correlate with low *Abundant* scores.	The primal *Abundant* is used to interpret childhood material circumstance while being itself marginally affected by it. Therefore, low childhood SES should be marginally related or orthogonal to *Abundant* scores.
6		Family income	Being poor often results in seeing the world as a more barren place with fewer resources and opportunities. Therefore, low family income should correlate with low *Abundant* scores.	The primal *Abundant* is used to interpret material circumstances while being itself marginally affected by it. Therefore, low family income should be marginally related or orthogonal to *Abundant* scores.
7		Neighborhood mean income	Living in a poor neighborhood often results in seeing the world as a more barren place with fewer resources and opportunities. Therefore, living in a lower-income area should correlate with low *Abundant* scores.	The primal *Abundant* is used to interpret material circumstances while being itself marginally affected by it. Therefore, living in a lower-income area should be marginally related or orthogonal to *Abundant* scores.
8	*Pleasurable* (vs. miserable)	Chronic pain	Being in chronic physical pain often results in seeing the world as a more miserable and uncomfortable place. Therefore, chronic pain exposure should correlate with low *Pleasurable* scores.	The primal *Pleasurable* is used to interpret experiences of pain while being itself marginally affected by it. Therefore, experiencing chronic pain should be marginally related or orthogonal to *Pleasurable* scores.
9		Childhood SES	Higher SES while growing up corresponds with having more frequent and intense pleasurable experiences in childhood, which often results in seeing the world as a more pleasurable place. Therefore, higher childhood SES should correlate with *Pleasurable* scores.	The primal *Pleasurable* is used to interpret pleasurable experiences in childhood while being itself marginally affected by it. Therefore, high childhood socio-economic status should be marginally related or orthogonal to the belief that the world is pleasurable.
10		Family income	High family income allows more frequent and intense pleasurable experiences, often resulting in seeing the world as a more pleasurable place. Therefore, higher family income should correlate with *Pleasurable* scores.	The primal *Pleasurable* is used to interpret pleasurable experiences while being itself marginally affected by them. Therefore, family income should be marginally related or orthogonal to *Pleasurable* scores.
11	textitProgressing (vs. declining)	Change in SES from childhood to adulthood	Experiencing decline in your SES often results in seeing the world as declining. Therefore, decline in SES from childhood to adulthood should correlate with lower *Progressing* scores.	The primal *Progressing* is used to interpret decline in SES while being itself marginally affected by it. Therefore, decline in SES from childhood to adulthood should be marginally related or orthogonal to *Pleasurable* scores.
12		Change in neighborhood mean income	Living in a declining neighborhood often results in seeing the world as declining. Therefore, living in an area that is in economic decline should correlate with lower *Progressing* scores.	The primal *Progressing* is used to interpret neighborhood decline while being itself marginally affected by it. Therefore, neighborhood decline should be marginally related or orthogonal to *Progressing* scores.

as less benevolent at $r(158) = 0.31$. This is *clearly consistent* with the retrospective prediction and *clearly inconsistent* with the interpretive prediction—but barely so. Using the World Assumptions Scale, Kaler et al. (2008) found in a sample of 735 undergraduates that increased lifetime trauma correlated with world benevolence beliefs at $r = -0.14$ and recent trauma did not seem to have any impact on these beliefs. Given the severity of the Holocaust compared to, say, getting mugged, could it be that $r = 0.31$ approximates an upper-limit trauma effect?

However, because hypotheses concern several primals that only the Primals Inventory measures and because the Primals Inventory is a superior measure of primals (largely by default; for a detailed discussion see Clifton, in press), it is ideal if all twelve hypotheses are examined using the Primals Inventory. To some extent this too has been done. Buried on pages 310–323 of Clifton et al.'s (2019) supplement is a large correlational matrix showing relationships among 524 Americans, ages 18–75 ($M = 37$), who were approximately 50% women and 50% college graduates.

- Concerning Hypothesis #4, women did not see the world as more dangerous than men ($r = 0.01$, $p > 0.05$).
- Concerning Hypothesis #5, growing up poor did not correlate with seeing the world as less *Abundant* ($r = -0.07$, $p > 0.05$).
- Concerning Hypothesis #6, those in families with higher incomes did not see the world as more *Abundant* ($r = 0.05$, $p > 0.05$).
- Concerning Hypothesis #9, growing up poor did not correlate with seeing the world as less *Pleasurable* ($r = -0.06$, $p > 0.05$).
- Concerning Hypothesis #10, high family income did not correlate with seeing the world as more *Pleasurable* ($r = 0.03$, $p > 0.05$).

These results are, based on above thresholds, *clearly inconsistent* with retrospective predictions and *clearly consistent* with interpretive predictions. But these results also come from one sample in which only a preliminary version of the Primals Inventory was used, literally thousands of correlational relationships were examined without correcting for multiple comparisons, above hypotheses were not pre-registered, and most of the twelve hypotheses "were not examined". Much remains unclear.

WHERE SHOULD RESEARCHERS LOOK INSTEAD?

If researchers find that retrospective theories are generally inaccurate, does that mean that experiences do not shape primals? No. Interpretive theories only presume that primals do not reflect the content of past experiences in a straightforward manner, but experiences come in many shapes and sizes and might influence primals in a variety of less straightforward ways. Where could researchers look next? What experiences might researchers focus on?

These questions are impossible to answer without a reasonably exhaustive framework by which a breadth of human experiences can be considered. After recently introducing the primals construct (Clifton et al., 2019), I asked the same question that many researchers before me have asked: *Which experiences influence (or are influenced by) my construct?* Failing to unearth some sort of comprehensive framework or measurement tool that identifies a broad range of psychologically important human experiences that I could use as a basis for systematic theorizing about experiences in relation to my construct, I created the following Cube Framework. I provide it here to aid other researchers examining other constructs, to highlight areas for further research on the primals construct, and to invite comment before using it to build a more comprehensive experience checklist than is currently available.

Three Dimensions of the Cube Framework

There are three major psychologically salient continuous dimensions by which all experiences vary. For practicality, the Cube Framework simplifies these dimensions into dichotomies. The point is not to know precisely where a particular experience falls on a dimension but for the researcher to have a tool to guard against the consideration of only a narrow slice of human experience.

Chronic-Acute

All experiences happen in time. Thus, all experiences can be sorted into more acute experiences that take moments/days/weeks and more chronic experiences that take months/years/decades. Previous experiences checklists have generally ignored chronic life experiences, such as having a chronic illness or negative boss. However, demographic information is often important precisely because it captures chronic experiences, such as being male or poor.

Internal-External

All experiences are to varying degrees under the individual's control. Several literatures draw attention to the psychological importance of this distinction including learned helplessness, attribution theory, optimism/explanatory style, personality, locus of control, and incremental theory (Lewin, 1936; Rotter, 1966; Abramson et al., 1978; Peterson and Seligman, 1984; Blackwell et al., 2007; Harvey et al., 2014). Though many experiences, such as going to college, can be either internally driven or more externally imposed, many experiences can be fairly readily categorized as more often one or the other. A death in the family or inheriting a fortune, for example, are experiences that are usually externally imposed.

Positive-Negative

All experiences vary by subjective desirability (good, neutral, or bad). Though most difficult to measure objectively, this dimension is also the most psychologically impactful. There is a massive gulf, after all, between a good childhood and a bad childhood, a good sex life and a bad sex life, and so forth. However, like the internal-external dimension, exactly where any given experience falls on the positive-negative dimension may be up for debate. Nevertheless, many experiences will be readily characterizable. Death and injury, for example, can be thought of as

negative. Receiving a promotion or falling in love can be considered positive.

Eight Types of Experiences in the Cube Framework

The permutations of these three dimensions reveals eight types of human experience (**Figure 2**).

Bad Choices

Acute, internally driven, negative experiences—*bad choices*—may include losing one's savings in a poor investment, stealing, cheating, sexually assaulting someone, sleeping with a friend's spouse, deciding to drive home drunk, or joining a cult.

Bad Habits

Chronic, internally driven, negative experiences—*bad habits*—may include a gambling habit, smoking, pessimism, distrust, overeating, overspending, continually returning to an abusive partner, or staying in a cult.

Bad Luck

Acute, externally imposed, negative experiences—*bad luck*—may include natural disasters, car accidents, stroke, fire, and sudden deaths in the family. The large majority of experiences mentioned by the Social Readjustment Rating Scale (Holmes and Rahe, 1967) and the Life Experiences Survey (Sarason et al., 1978) consists of such *bad luck* experiences. Studying them is worthwhile, but they represent only a narrow slice of life.

Bad Times

Chronic, externally imposed, negative experiences—*bad times*—may include being raised by a negative parent, growing up receiving person praise rather than process praise (Kamins and Dweck, 1999); coping with chronic pain, being unemployed, having an unkind boss, involuntarily fighting in a war, or living in a society prejudiced against your gender or race.

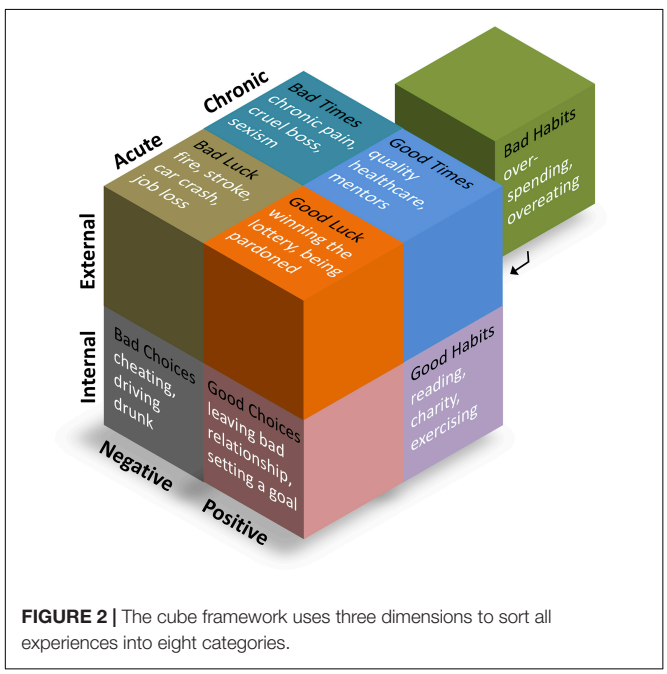

FIGURE 2 | The cube framework uses three dimensions to sort all experiences into eight categories.

Good Choices

Acute, internally driven, positive experiences—*good choices*—may include falling in love, identifying your mission in life, taking a backpacking trip across Europe, or converting to a religion.

Good Habits

Chronic, internally driven, positive experiences—*good habits*—may include staying physically active, mastering a skill, engaging in some life-giving activity like ballroom dancing or playing in the local philharmonic, chronically believing the best about others, being an avid reader, gardening, spending time outdoors, being in a committed relationship, being an avid traveler, taking care of a dog, volunteering for charity, or raising children.

Good Luck

Acute, externally imposed, positive experiences—*good luck*—may include inheriting a fortune, winning the lottery, getting adopted, being recruited for a job, being granted a pardon, or receiving a voucher to go to a better school.

Good Times

Chronic, externally imposed, positive experiences—*good times*—may include living in a peaceful society, being raised by a highly supportive parent, receiving a 4-year liberal arts education, enjoying sustained access to medical care, or being mentored by an incredible teacher.

Using the Cube Framework

Instead of listing out all human experiences, the Cube Framework provides a method that researchers can use to systematically theorize about a diversity of experiences. I suggest using it in two ways. First, the researcher can ask themselves eight questions about each experience type. For example, *What good choices might influence or be influenced by my construct?* However, examining experiences only by type risks the Cube Framework becoming a filter such that only experiences that fit neatly within each type are considered. Addiction, depression, and obesity, for example, are clearly chronic and negative (and important to study) but less clearly categorized along the internal-external dimension, and thus may not emerge from eight questions about the eight types. Therefore, second, I suggest that psychologists also theorize by dimension, one dimension at a time. For example, when considering the acute-chronic dimension I might ask myself: *What experiences that relate my construct might happen in a moment. . .in an hour. . .in a day. . .in a week, in a month. . .in a year. . .in a decade. . .or last a lifetime?* Using both by-type and by-dimension approaches ensures that a diversity of experiences are considered.

The Cube Framework allows flexibility because it is able to incorporate any additional fourth dimension the researcher might deem important. For example, there is arguably at least one other psychologically important dimension on which all experiences vary that the Cube Framework does not

incorporate: all experiences can be sorted by the age at which an experience occurs in the life of the person. The Cube Framework does not include this dimension because I found adding it led to the identification of relatively few novel hypotheses, lowered the utility of the framework by complicating it, and, most importantly, age is a characteristic of the person rather than the experience. However, if a researcher wishes to ensure diversity along this or any other fourth dimension, researchers can consider not one cube but two cubes, with each cube labeled according to the fourth dimension, such as *Childhood Experiences* and *Adulthood Experiences*. Then the researcher can consider *childhood bad times* separately from *adulthood bad times, childhood good choices* separately from *adulthood good choices*, and so forth.

Promising Areas for Further Primals Research

With the big exception of research over the last two decades in positive psychology, psychologists have historically focused on acute, externally imposed, negative (i.e., *bad luck*) experiences like trauma and neglected experiences that last longer, are internally driven, and positive. Thus, when considering which experiences might influence primals, positive and chronic experiences (*good times* and *good habits*), such as having a highly supportive parent or teacher, might be worth further examination. Positive acute experiences, such as powerful moments of transcendence, are also promising.

Furthermore, if retrospective theories are typically inaccurate—if exposure to *X* quality typically has no impact on ways of thinking about the world generally—then perhaps exposure to alternative ways of thinking about *X* quality is what matters. This exposure might occasionally be self-driven by the philosophically adventurous but more typically result from personal social interactions with mentors, friends, colleagues, therapists, parents, or others who see the world differently. Exposure may also occur through storytelling via, for example, movies and novels. For example, a premise of the 2003 and 1999 hit films *Love Actually* and *American Beauty* is that love and beauty are everywhere, even in the midst of pain and suffering—even perversion. Whatever the medium, encounters with alternative lenses on reality may sometimes result in one coming to prefer them. Informal social pressures may also be at work. For example, one unpublished primals research study awaiting duplication indicates that students are more likely than the general public to see the world as dangerous. Is this because the student context is a particularly dangerous one—the retrospective explanation? Likely not. Instead, perhaps the task itself or particular subcultures implicitly encourage—teach—this primal through a variety of formal and informal incentives and social mechanisms. If exposure to different lenses on reality impacts which lenses we choose for ourselves, perhaps researchers will find that one experience that shapes primal world beliefs is taking the Primals Inventory, learning what primals one holds, and discovering one has options.

FINAL REMARKS

In this article I have asked the typical question a researcher asks after introducing a construct: *Which experiences influence (or are influenced by) my construct?* In the case of primals, I have discussed two broad possibilities. The first holds that primals generally reflect our backgrounds in a fairly straightforward manner (retrospective theories). The second suggests that primals are used to interpret experiences while being themselves marginally influenced by them (interpretive theories). This article has specified twelve empirical tests to determine which approach is typically more accurate, which I hypothesize will most often be interpretive theories despite having less intuitive appeal and running counter to some existing theory. If research confirms this, researchers will have to look elsewhere to determine which experiences might impact primals. To facilitate that search, I have provided the Cube Framework as a tool for methodically considering a range of human experiences and generating hypotheses. My own use of it suggests that a promising place to look will be chronic and positive experiences, such as having a supportive and esteemed parent or mentor who implicitly or explicitly encourages certain primals, as well as acute and positive experiences, such as transcendent experiences.

In closing, however, I confess some pessimism. It may be that few naturally occurring life experiences reliably influence primals. Perhaps primals typically emerge early in life for idiosyncratic reasons in a process non-deterministically yet strongly impacted by genetics. Primals could then perpetuate themselves through mechanisms associated with schemas. This would not mean, however, that primals cannot be changed by experiences, just that they generally are not. Researchers already know that beliefs very similar to primals can be reliably altered through Cognitive Behavioral Therapy (e.g., Beck, 2005). Thus, even if experiences that influence primals cannot be found, perhaps they can be designed.

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The first and sole author is responsible for all the content of the article.

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frontiers in Psychology

ORIGINAL RESEARCH
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Does Blindness Boost Working Memory? A Natural Experiment and Cross-Cultural Study

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Intelligence requires sufficient working-memory capacity. Traditionally, working memory was seen as a process and as a prerequisite for fluid intelligence. Working memory was assumed to be determined by maturation and health. There is a gap in the literature: It is still not fully understood to which extent and how working memory can be influenced. So this study tested how visual impairment and the extent of visual impairment are related to working memory capacity. In our study we compared N = 249 children (6–16 years) with and without visual impairment (blind, visually impaired, and sighted) in two countries (South Africa and Austria) at different development levels on their working-memory capacity and verbal comprehension. Using the WISC-IV, blind and visually impaired children showed higher working-memory capacity than sighted children (r = + 0.35, 14, and 3 IQ points, respectively). On the other hand, visually impaired children showed a weakness in verbal comprehension (r = −0.39, on average 13 IQ points lower). The pattern remained robust when SES and race-ethnicity were controlled. Our natural (quasi-)experiment shows a pattern, which is unlikely to be genetic, and so supports the view that working memory and intelligence scores can be modified.

Keywords: working-memory capacity, intelligence, cognitive ability, modifiability, blindness, cross-cultural comparison, natural experiment

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INTRODUCTION

Changeability of Cognitive Ability

A question that has been hotly debated for a long time in intelligence research is the changeability of cognitive ability. On the one hand, studies showed a long-term stability of individual differences in IQ across the lifetime, e.g., from age 11 to age 77 years r = 0.63 (Deary et al., 2000), and training and intervention studies frequently showed small effects or effects that faded out (Protzko, 2015). On the other hand, there is a huge increase in intelligence in youth due to learning in school and there is a decrease in old age (e.g., Cattell, 1987/1971; Rindermann, 2011; Ritchie and Tucker-Drob, 2018). While knowledge and specifically crystallized intelligence are generally seen as modifiable by learning and environment, fluid intelligence (culture-reduced reasoning) and

especially basic cognitive processes and competences, such as mental speed and working memory, are generally considered as hardly changeable.

We define intelligence as the ability to think: (1) to solve new problems by thinking, (2) to inductively and deductively infer, (3) to think abstractly, and (4) to categorize and to understand. Intelligence is an essential precondition for academic performance and professional success (e.g., Gottfredson, 2003; Hunt, 2011). Together with mental speed, working memory is a basic cognitive process in thinking (Jensen, 2006; Rindermann et al., 2011). Mental speed is needed to quickly process information. Working memory is the ability to simultaneously compare and store different information in short-term memory (Baddeley, 2007). Working-memory capacity – a stable individual differences variable – is highly correlated with intelligence: Various researchers found correlations at around $r = 0.50$ (Ackerman et al., 2005); in a study by Kyllonen and Christal (1990), the correlations even reach a value of $r = 0.80$–0.90. These values are much higher than the usual values of the correlations between mental speed and IQ (around $r = 0.20$–0.30; Jensen, 2006).

As intelligence scores are excellent predictors of school achievement and job performance, the question whether working memory can be effectively trained is of great scientific and practical importance. Jaeggi et al. (2008) developed a working-memory training program and the authors concluded that the outcomes showed positive effects on working-memory capacity and intelligence, but these conclusions were not generally accepted (e.g., Moody, 2009; Redick et al., 2013; Melby-Lervåg et al., 2016). While some meta-analytic evidence strengthened Jaeggi's position (e.g., the average training effect across 24 measures on fluid intelligence was $d = 0.24$; Au et al., 2015), other meta-analyses reported less supportive outcomes (e.g., $d = 0.08$–0.15 for IQ; Melby-Lervåg et al., 2016). Some authors of meta-analyses argued in particular, that cognitive training programs such as on working memory do not sustainably improve overall cognitive performance (i.e., fluid intelligence), but only the performance on certain working-memory tasks (e.g., Protzko, 2017; especially for children see Simons et al., 2016; or Takacs and Kassai, 2019).

However, looking at direct effects on working memory itself, the training effects are more favorable, e.g., on verbal working memory $d = 0.31$–0.42, on visuospatial working memory $d = 0.28$–0.51, and on specific study criterion measures $d = 0.80$–1.88 (Melby-Lervåg et al., 2016, their **Table 1**). These findings are corroborated by a second meta-analysis by Soveri et al. (2017): the effect on working memory measured using n-back tasks was $d = 0.62$, on other working-memory tasks $d = 0.24$, but on fluid intelligence $d = 0.16$. So, it is clear that working memory itself benefits from working-memory training.

Blindness as a Natural Experiment to Test Changeability

Nevertheless, there still remains an important theoretical objection as working memory is seen as being determined by maturation and health. Working-memory capacity increases in childhood and declines in old age, suggesting a strong biological cause (e.g., Salthouse, 1990). A different approach can help determine to what degree working memory is alterable: We used data from a natural experiment (Dunning, 2012), a quasi-experiment "in the field," looking at children with a visual disability – the visually impaired and even completely blind persons – as they depend much more than the sighted on their working memory to process information. While solving cognitive tasks these persons cannot draw on external visual representations of information, such as texts or figures. Hence, persons with a visual disability have to rely particularly on *internal* representation, storage, and processing of information and this is more demanding of working memory. So, they need to compensate for not having the possibility of external storage for information (e.g., written texts, figures, tables, or graphs). If working-memory capacity is changeable through experience, it seems logical to assume that the more intensive use of working memory due to a visual impairment should boost working-memory capacity (e.g., Hupp, 2003). Furthermore, research suggests that a form of brain plasticity can also lead to superior working memory. Various studies observed that blind persons can use additional brain resources which are otherwise invested in processing visual input to enhance cognitive abilities in other domains (Röder et al., 2002; Bedny et al., 2015; Abboud and Cohen, 2019). Amedi et al. (2003), for instance, indicated that superior verbal memory performance in blind subjects could be due to activation of the cortical visual system. Other authors such as Kattner and Ellermeier (2014) showed that blind people are more resistant to irrelevant auditory speech-like stimuli in regard to their working-memory performance (Kattner and Ellermeier, 2014).

Additionally, certain educational aids such as braille, auditory explanation of pictures and graphs, and auditory books may further enhance working-memory capacity. Following the same reasoning, because all access to printed information and to visual information is limited for persons with visual impairment, they are expected to have less extensive knowledge. Some studies already hinted that compared to non-blind persons blind persons have some advantage on working-memory tasks (e.g., Tillman and Osborne, 1969; Smits and Mommers, 1976; Hull and Mason, 1995; Hupp, 2003; Withagen et al., 2013; Pigeon and Marin-Lamellet, 2015), and that participants with a visual disability may perform worse on knowledge-based scales (e.g., Wyver and Markham, 1999; Hupp, 2003). The results of the studies mentioned are in line with the assumption that visual disability acts like a training for working memory but at the same time impedes the acquisition of crystallized intelligence. In this context, several neuropsychological studies have addressed the hypothesized association between working memory and sentence comprehension (e.g., Varkanitsa and Caplan, 2018). There is an ongoing debate whether working memory and sentence comprehension are connected to the same or different neuronal systems (e.g., Pisoni et al., 2019).

TABLE 1 | Sample characteristics for the South African and the Austrian sample.

Sample	Gender (*N* = 249)	Age (*N* = 249)	Social status (*N* = 212)	
South Africa	Male: *N* = 77 (49.7%)	*M* = 13.38	SES1 (township)	*N* = 35 (22.6%)
(*N* = 155)	Female: *N* = 78 (50.3%)	*SD* = 2.18	SES2 (lower class)	*N* = 62 (40.0%)
			SES3 (middle class)	*N* = 58 (37.4%)
			SES4 (upper class)	*N* = 0 (0.0%)
Austria	Male: *N* = 45 (47.9%)	*M* = 12.34	SES1 (township)	*N* = 1 (1.1%)
(*N* = 94)	Female: *N* = 49 (52.1%)	*SD* = 3.58	SES2 (lower class)	*N* = 7 (7.4%)
			SES3 (middle class)	*N* = 44 (46.8%)
			SES4 (upper class)	*N* = 5 (5.3%)

$N_{(social\ status)} \neq [N_{(South\ Africa)} + N_{(Austria)}]$ *because not all participants provided information on their social status.*

Hypotheses

Four hypotheses were tested using two samples from highly diverging environments, namely Africa and Europe:

(1) Children with a visual disability have better working-memory capacity (WMC) than sighted children.
(2) Children with a visual disability have lower verbal comprehension than sighted children.
(3) The more serious the visual disability, the better the working-memory capacity and the lower the verbal comprehension (dose-response relationship).
(4) Blind-sighted differences in working-memory capacity and verbal comprehension (VC) should be environmentally caused (based on experience as a person with a visual disability).

MATERIALS AND METHODS

Design and Eyesight

We used the natural experiment of blindness to test these hypotheses and compared sighted, visually impaired, and blind children in two countries at different developmental levels. Eyesight was determined by visual acuity (VA). A person's visual acuity is reported as a quotient: It is the distance where that person can visually recognize a certain stimulus, divided by the average distance where this stimulus normally can be visually recognized. In practice, stimuli of different sizes (mostly letters on a board) are presented to the participant while he or she sits at a certain fixed distance from the stimuli (for a more detailed description see Kniestedt and Stamper, 2003). Visual acuity was always tested under optimal conditions (best eye, with vision aid).

Visual ability (eyesight, degree of visual impairment) was the independent variable, and it consisted of three categories: blind (VA $<$ 1/20), visually impaired (VA of 3/10–1/20), and sighted (VA of $>$3/10 or visual field in case of central fixation is less than 5°). This classification was taken from the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10). As dependent criteria, working-memory capacity and verbal comprehension were measured.

Further possible determinants and biasing factors, such as SES, race-ethnicity, gender, age, and age of onset of visual impairment were measured.

Sample

As mentioned before, the meta-analyses of Melby-Lervåg et al. (2016) and Soveri et al. (2017) have shown that working-memory capacity is changeable by training (depending on criteria and control groups with effects between d = 0.24 and 1.88). Because a visual impairment can influence fluid intelligence and its components much longer and stronger than a temporary exceptional training, we expected a medium effect size of d = 0.50 between children with and without visual disability regarding their working-memory capacity. To ascertain adequate power of 95% to find this effect (assuming a conventional error probability of α = 0.05), a sample size of 132 children with and 66 children without visual disabilities was recommended. *De facto* we were able to recruit a total of 153 children with visual disabilities and 96 children without visual limitations.

The South African sample was from Cape Town and Worcester, situated 120 km from Cape Town, and consisted of 155 children (mean age 13.38 years, range 6–16 years). 45 were blind, 58 were visually impaired, and 52 had no visual handicaps (sighted). 77 were boys, 78 girls. 35 children had the lowest social-economic status (SES), 62 had low SES, 58 had medium SES, and none had high social status. 64 were Black, 52 Colored (the conventional term in South Africa), and 39 White. 26 spoke English, 66 Afrikaans, and 63 Xhosa as their first language. SES was measured according to criteria developed by Statistics South Africa (2000): accommodation (informal vs. formal settlement), home equipment (running water, electricity, bathroom, and telephone), highest educational degree of parents and of further adults living in the home, number of persons per room, and family income. The same measure was applied to the Austrian sample.

The Austrian sample was from, respectively, the province of Styria and the Austrian capital Vienna, and consisted of 94 children (mean age 12.35 years, range 6–16 years). 19 were blind, 31 were visually impaired, 44 had no visual handicaps (sighted). 45 were boys, 49 girls. One child had the lowest social status, seven low SES, 44 medium SES, and five high social status (rest missing data). All were White.

85 spoke German, five Serbo-Croatian, and four Turkish as their first language. **Table 1** gives information on gender, age, and social status.

Table 2 gives an overview of the groups of blind, visually disabled and sighted participants of both (South African and Austrian) samples. In both samples, the blind as well as the children with a visual disability went to special schools. Those schools use didactical techniques adjusted to students with severely limited or no visual ability and were specialized in teaching braille. But the curricula of the blind and the students with visual disability in our sample was still broadly similar to those of general public schools, e.g., both teaching mathematics, language, and history. In our sample of participants with visual disability, no students with multiple disabilities were included. The blindness or the visual disability in our samples had various causes and was either congenital (N = 114) or acquired (N = 39).

Procedure

The selection of the participants was as follows: in South Africa, two institutions especially for the blind ("Athlone School for the Blind" in Cape Town and "Pioneer School" in Worcester) were contacted to get access to a larger group of children with visual disabilities. Additionally, public schools in Cape Town and Worcester with special integration classes for children with visual disabilities were contacted to acquire children with visual disabilities. To generate a corresponding, representative sample of children with no visual limitations, regular public schools and community centers in Cape Town and Worcester were randomly selected and asked to participate. After the various institutions confirmed their willingness to support the study, the students (and their parents) decided voluntarily whether they wanted to participate in the study.

In Austria, the procedure was quite similar: the Odilien-Institut in Graz (province of Styria) and the Federal Institute for the Blind in Vienna had been contacted to acquire an adequate sample of children with visual disabilities. In addition, general public schools in Graz and Vienna were randomly contacted to generate an adequate sample of sighted children. After the institutions confirmed their willingness to participate, the students and their parents voluntarily assented to the study. The working-memory tests and the verbal ability tests were administered in the respective schools as group tests. Only some of the South African participants (single blind students at the Pioneer school and the public schools with integration classes) had to be tested at home due to time constraint and organizational limitations.

Tests

Working-memory capacity (WMC) and verbal comprehension were measured with subtests of the Wechsler Intelligence Scale for Children IV (WISC-IV; Wechsler, 2003). Both scales can be administered without using paper and pencil. The South African sample was directly tested using the original English version of the test, whereas the German translation of the WISC-IV was used for the Austrian sample (Hamburg-Wechsler-Intelligenztest für Kinder, HAWIK-IV; Petermann and Petermann, 2007, 2011).

The compound score of *working memory* combines the scores on two subtests (1) digit span (repeating numerical series in proper or reverse order) and (2) letter-number sequencing (repeating a given set of numbers and letters in numerical or alphabetical order). A third subtest, measuring arithmetic (solving mental-calculation tasks that are orally presented), is less appropriate and is only supplemental (e.g., it can be used if one of the main subtests cannot be applied; Petermann and Petermann, 2011, p. 16). In the current study, the third subtest was taken but only used for the *g*-factor analysis.

The compound score of *verbal comprehension* combines the scores on three subtests: (1) similarities (finding a hypernym for a given set of words), (2) vocabulary (defining a given word), and (3) comprehension (knowledge about social policies and everyday problems). The supplemental subtest information (knowledge about public events, issues, and persons) was also taken, but because none of the regular subtests had to be replaced, it was used only for the *g*-factor analysis.

TABLE 2 | Sample characteristics for the participants with and without visual disability.

Sample	Gender (N = 249)	Age (N = 249)	Social status (N = 212)	
Blind	Male: N = 25 (39.1%)	M = 13.21	SES1 (township)	N = 11 (20.4%)
(N = 64)	Female: N = 39 (60.9%)	(SD = 2.67)	SES2 (lower class)	N = 22 (40.7%)
			SES3 (middle class)	N = 20 (37.0%)
			SES4 (upper class)	N = 10 (1.9%)
Visually impaired	Male: N = 50 (56.2%)	M = 13.33	SES1 (township)	N = 15 (20.8%)
(N = 89)	Female: N = 39 (43.8%)	(SD = 2.68)	SES2 (lower class)	N = 27 (37.5%)
			SES3 (middle class)	N = 30 (41.7%)
			SES4 (upper class)	N = 0 (0.0%)
Sighted	Male: N = 47 (49.0%)	M = 12.52	SES1 (township)	N = 10 (11.6%)
(N = 96)	Female: N = 49 (51.0%)	(SD = 3.03)	SES2 (lower class)	N = 20 (23.3%)
			SES3 (middle class)	N = 52 (60.4%)
			SES4 (upper class)	N = 4 (4.7%)

$N_{(social\ status)} \neq [N_{(blind)} + N_{(visual.\ handic.)} + N_{(sighted)}]$ *because not all participants provided information on their social status.*

To combine the results of the South African and Austrian samples, the results on both subtests were standardized using the norm values of the German HAWIK-IV. As usual, subtests were age-normed, so the mean age difference of 1 year between the South African and Austrian students had no influence.

Analyses

We compared for each of the two samples (South Africa and Austria) and within each of the three groups (the blind, visually impaired, and sighted) averages in working-memory capacity and verbal comprehension. We computed means and standard deviations, correlations (Pearson and Spearman for robustness checks) with eyesight, differences in IQ points (using the standard deviations of the nationally representative samples), and differences in standard deviations using sample *SDs*. Significance tests were not used for interpretation (for an in-depth justification, see, e.g., Cohen, 1994; Gigerenzer, 2004; Wasserstein et al., 2019).

In regression analyses we checked the robustness of the visual impairment effect for country (South Africa "0" vs. Austria "1"), SES (township "1," lower class "2," middle class "3," and upper class "4") and ethnicity (race; black "0," colored "1", and white "2").

Finally, we performed two *g*-factor analyses in an attempt to answer the following questions: are eyesight differences larger on the two working-memory capacity and verbal comprehension *g* factors than on the two mean scales? Are *g*-factor loadings correlated with the subtest-eyesight correlations? If blind-sighted differences are larger on *g* factors and if these differences are correlated with *g*-factor loadings this would hint to a genetic causation; if they are not larger on *g* factors and not correlated with *g*-factor loadings this suggests an environmental causation (te Nijenhuis and van der Flier, 2013). Due to the small number of subtests ($k = 3$ WM subtests and $k = 4$ VC subtests) these analyses are exploratory.

RESULTS

The average results in working-memory capacity and verbal comprehension of the blind, visually impaired, and sighted South African and Austrian children are presented in **Table 3** and **Figure 1**.

Blind students outperformed sighted students on working memory, both in South Africa ($r = +0.52$, Spearman $r_S = +0.54$, IQ +17, $d = +1.67$) and Austria ($r = +0.11$, $r_S = +0.04$, IQ +7, $d = +0.40$). As predicted, blind students scored worse on verbal comprehension than sighted students and this is true for both the South African ($r = -0.40$, $r_S = -0.43$, IQ −12, $d = -1.22$) and Austrian sample ($r = -0.32$, $r_S = -0.36$, IQ −10, $d = -0.89$). Within the subsamples of visual disabilities, the trend is monotonous only for the working-memory capacity of South African students: the more strongly the visual disability was, the better were the working-memory test scores (from IQ 103.21–110.43 and 120.47). A weak trend could be found for the scores on verbal comprehension of Austrian students: the better the eyesight, the higher their verbal comprehension (from IQ 89.63–90.29 and 99.50). Across all groups and all samples, the results on the verbal comprehension subtest were lower than the results on working memory. The overall correlation between both scales, working memory and verbal comprehension, was $r = 0.22$, which is not high.

Checking the effects at the level of subtests of working memory, visual impairment was positively correlated with digit span (for all three groups of eyesight: $r = +0.40$, South Africa: $r = +0.60$, Austria: $r = +0.11$) and letter-number sequencing span ($r = +0.20$, South Africa: $r = +0.24$, Austria: $r = +0.15$) separately, for working memory (mean score) the correlations were $r = +0.35$ ($r_S = +0.37$; South Africa: $r = +0.52$, $r_S = +0.54$, Austria: $r = +0.11$, $r_S = +0.04$).

There were only minor or unsystematic differences between the general cognitive ability levels (WM and verbal comprehension averaged) of the blind ($M = 100.76$, $SD = 10.79$), impaired ($M = 95.16$, $SD = 11.91$) and sighted ($M = 100.16$, $SD = 9.83$). Blindness does not necessarily lead to reduced intelligence, particularly not for children attending special schools for students with visual disability, as is the case for both our samples. There are also only small differences between South African ($M = 97.23$, $SD = 9.63$) and Austrian ($M = 100.66$, $SD = 12.95$) students. This is at odds with the generally found large gap between Western and sub-Saharan African samples (Rindermann, 2018). However, on closer inspection the South African data reveal a racial-ethnic gap of around 14 IQ points that is stable across all three groups of eyesight. The South African Whites' average IQ of 105.78 ($SD = 5.02$) suggests that the South African sample was positively selected. The Austrian sample seems not to be selected (grand mean IQ 100), but the same ability pattern for eyesight was found (i.e., blind vs. sighted and working memory vs. verbal).

Visual impairment (sighted "0," visually disabled "1," blind "2") was not correlated with country, gender, social status, ethnic background, and first language (all correlations below $r = 0.15$). At best, there was a small negative correlation between visual impairment and SES ($r = -0.13$ and -0.12 in South Africa and Austria, using Spearman's rank correlation $r_S = -0.13$ and -0.18). However, country and SES ($r = 0.44$, $r_S = 0.45$) were substantially correlated. Within South Africa, social status and racial-ethnic background were highly correlated with verbal comprehension ($r_{SES} = 0.61$, $r_{Ra} = 0.62$, $r_S = 0.64$ and 0.62, respectively), and also SES with race-ethnicity ($r = 0.71$, $r_S = 0.71$).

Gender was not correlated with eyesight ($r = 0.06$), WMC ($r = 0.09$), and VC ($r = -0.01$). Age was weakly correlated with eyesight ($r = 0.11$), WMC ($r = 0.05$), and VC ($r = -0.23$). The negative correlation between age and verbal comprehension ($r = -0.23$, South Africa $r = -0.04$, Austria $r = -0.31$) showed no systematic covariation with eyesight (e.g., in Austria for the sighted higher, in South Africa for the blind even weakly positive).

Age of onset of visual impairment (with birth/congenital 0, later 1) was not correlated with eyesight (impaired or blind, $r = 0.02$) and only weakly with WMC ($r = 0.05$) and VC ($r = -0.14$). That means persons with later-developed visual impairment had a slightly lower verbal comprehension compared to those with congenital visual impairment. Blind persons suffer

TABLE 3 | Average WMC and verbal comprehension scores depending on visual ability.

Sample	Blind *M* (*SD*)	Visually impaired *M* (*SD*)	Sighted *M* (*SD*)	*r* [95% CI]	Cohen's *d* [95% CI]
South Africa (*N* = 155)					
WMC	120.47 (10.47)	110.43 (12.94)	103.21 (10.14)	+0.52 [+0.39, +0.63]	+1.67 [+1.42, +1.93]
VC	80.16 (10.82)	78.53 (11.71)	92.06 (8.68)	−0.40 [−0.52, −0.26]	−1.22 [−1.45, −0.97]
Austria (*N* = 94)					
WMC	114.00 (21.35)	102.58 (17.29)	106.77 (14.10)	+0.11 [−0.09, +0.31]	+0.40 [+0.17, +0.62]
VC	89.63 (9.44)	90.29 (13.55)	99.50 (12.69)	−0.33 [−0.49, −0.13]	−0.89 [−1.12, −0.65]
All together (*N* = 249)					
WMC	118.55 (14.69)	107.70 (14.98)	104.84 (12.18)	+0.35 [+0.24, +0.45]	+1.02 [+0.78, +1.25]
VC	82.97 (11.24)	82.63 (13.53)	95.47 (11.28)	−0.39 [−0.49, −0.28]	−1.11 [−1.35, −0.87]

WMC, working-memory capacity; VC, verbal comprehension; r, correlation between visual ability (sighted: "0," visually impaired: "1," blind: "2") and ability results in the respective IQ dimension; d = intelligence difference between the blind and sighted expressed in standard deviation units (M = 0, SD = 1) using the averaged standard deviations of the blind and sighted of this sample (not SD = 15), positive values mean higher results for the blind.

more from later visual impairment (for the visually disabled onset and WM $r = 0.15$, onset and VC $r = -0.06$; for the blind onset and WM $r = -0.12$, onset and VC $r = -0.28$).

We checked whether the visual impairment (VI) effect on WM and VC depends on other factors (country/"Co", SES, race/"Ra"). In common analyses (both countries together) on WMC, visual impairment showed the strongest effect (a positive one): $\beta_{Co \rightarrow WMC} = -0.14$, $\beta_{SES \rightarrow WMC} = 0.16$, $\beta_{Ra \rightarrow WMC} = 0.23$, and $\beta_{VI \rightarrow WMC} = 0.49$. Within South Africa the results are similar ($\beta_{SES \rightarrow WMC} = 0.18$, $\beta_{Ra \rightarrow WMC} = 0.21$, and $\beta_{VI \rightarrow WMC} = 0.55$), also within Austria ($\beta_{SES \rightarrow WMC} = 0.06$ and $\beta_{VI \rightarrow WMC} = 0.31$). For verbal comprehension (VC) the effect of visual impairment is also robust (a negative one): $\beta_{Co \rightarrow VC} = 0.05$, $\beta_{SES \rightarrow VC} = 0.24$, $\beta_{Ra \rightarrow VC} = 0.40$, and $\beta_{VI \rightarrow VC} = -0.30$. Within South Africa the results are similar ($\beta_{SES \rightarrow VC} = 0.29$, $\beta_{Ra \rightarrow VC} = 0.40$, and $\beta_{VI \rightarrow VC} = -0.34$), also within Austria ($\beta_{SES \rightarrow VC} = 0.15$ and $\beta_{VI \rightarrow VC} = -0.29$). For working memory, eyesight is always the most important variable. However, for verbal comprehension race-ethnicity reveals to be even more important than country, SES or eyesight, but there is still a stable negative impact of visual impairment ($\beta_{VI \rightarrow VC} = -0.30$, -0.34, and -0.29). Remarkable is also the small country effect when controlled for SES and race (and eyesight). In the **Supplementary Material**, the analyses are also repeated now using a *g* factor score instead of scale means.

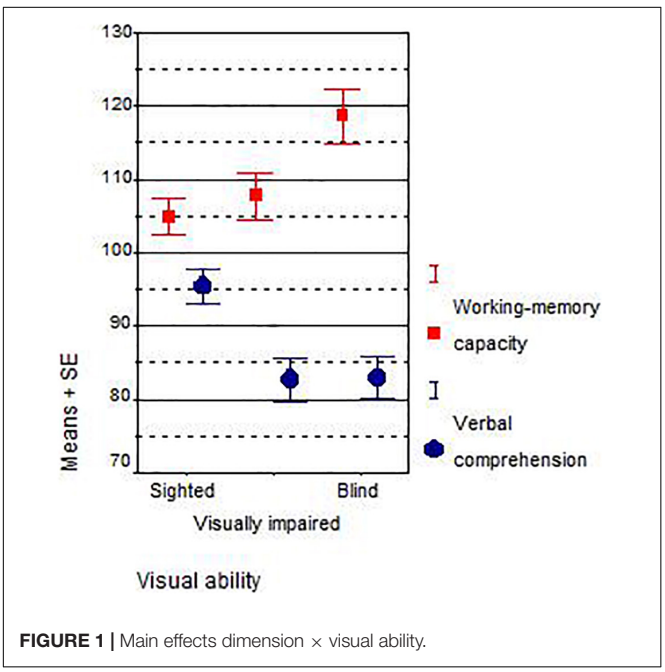

FIGURE 1 | Main effects dimension × visual ability.

DISCUSSION

Previous meta-analyses have shown that working-memory capacity is changeable by training (depending on criteria and control groups between $d = 0.24$ and 1.88; Melby-Lervåg et al., 2016; Soveri et al., 2017). Our results using a natural experiment comparing visually impaired with sighted persons, shows even larger effects. Blind and sighted and visually impaired and sighted persons in two countries differ in working memory: the blind score 14 IQ points higher and the visually impaired score three IQ points higher, whereas the opposite pattern was found for verbal comprehension.

Our conclusion is backed by several studies that came to similar results (Tillman and Osborne, 1969; Smits and Mommers, 1976; Hull and Mason, 1995; Hupp, 2003; Withagen et al., 2013; Pigeon and Marin-Lamellet, 2015): blindness seems to raise working memory. Of course, it is *not blindness itself*, but the individual and institutional reaction to blindness compensating for a shortage in visual information and in external visual storage of information.

The blind and sighted are quite similar in total IQ (average of working memory and verbal comprehension combined). This might be caused by the special schools for the blind attempting to compensate for the negative effects of serious deprivation by supplying specially tailored cognitive stimulation (e.g., the usage of special learning materials or technical devices, additional learning opportunities within working group).

Regressions with country, with SES, and with race-ethnicity controlled for, show a robust effect of visual impairment.

Nevertheless, eyesight is not the only relevant factor explaining individual differences in working memory and verbal comprehension. While gender was not correlated with the two cognitive measures, social status and race-ethnicity showed a correlation, especially with verbal comprehension (for the total sample $r = 0.62$, $r = 0.58$), the correlation with country was smaller ($r = 0.39$). The correlations were higher in South Africa than in Austria (social status and VC: $r_{ZAF} = 0.60$ vs. $r_{AUT} = 0.19$).

LIMITATIONS

In our study, WMC and verbal comprehension were both measured using the WISC-IV. This test was often used in studies on the changeability of WMC (e.g., Au et al., 2015) and enabled us to measure both abilities in a valid and economic way (Kaufman et al., 2006). Additionally, the WISC-IV is available in comparable versions in English and German and therefore can be directly administered in both of our samples. However, the WISC-IV is measuring only three facets of WMC (digit span, letter-number sequencing and the supplemental facet arithmetic). So further research should check the results of this study by measuring WMC in a more non-verbal way (e.g., analogous block span tests or the self-ordered pointing test; see Baron, 2005).

The trend found in this study is not always monotonous (from sighted to visually disabled to totally blind). Especially in the Austrian sample, the students with visual disability are outliers with concern to working memory. One plausible explanation is that not the degree of visual impairment itself is important, but the personal and environmental reaction how to deal with this impairment. However, the general trend shows that cognitive ability seems to be modifiable by visual impairment. Or in other words: Human working memory seems to adapt to special experiences such as blindness which, few would argue, is one of the strongest experiences known.

In fact, our study cannot conclusively distinguish whether and to which degree neuro-biological factors (neuroplasticity, so that brain resources which are otherwise invested in processing visual input can be used for other cognitive processes) or environmental factors (e.g., education adapted to blind persons, the use of braille, receiving similar assistance) lead to improved WMC of persons with visual impairment. Therefore, further studies should differentiate between individuals with visual impairment at birth and visual impairment acquired later in life.

CONCLUSION

Based on our findings, it can be ruled out that other factors which are completely independent of visual impairment can account for the clear pattern of effects (WMC increased and VC decreased) found in our study. Especially, as the effects found were controlled for social status, race-ethnicity, and even country, and are in line with other studies showing the same stable pattern of effects across different samples, different decades, different countries, as well as different authors.

Our data also suggest that those differences in working-memory capacity are not on *g*, which could be seen as suggesting they are not genetic or biological. Accordingly, no theory assumes common genetic effects on intelligence and eyesight. The modest number of subtests did not allow the use of multi-group confirmatory factor analysis. So, further research using more subtests is strongly recommended. Nevertheless, our results seem to suggest that the differences in WMC are not genetic or biological.

That family background factors have an impact on children's cognitive ability measures is not surprising; in a study covering seven countries, including developed and developing countries, the statistically most important factor was ethnicity-migration background followed by parental educational level (Rindermann and Ceci, 2018). Important in our study is, that eyesight still has a robust positive effect on working memory (increasing) and robust negative effect on verbal comprehension (decreasing).

We cannot rule out the possibility that the quality of the schools for the blind was at a higher level than the quality of regular schools. At least, the schools for the blind are comprehensively adapted to the special needs of the visually impaired and the blind. So, current inclusion-based attempts to close such schools and to send students with a visual disability to regular schools, where they usually do not receive the intensive treatment by specialist staff, may endanger the development of children with special needs such as students with visual disability. Here, the current study is of course just one first "piece of evidence": More extensive research controlling for potentially different quality of schools for students with versus without visual impairment is needed. Finally, meta-analyses should be carried out, including controlling for publication bias.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request 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 to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

HR: conceptualization and methodology and investigation. AA: project administration and writing – original draft and preparation. HR and JN formal analysis and writing – review and editing. 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.2020.01571/full#supplementary-material

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The Effects of an Ecological Diversifying Experience on Creativity: An Experimental Study

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Sometimes, life houses rare and unexpected events, such as moving abroad or meeting a special person unexpectedly. Recently, these situations have been indicated as "diversifying experiences" (DEs), defined as unusual and unexpected events that drag people outside their daily routine and accustomed schemas. The core mechanism of DEs would entail the disruption of our mental schema, which can facilitate unexpected connections among even distant ideas, thus enhancing people's cognitive flexibility, that is, a key component of creative thinking. Despite both qualitative and lab-based studies have investigated the features of these experiences, an ecological assessment of their properties also in relation with creativity is still an open issue. The aim of this research is to study the DE–creativity link in a more ecological way, on the basis of a real-life disruptive experience of light deprivation. Specifically, we compared an ecological DE artistic established entertainment format (i.e., "dialogue in the dark," which is seeing people perform several daily life activities but in the absence of light) with an equivalent experience in which the same activities were acted in the sunlight. The absence of light played the role of violating mechanism, framed within the ecological experiential format of the "dialogue in the dark." We compared visitors' emotional profile [Positive and Negative Affect Schedule (PANAS), *ad hoc* Adjective Checklist], perceived impact of the experience [Centrality of Event Scale (CES)], and creative performance [Torrance Tests of Creative Thinking (TTCT)] in both groups of sighted people (in absence of light vs. in presence of light); and we also controlled for people's openness to experience and need for cognitive closure, as dispositions. Results showed that (vs. control group) "dialogue in the dark" (i) led to worse creative performances, (ii) produced more intense positive affect, and (iii) resulted as a more impacting experience. Intense short-term impact of DE could have been detrimental for participants' creativity. People may need more time to elaborate the DE and accommodate existing schema to generate more creative ideas. This is the first study proposing and succeeding in demonstrating the feasibility to investigate even real complex DEs in a controlled way, thus outlining how their link with creativity can take place in real life.

Keywords: creativity, diversifying experience, cognitive flexibility, divergent thinking, Torrance test, dialogue in the dark, schema violation

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INTRODUCTION

As defined by Ritter et al. (2012) and Damian and Simonton (2014), diversifying experiences (DEs) involve unusual, unexpected and disruptive events, different from our daily routine; thus, they are able to drag people outside their "realm of normality" (Damian and Simonton, 2015). With this regard, all DEs would share a common underlying mechanism entailing a violation of our accustomed mental structures, which people use to process the complexity of the environment and to generate predictions concerning the outside world (Gocłowska et al., 2014). Mental schema are abstract generalizations of information at the base of people's expectancies toward the world, themselves, and the others, which are crucial to orient our behavior in the world (Roese and Sherman, 2007). Phylogenetically, approaching and exploring unpredictability by overcoming accustomed mental schema have been a highly desirable functional ability (Gocłowska et al., 2017). For example, our ancestors' preference for novelty and surprise encouraged them to explore the world and to discover new habitats and foods. Indeed, the pursuit and acceptance of unusual ideas have led to the development of pioneering innovations that required innovators to go against their knowledge and violate their assumptions about the world (Gocłowska et al., 2017).

With this regard, the main potential of schema violations as a core component of DEs consists in creating a bridge between these unusual experiences and creativity (Damian and Simonton, 2014) or, at least, between DEs and a specific component of creative thinking (Ritter et al., 2012), which is cognitive flexibility (Oztop, 2017). Cognitive flexibility can be defined as the ability of our cognitive system to adapt to changes by shifting the focus of attention, formulating new action plans and new states of activation, and modifying internal cognitive processes (Deak, 2003). Damian and Simonton (2014) and more recently, Gocłowska et al. (2018) compared DE with stressful events, and they elaborated that DE–creativity link should be depicted as an inverted U shape, where moderate levels of novelty and unconventionality stemming from a DE could result into increased creative thinking. In other terms, to maximize the potential of DEs for enhancing creative thinking, the perceived intensity of DE should be moderate, stimulating people's resources instead of just exploiting them. Therefore, not all DEs can be conductive to creativity.

With this regard, empirical evidences, albeit heterogenous, have investigated specific conditions leading to a link between DEs and creativity (for a review, see Damian and Simonton, 2014) or more specifically, between schema violations and cognitive flexibility (e.g., Ritter et al., 2012) as a core component of creativity thinking process (Torrance, 1969). Particularly, it would be possible to identify specific approaches to the study of DEs and creativity. Each of them either scaled up DE by conceiving it as complex experience (*macrolevel of analysis*) with its subcomponents or scaled down DE by manipulating specific schema violation (*microlevel of analysis*).

A Macrolevel of Analysis: Diversifying Experiences as Complex Experiences

Damian and Simonton (2014) assumed that the link between a complex DE and creativity can be nurtured by seeing things in an unconventional way, thus leading people to imagine the impossible. They suggested that this process would lead to new cognitive paths, as a source of mental flexibility (Simonton et al., 1999). DEs can include, but are not limited to, biculturalism, multilingualism or bilingualism, psychopathology, and familiar unpredictability (Damian and Simonton, 2014). Correlational, historiometric, and psychometric studies evidenced a link between these special types of DEs and with both exceptional (Big-C) and everyday creativity (little-c) (Damian and Simonton, 2014). For instance, multiculturalism was beneficial for little-c creativity only if people were high in openness to experience (Leung and Chiu, 2008). It maybe that individuals high in this trait would have also a higher predisposition to deal with different ideas or perspectives at the same time, thus overcoming initial strain related to managing diversity. Actually, diversity acts as a facilitating factor for cognitive flexibility and creativity at general, not only at the individual level but also at the group level (Cox and Blake, 1991; McLeod et al., 1996). However, group members should be willing to adopt other members' diverse perspective and should be guided by beliefs in favor of diversity instead of supporting a cognitive attitude toward similarities (Hoever et al., 2012). In other terms, a certain amount of openness toward diversity was needed also at the group level to lead teams toward better creative performances and a more flexible style of thinking.

A Microlevel of Analysis: The Role of Schema Violation

If is largely accepted that that schema violation acts as a central factor in DE–creativity link, it is crucial to outline empirically how they can modulate this relationship. With this regard, DEs have been scaled down at the level of specific schema violations reproduced in the lab. Laboratory studies provide conflicting results showing that cognitive violation not always leads to a better creative performance. For instance, Ritter et al. (2012) used simulations of situations that violated the logic of physics (e.g., a fallen glass lifting instead of shattering into thousand pieces) involving participants actively [through a virtual reality (VR) simulation] or passively (through a movie). Results revealed that when individuals were actively involved into the violation, their cognitive flexibility increased significantly than when they watched only the movie. This can suggest that even small-scale violations could "open people's mind," connecting ideas that were previously far apart. This happened also when individuals were not directly engaged into specific paradoxical action plans but when they identified with other individuals realizing paradoxical actions (Ritter et al., 2014).

However, when individuals actively interacted with another person in the lab, who violated their stereotype-related schema, and their psychophysiological reaction was primarily of threat, subsequent affect associated with the human actor was more negative and creative performance worsened (Mendes et al., 2007). Schema violation and creativity link did not hold under

all circumstances, especially if there was an involvement with a real person and not just a simulation of it (e.g., VR) and when specific schema was violated.

With this regard, according to the most recent model on DEs (Gocłowska et al., 2018), appraisals activated by individuals to process the schema violation stemming from a DE should play a central role in facilitating (or not) creativity. Indeed, depending on the evaluation of schema violation, individuals' general attitude toward a DE would change significantly, either as a threat or as a challenge. Only the latter positive attitude (i.e., challenge) should be related to higher creative flexibility. With this regard, two key appraisals should be at the base of a positive evaluation of a violation, that is, surprise and interest (Gocłowska et al., 2017). Both are epistemological emotions (Silvia, 2010), but surprise would act as a potential trigger of interest, which would be directly responsible for a positive evaluation of a given violation. Therefore, being surprised in front of something able to challenge our expectancies should be not enough to evaluate the source as positive. Being motivated to look for more information, connecting even distant ideas and process more data should be the key. Whereas being high in openness to experience personality trait should facilitate an appraisal of interest, being high in the need for structure, cognitive closure, and fixed rules would be detrimental (Gocłowska et al., 2017). Crucially, people with a higher need for fixed structure, hardly benefit from schema violations and showed worse creativity self-efficacy and creative thinking abilities (Gocłowska et al., 2017). Finally, besides the mere cognitive aspects, also the role of the body emerged as a key variable determining whether a violation would be either conductive to cognitive flexibility or not (Huang and Galinsky, 2011). This may suggest that even realistic VR simulation can lack of important body-related components that should be considered in the equation of DE–creativity link.

This Study: The Dialogue in the Dark Experience

If the existence of a link between DEs and creativity both at a macrolevel and a microlevel of analysis has been accepted, evidence still show inconsistencies due to the type of DEs and violations considered, the low control of correlational and psychometric research, and the high control but low degree of ecological validity of current experimental manipulations of DEs.

VR simulations provided by Ritter et al. (2012, 2014) provided crucial initial evidence on the role of realistic basic schema violations without social interactions – disembodied experiences – on creative thinking but are still far from the real occurrence of DE in reality. Both scaling up DEs as complex experiences and scaling down them as schema inconsistencies reproduced in the lab could hinder a full comprehension of this phenomenon in real life (Damian and Simonton, 2014).

To address this issue, we built upon existing theoretical and experimental evidence on DE to advance the knowledge on how real DEs would impact individuals' creativity. This allowed for enhancing ecological validity while maintaining a controlled setting. We identified an artistic established format composed by a set of real-life group activities to be performed in the absence of light, which is called "dialogue in the dark," as a potentially diversifying and ecological experience.

"Dialogue in the dark" violates people's most basic expectancies regarding light, which is a primary source of information in our daily life. Sighted people heavily rely on vision to represent their peri-personal space. On the contrary, blind people use the haptic system (Postma et al., 2007). What would it be like to live as a blind person for some time? This artistic format answers this question. "Dialogue in the dark" violates sighted people's typical ways of representing space, forcing them to activate an alternative system (haptic system instead of vision) (Postma et al., 2007).

This study can advance current paradigms in the study of DEs at two levels. First, it can provide an ecological setting resembling real-life DE. Then, it can allow observing the effect of this experience of people's creativity immediately after its occurrence in a controlled setting.

MATERIALS AND METHODS

Research Design, Measures, and Instruments

This research is composed of two studies. In both studies, before signing the informed consent, participants were fully briefed about the research purpose and were informed that they could take part on a research conducted by the Università Cattolica del Sacro Cuore in collaboration with the Institute of the Blinds. They were also told that they were free to leave the study at any time. The experimental protocol was approved by the Ethical Committee of the Università Cattolica del Sacro Cuore prior to data collection. Each participant provided written informed consent for study participation. The whole procedure was carried out in accordance with the Declaration of Helsinki.

In Study 1, the "diversifying" nature of the "dialogue in the dark" was measured following the guidelines provided by the reference framework on DEs (Ritter et al., 2012; Damian and Simonton, 2014; Gocłowska et al., 2018).

Specifically, "dialogue in the dark" diversifying nature was measured by means of the following:

(i) *Ad hoc* Adjective Checklist. This self-reported instrument was designed *ad hoc* for this study to measure the diversifying potential of the "dialogue in the dark." The scale was created from the adjectives that Ritter et al. (2012) and Damian and Simonton (2014) attributed to DEs. The adjectives that constitute the scale were unusual, unexpected, engaging, ordinary, and intense. Participants were asked to indicate their degree of agreement with the adjectives listed in 5-point Likert response scale format (1 = not at all; 5 = at all). Because Cronbach alpha was.71, we chose to consider each item separately.

(ii) Centrality of Event Scale (CES). According Gocłowska et al. (2018), DEs require individuals to cope and adapt; thus, they are comparable with stressful events. The long 20-item version of the CES was composed of three dimensions on a 5-point Likert scale from 1 (strongly disagree) to 5 (totally agree), measuring the extent to which the memory of the event becomes (a) a reference

point in everyday life, (b) a key component of personal identity, and (c) a turning point in the personal life story (Berntsen and Rubin, 2006; Ionio et al., 2018). To be more conservative, we both aggregated the scores to obtain a global CES score, and we also computed specific analyses for each single item (subdimension) of the scale: (i) "I feel that this event has become part of my identity" (label: "Part of identity"); (ii) "This event has become a reference point for the way I understand myself and the world" (label "Comprehension"); (iii) "I feel that this event has become a central part of my life story" (label: "Central in life"); (iv) "This event has colored the way I think and feel about other experiences" (label: "Other experiences"); (v) "This event permanently changed my life" (label: "Life change"); (vi) "I often think about the effects this event will have on my future"; and (vii) "This event was a turning point in my life" (label: "Turning point"). The CES (α coefficient = 0.88) was selected to assess the personal impact of DE as a potentially stressful event (Folkman and Lazarus, 1984). In Study 1, this scale was assessed after 2 weeks of the "dialogue in the dark" experience.

In Study 2, a comparison between the "dialogue in the dark" and an equivalent experience that consists of the same set of activities preformed in the presence of light was carried out (control condition). This control experience was as much similar as possible – for content and duration – to the experimental one. "Dialogue in the dark" and control experience differed regarding the presence (vs. absence) of light. In the "dialogue in the dark," participants performed a set of daily activities in the absence of light. Conversely, the control condition consists of the same set of activities performed in a park in the presence of light.

Specifically, dialogue in the dark is an experience in the dark, where blind guides lead visitors in small groups (eight people with normal or corrected sight persons, in this study) through different settings, that is, playing with a ball together, walking on the grass, touching the water of a little lake, tasting some spices, and so forth, in the absence of light.

The control group, instead, lived an equivalent experience in Parco Sempione (a renowned park in Milan), which was equivalent in duration and content to the "dialogue in the dark" but more "ordinary" because the same daily activities were done in the presence of light. At the end of both the experiences, a debriefing procedure was carried out in a pub, so that participants could talk about the experience they just lived.

Study 2 followed a *between-subjects* design, where participants were assigned only to the "dialogue in the dark" (experimental) or to the control condition.

Immediately after both experiences, participants were required to complete the *ad hoc* Adjective Checklist and the CES, again, as well as the following self-reported instruments:

(i) Creative thinking. Participants completed the Italian version of subtest 5 (i.e., unusual uses of a box) of the Torrance Tests of Creative Thinking (TTCT) (Torrance, 1974; Torrance et al., 1989). This subtest was scored according to Guilford's divergent thinking factors: fluency (i.e., number of relevant responses), elaboration (i.e., the number of details in the answers), originality (i.e., statistically infrequent but relevant answers), and flexibility (i.e., the number of different categories within relevant responses) (Guilford, 1950, 1959, 1967). The "Unusual Uses" task lasted 10 min, and participants were tasked to generate as much solutions as possible concerning interesting and unusual ways of using a cardboard box.

Instructions are reported as follows:

"Almost everyone is used to throw away used cardboard boxes, yet there are thousands interesting and unusual ways of using them. In the lines of the current page and the following one, please, make the longest list of interesting and unusual ways of using the cardboard boxes that you can imagine. Do not think only about boxes of particular size. You can use all kinds of boxes you want. Do not limit yourself to the uses you have seen or heard before. Try to imagine as many new uses as possible." With every measure, "the instructions are designed to motivate respondents to give unusual, detailed responses" (Cramond et al., 2005; p. 284). Torrance based TTCT's scoring on Guilford's divergent thinking factors: fluency, which refers to the number of relevant responses; flexibility, which is the number of different categories within relevant responses; originality, which refers to statistically infrequent but relevant answers; and elaboration, which refers to the number of details in the answers (Cramond et al., 2005). Here, we involved two independent raters to score participants' performances at subtest 5 for fluency, flexibility, originality, and elaboration, achieving good levels of reliability (Rater 1 and Rater 2: Cronbach α = 0.80).

(ii) The Positive and Negative Affect Schedule (PANAS). The Italian version of the PANAS (Terraciano et al., 2003) [α coefficients: 0.86–0.90 for positive affect (PA) and 0.84–0.87 for negative affect (NA)] was used. The scale measures PA and NA states at a certain time. It is composed of 10 adjectives indicating PAs and the other 10 referring to NAs. Participants had to indicate how much the adjectives described how they felt in that moment – after the "dialogue in the dark"/control experience – by using a 5-point Likert scale. This scale combined with the *ad hoc* Adjective Scale allowed assessing participants' emotional experience. Gocłowska et al. (2018) suggested that only when a DE avoids a negative appraisal of threat could better creative abilities be achieved.

Finally, following up main findings on schema-violation effectiveness for enhancing creative thinking (e.g., Huang and Galinsky, 2011; Gocłowska et al., 2014, 2017), also participant's openness to experience and need for closure were measured and included as covariates. Specifically, participants completed the following:

(i) The Openness to Experience Scale. The *Openness to Experience Scale* (α coefficient = 0.80) was used to measure participants' mental openness. This is a subscale

of the Italian version of the Big Five Inventory (Ubbiali et al., 2013), selecting only those items tapping into the construct of Openness to Experience (10 items). Example items are "I am original, come up with new ideas." Participants were asked to complete the scale by using a 5-point Likert response scale.

(ii) The Need for Cognitive Closure Scale. The *Need for Cognitive Closure Scale* (Pierro et al., 1995) (α coefficient = 0.84) was used to detect the degree of personal need for structure of participants. The scale consists of 42 items relating to five main dimensions of the need for cognitive closure, namely, (a) need for order, that is, the need for structuring in one's environment; (b) intolerance for ambiguity, which refers to the emotional discomfort produced by living ambiguous situations; (c) decision making, which concerns the need to quickly get to a conclusion; (d) mental closure, as the tendency to prevent one's knowledge from being questioned by different or conflicting opinions; and (e) need for predictability, that is, the desire to have safe and generalizable knowledge, ensuring a sure predictability of the contexts in which one will be operating (Pierro et al., 1995). Participants were asked to express their agreement with all statements on a 7-point Likert scale.

Data Analysis

Two normality tests (i.e., Kolmogorov–Smirnov and Shapiro–Wilk) were carried out to determine if variables were normally distributed.

For Study 1, this did not have implications, because we relied only on descriptive statistics of affect (PANAS) and personal impact of the experience (CES).

In Study 2, because almost all variables were not normally distributed, first, intercorrelations among raters' creativity-dimensions scores were carried out by computing Spearman's rho coefficients. Then, a Mann–Whitney test for all variables was carried out, in order to test the effect of the "dialogue in the dark" (vs. control group) on creative thinking dimensions, affect, and personal impact of the experience.

Finally, a series of analysis of covariance (ANCOVA) with "group" ("dialogue in the dark" vs. control) as independent variable, Global CES score as measure, and all dimensions of the Openness to Experience and the Need for Cognitive Closure Scale as covariates were carried out.

All statistical analyses were performed using IBM SPSS Statistics software (Version 21, release 21.0.0.0 64 bit edition).

Study 1

Aim

The aim of this preliminary study was to measure the affective profile of the "dialogue in the dark" immediately at the end of the experience and its personal impact after 2 weeks.

Participants and Procedure

We conducted Study 1 with a separate group of volunteers, in order to test the extent to which the "dialogue in the dark" could be considered as a DE. Participants in Study 1 ($N = 30$; 19 females) were all sighted adults with mean age = 30.23 ($SD = 10.08$). They were recruited locally (i.e., at the Institute of the Blinds of Milan) among people willing to try the "dialogue in the dark" experience.

The procedure is composed of three steps: (i) participants were briefed on the aim of the study and were asked for their informed consent. (ii) Participants took part of the "dialogue in the dark" experience; participants answered the *ad hoc* Adjectives Scale immediately after the "dialogue in the dark" experience. (iii) Participants filled out the CES short Italian version (Ionio et al., 2018) – sent to them through email – 2 weeks after the experience, in order to measure the long-term impact of the "dialogue in the dark."

Results

Descriptive statistics showed that "dialogue in the dark" was a highly unusual, unexpected, involving, and intense but less ordinary experience [Unusual (mean = 4.1; $SD = 1.21$); Unexpected (mean = 3.57; $SD = 1.16$); Involving (mean = 4.93; $SD = 0.25$); Ordinary (mean = 1.33; $SD = 1.06$); and Intense (mean = 4.87; $SD = 0.35$), within a range from 1 to 5].

Personal impact of the experience after 2 weeks resulted as moderate: Part of identity (mean = 3.17; $SD = 0.98$); Comprehension (mean = 3.39; $SD = 1.08$); Central in life (mean = 2.56; $SD = 1.12$); Other Experiences (mean = 3.13; $SD = 1.01$); Life change (mean = 2.91; 1.04); Effects on future (mean = 2.7; $SD = 1.02$); and Turning point (mean = 2.53; $SD = 1.04$).

Study 2

Aim

The aim of this experimental study was to test whether an ecological DE based on clear violation of light deprivation, as the "dialogue in the dark," which follows a codified format, could significantly enhance participants' creative thinking abilities and lead to a higher PA and higher personal impact as compared with an equivalent control experience.

Participants and Procedure

Participants in this study ($N = 133$) were all sighted adult volunteers: 71 (31 males) with mean age 32.5 years ($SD = 11.4$) were in the experimental group, whereas 62 (30 males) with mean age 30.9 ($SD = 11.6$) were in the control one. There was no significant difference in the openness to experience disposition between the experimental group (mean = 3.26; $SD = 0.475$) and the control one (mean = 3.31; $SD = 0.484$). Moreover, participants of both groups did not significantly differ regarding all subdimensions of the Need for Closure scale: (i) *Decision Making*, experimental group (mean = 28; $SD = 5.06$) versus control group (mean = 27.6; $SD = 4.47$); (ii) *Need for Order*, experimental group (mean = 38.6; $SD = 7.47$) versus control group (mean = 38.8; $SD = 7.51$); (iii) *Need for Predictability*, experimental (mean = 27.9; $SD = 4.34$) versus control (mean = 27.5; $SD = 4.19$); (iv) *Intolerance for Ambiguity*, experimental (mean = 32.4; $SD = 6.79$) versus control (mean = 34.2; $SD = 8.37$); and (v) *Mental Closure*, experimental (mean = 30.3; $SD = 4.33$) versus control (mean = 30.1; $SD = 4.86$). Participants in the control group were recruited through social

media, and participants in the experimental group were recruited where the experience of the "dialogue in the dark" took place (i.e., Institute of the Blinds of Milan).

After participants in both the control and experimental groups read and signed the informed consent, they were asked to complete the Openness to Experience Scale and the Need for Cognitive Closure Scale. Then, the experimental group lived the "dialogue in the dark," whereas participants in the control group were recruited at the place in which this control experience was realized (in a park called Parco Sempione). Both experiences lasted around 1 h 15 min.

At the end of both experiences, all participants were asked to perform the same verbal form of the Torrance Tests "unusual uses for a cardboard box" (Torrance, 1966) immediately after the experience. After that, participants completed the Adjective Scale created *ad hoc* for validating the "dialogue in the dark" as a DE and the CES short Italian version (Ionio et al., 2018) again, and the PANAS (Terraciano et al., 2003), measuring affect.

Results

Creative Thinking

Spearman's correlations between rater 1 and rater 2' fluidity, flexibility, originality, elaboration scores, were computed to check for raters' level of agreement. Since their agreement was high, we proceeded by aggregating the scores of Rater 1 and Rater 2 for each of the creative thinking dimensions (i.e., fluidity, flexibility, originality and elaboration) (see **Table 1**). A Mann–Whitney test was used comparing each group ("dialogue in the dark" vs. control) regarding fluidity, flexibility, originality, and elaboration dimensions. Results showed a significant effect of the group on the scores of all the dimensions. Comparing experimental and group's means, we found out that the experimental group performed significantly worse than the control group in all the four dimensions: fluidity, flexibility, originality, and elaboration (see **Table 2**).

Diversifying Nature of "Dialogue in the Dark" Versus Control Condition

Scores at the *ad hoc* Adjective Scale showed that the experimental group evaluated the "dialogue in the dark" experience as significantly more unusual, unexpected, involving, and intense than did the control group (**Table 3**).

Personal Impact of "Dialogue in the Dark" Versus Control Condition

Personal impact of "dialogue in the dark" versus control condition resulted as significantly higher at the level of single items of CES but not for the global score (see **Table 4**).

Affective Profile of "Dialogue in the Dark" and Control Condition

The experimental group experienced significantly more intensive PA than the control group, whereas there were no differences regarding global NA (see **Table 5**).

Potentially Intervenient Factors

We conducted an ANCOVA to control for the potential influence of "openness to experience" and "need for structure" on DE–creativity link. Few significantly results were found.

A one-way ANCOVA was conducted to determine statistically significant differences between the experimental group and the control one on the CES items and CES global score, after controlling for the dispositional variables of Openness to Experience and Need for Cognitive Structure. Results showed that – after controlling the Openness to Experience Scale's global score – there was a significant effect of groups on the following items of the CES: *part of identity* [$F(1) = 10.3$, $p = 0.002$; $\eta_p^2 = 0.079$]; *comprehension* [$F(1) = 7.28$, $p = 0.008$; $\eta_p^2 = 0.057$]; *central in life* [$F(1) = 9.27$, $p = 0.003$; $\eta_p^2 = 0.072$]; *life change* [$F(1) = 24.39$, $p < 0.000$; $\eta_p^2 = 0.169$]; and *turning point* [$F(1) = 10.01$, $p = 0.002$; $\eta_p^2 = 0.077$]. With the covariate, all the experimental group's means increased, whereas the control group's ones decreased. Moreover, results showed a significant effect of groups on the item *life change*, after controlling both the *Need for Order* factor of the Need for Cognitive Closure Scale [$F(1) = 22.62$, $p < 0.001$; $\eta_p^2 = 0.159$] and the *Intolerance for Ambiguity* factor [$F(1) = 24.61$, $p < 0.001$; $\eta_p^2 = 0.170$]. After the *Mental Closure* factor of the Need for Cognitive Closure Scale was controlled for, results showed a significant effect of groups on these CES items: *Part of Identity* [$F(1) = 9.13$, $p = 0.003$; $\eta_p^2 = 0.071$]; *Comprehension* [$F(1) = 5.76$, $p = 0.018$; $\eta_p^2 = 0.046$]; *Central in life* [$F(1) = 7.95$, $p = 0.006$; $\eta_p^2 = 0.062$]; *Life change* [$F(1) = 22.32$, $p < 0.001$; $\eta_p^2 = 0.157$]; and *Turning point* [$F(1) = 8.14$, $p = 0.005$; $\eta_p^2 = 0.064$].

DISCUSSION

We assessed the effect of an ecological DE consisting in the format of the "dialogue in the dark" hosted by the Institute of Blinds in Milan on participants' creative thinking dimensions of fluency, flexibility, elaboration, and originality. Drawing from existing theoretical and empirical evidence (e.g., Huang and Galinsky, 2011; Gocłowska et al., 2014, 2017, 2018), we tested the diversifying potential of this experience, and we identified the absence of light as a core violation. With this regard, a DE should be enough "stressing" to activate people's resource while not exploiting them by turning into a threat instead of a challenge (Gocłowska et al., 2018). Indeed, "dialogue in the dark" resulted as a highly unusual and unexpected experience as well as highly personally impacting after 2 weeks, as measured by CES and its single components.

We reported a detailed description of the impact of "dialogue in the dark" on creative thinking, personal relevance, and affect in the following. We presented a final discussion linking all these aspects in the final part.

When people undergoing "dialogue in the dark" experience were compared with a group of individuals performing an equivalent experience but in the presence of light, regarding their creative thinking abilities, the control group outperformed those people undergoing "dialogue in the dark." Despite that

TABLE 1 | Spearman's correlations between rater 1 and rater 2 scores.

Rater 2	Rater 1			
Creativity dimensions	**Fluidity**	**Flexibility**	**Originality**	**Elaboration**
Fluidity	**0.886****	0.847**	0.822**	0.183**
Flexibility	0.845**	**0.870****	0.760**	0.172**
Originality	0.850**	0.800**	**0.828****	0.077**
Elaboration	0.185**	0.158**	0.171**	**0.591****

** = p < 0.05; ** = p < 0.001. In bold are all correlation coefficients on the same dimension of creative thinking.*

raters' agreement was high and we controlled for potentially intervenient factors as openness to experience trait and need for closure, this difference in creativity in favor of the control group (vs. "dialogue in the dark") still remained. A higher personal disposition to openness to experience increased the cognitive impact of the DE, in terms of experience's comprehension, centrality in one's life, feature as changing event, and turning point. On the other hand, a greater personal need for structure reduced the cognitive impact of the experience on both the experimental and control groups. Although this last result was in line with that of existing literature (e.g., Gocłowska et al., 2014, 2017, 2018), the detrimental effect of "dialogue in the dark" on creative thinking compared with that of the control group was not.

Conversely, the personal impact of "dialogue in the dark" group was significantly higher than that of the control group. The experimental group assessed the "dialogue in the dark" experience as significantly more engaging, unusual, unexpected, and extraordinary than the assessment given to the control experience by the control group. At the same time, the control group evaluated the experience in the park as significantly more ordinary. Participants in the experimental group performed poorly than did those in the control group. This result strengthened the diversifying nature of the selected "dialogue

TABLE 2 | Mann–Whitney test with group as independent variable; and fluidity, originality, and elaboration as dependent variables.

Creativity dimension	Experimental		Control		Mann–Whitney	
	Mean	**Mdn**	**Mean**	**Mdn**	**Sign.**	***U***
Flexibility	8.29	8	10.22	10	**0.006**	2,795.5
Fluidity	12.29	10.5	18.45	16.5	**<0.001**	3,088.5
Originality	10.96	10	16.07	14.75	**0.001**	2,956
Elaboration	1.81	1	3.77	2.5	**0.001**	2,886

In bold are all significant values.

TABLE 3 | Mann–Whitney test and group statistics with group as independent variable and Adjective Scale items as dependent variables.

Adjectives	Experimental		Control		Mann–Whitney	
	Mean	**Mdn**	**Mean**	**Mdn**	**Sign.**	***U***
Unusual	4.42	5	3.98	4	0.009	1,409
Unexpected	3.94	4	3.42	4	0.012	1,411.5
Involving	4.84	5	4.32	4	0.000	1,156
Ordinary	1.31	1	1.88	2	< 0.001	2,530
Intense	4.67	5	3.73	4	< 0.001	754.5

Maximum score was 5.

TABLE 4 | Mann–Whitney test and group statistics with group as independent variable and Centrality of Event Scale's items as dependent variables.

Personal impact	Experimental		Control		Mann–Whitney	
	Mean	**Mdn**	**Mean**	**Mdn**	**Sign.**	***U***
Part of identity	4.38	4.5	3.56	3	**0.002**	1,280.5
Comprehension	4.56	4	3.93	4	**0.037**	1,483.5
Central in life	3.77	4	2.98	3	**0.003**	1,318.5
Marking event	4.56	5	4.14	4	**0.109**	1,577
Life change	4.56	5	3.22	3	**<0.001**	1,027.5
Effects on future	4.28	4	3.92	4	**0.322**	1,695
Turning point	3.61	4	2.76	3	**0.005**	1,339
Global score of CES	26.1	29.0	24.1	23.0	0.066	1,783

In bold are all significant values. Maximum score was 7. (i) "I feel that this event has become part of my identity" (label: "Part of identity"); (ii) "This event has become a reference point for the way I understand myself and the world" (label "Comprehension"); (iii) "I feel that this event has become a central part of my life story" (label: "Central in life"); (iv) "This event has colored the way I think and feel about other experiences" (label: "Other experiences"); (v) "This event permanently changed my life" (label: "Life change"); (vi) "I often think about the effects this event will have on my future" (label: "Effect on Future"); and (vii) "This event was a turning point in my life" (label: "Turning point").

TABLE 5 | Mann–Whitney test and group statistics with group as independent variable and PANAS items as dependent variables.

Items	Experimental		Control		Mann–Whitney	
	Mean	**Mdn**	**Mean**	**Mdn**	**Sign.**	***U***
Attentive	4.29	4	3.88	4	0.006	1,380.5
Enthusiastic	4.29	4	3.76	4	0.001	1,258.5
Concentrate	4.08	4	3.45	3.5	<0.001	1,118
Nervous	1.52	1	1.90	2	0.015	2,253
Jittery	1.56	1	1.82	2	0.047	2,212.5
Excited	3.19	3	2.78	3	0.046	1,485.5
Irritable	1.54	1	1.75	1.5	0.041	2,173
Positive Affect	37.92	38	35.52	36	0.020	1,356

Maximum score was 5. Only significant results were reported. PANAS, Positive and Negative Affect Schedule.

in the dark" group versus control group (Ritter et al., 2012; Ritter et al., 2014; Gocłowska et al., 2018). Moreover, despite that "dialogue in the dark" group and control group did not significantly differ regarding the global score of CES, the personally impacting nature of "dialogue in the dark" emerged at four main levels. "Dialogue in the dark" resulted as significantly more impacting at the level of identity, because participants felt that this experience had become a part of their personal identity more than did the control group. In addition, the experimental group felt that this experience changed their way of comprehending the world and others more than did the control group. Finally, the centrality of this experience resulted at the level of importance attributed to "dialogue in the dark" and the fact that it was perceived as a turning point more than did the control group.

At the level of affect, the "dialogue in the dark" experience group generated significantly more intense positive emotions than the control experience, thus supporting another asset of DEs, which is the positive perception associated with them, instead of that of threat (Gocłowska et al., 2018). No differences on NA and specific adjectives were found. This reassured regarding the affective similarity between the two experiences. "Dialogue in the dark" and control group experience differed only regarding PA, which was the main aim of an effective DE conductive of creativity. Participants of the experimental group self-reported higher levels of attention, enthusiasm, and concentration. Conversely, the control group felt more excited, nervous, irritable, and jittery.

To synthetize, results showed that despite that "dialogue in the dark" featured all the main assets of a creativity-conductive DE (i.e., unusualness, personal impact, positive perception instead of the negative one, and challenging nature), it did not enhance creativity assessed immediately after its occurrence.

It may be that "dialogue in the dark" was so intense that it induced a high cognitive and perceptual load, which, in turn, impacted their mental flexibility and creativity on the short term. Indeed, as Eimer (2004) claimed, for sighted people, vision dominates spatial perception, and the localization of events in external space involves a visually defined spatial reference frame (Eimer, 2004). Therefore, sighted people are impaired in the presence of conflicting external spatial information, and this may be linked to Dickerson and Kemeny's (2004) framework: the response of an individual to a stressful condition depends on both the number of socio-evaluative threats and the number of uncontrollable elements present in the surrounding environment (Byron et al., 2010). Concerning the uncontrollability aspect, the dialogue in the dark experience deprived participants of their sight and, hence, of their accustomed reference frame. Therefore, it may have generated a condition of uncontrollability that, in turn, generated high stress in participants. This would be consistent with Mendes et al. (2007) findings, according to which individuals' interaction with the unexpected (in their experiment: people who violated traditional stereotypes) leads to answers that are formulated through two evaluation components, identified by expectancy violation theory: (i) uncertainty and (ii) required effort (Bartholow et al., 2001). Therefore, it may be that the lack of familiarity and the uncontrollability of the event could have increased the uncertainty and required a high cognitive effort to make sense of the unexpected and unusual information (Bartholow et al., 2001). This would be consistent also with Bartholow et al. (2001), who asked participants to interact with partners who violated their expectations. These individuals were also more prone to employ greater cognitive and attention resources during these interactions. Also, Byron et al. (2010) claimed that too low or too high activation "can [. . .] cause cognitive interference, which can hinder performance on cognitively demanding tasks" (Byron et al., 2010, p. 202).

These results may suggest two main aspects:

(i) The intense short-term impact of DE on people's mental schema, thus hinting at a long-term benefit – in terms of creativity – associated with this kind of experiences. People would need more time to "elaborate" the experience and embody it into current mental schema or just to accommodate existing schema to expand the possibility to connect even far ideas.
(i) A highly intense experience could negatively impact on people's mental flexibility by overloading their cognitive resources to make sense of the violation itself.

CONCLUSION

This is the first study proposing and succeeding in demonstrating the feasibility to investigate even complex DEs in a controlled way, thus outlining their creative and emotional profile. This study explored the effect of an ecological but controlled DE on people's creative thinking. This research advanced previous studies by introducing a variant of DE with higher ecological validity. Moreover, in this study, the focus was on the schema-violation mechanism–creativity link, and also on the whole DE–creativity link. Although preliminary, this study showed that DEs are very complex phenomena and that they cannot be studied by being limited neither to their schema-violation mechanism – even if it is considered their core – nor to the experience built within the laboratory.

Limitations and Future Directions

Preserving ecological validity and control at the same time is an enormous challenge. We maintained all the conditions as constant as possible expect for the dimension of presence versus absence of light, however, other factors could influence the final outcome. For instance, other personality measures, such as the Big Five Inventory, could act as moderators of the ecological DE–creativity link, as well as the cognitive effort perceived by participants immediately after the "dialogue in the dark" compared with the control one. In this regard, administering a cognitive task immediately after an intense and potentially stressful experience, as a DE should be, could have overloaded participants' cognitive resources instead of nurturing them. Conversely, TTCT could have resulted as boring owing to the nature of the subtest we selected (i.e., unusual uses of a box). Therefore, as a future step, cognitive effort perceived by participants should be measured after they have

completed the creativity task. In addition, a repeated assessment of participants' creativity, after 1 week and 1 month, would be useful to understand whether allowing participants to recover from the experience and starting building upon it is beneficial for capitalizing on an ecological DE. Finally, another future step would regard the instruments that could be used. Other instruments could be used to measure DE's impact, besides the CES, even though – owing to the potentially stressful nature of DEs and the exploratory aim of the study – this scale resulted as the most appropriate measure. Moreover, other instruments besides subtest 5 of the Torrance Tests could be used, maybe some measures less sensitive to the specific anticipatory task performed by participants (Glăveanu et al., 2019). Finally, although we replicated the recruitment method for both groups, our experience was not a well-established format as the "dialogue in the dark" experience; thus, this could be a potential limitation, despite that all groups were matched regarding all target variables.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethical Committee of the Università Cattolica del Sacro Cuore. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

AG, AC, and SC contributed to the conception and design of the study. SC collected the data in Study 1 and Study 2 and wrote the first draft of the manuscript. AC and SC organized the database, performed the statistical analysis, and wrote the final draft. SB and EG reviewed the final version of the manuscript. AG supervised the entire work. All authors contributed to the article and approved the submitted version.

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A Bottom-Up Validation of the IAPS, GAPED, and NAPS Affective Picture Databases: Differential Effects on Behavioral Performance

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The concept of emotion is a complex neural and psychological phenomenon, central to the organization of human social behavior. As the result of subjective experience, emotions involve bottom-up cognitive styles responsible for efficient adaptation of human behavior to the environment based on salient goals. Indeed, bottom-up cognitive processes are mandatory for clarifying emotion-cognition interactions. Accordingly, a huge number of studies and standardized affective stimuli databases have been developed (i.e., International Affective Picture System (IAPS), Geneva Affective Picture Database (GAPED), and Nencki Affective Picture System (NAPS)). However, these neither accurately reflect the complex neural system underlying emotional responses nor do they offer a comprehensive framework for researchers. The present article aims to provide an additional bottom-up validation of affective stimuli that are independent from cognitive processing and control mechanisms, related to the implicit relevance and evolutionistic significance of stimuli. A subset of 360 images from the original NAPS, GAPED, and IAPS datasets was selected in order to proportionally cover the whole dimensional affective space. Among these, using a two-step analysis strategy, we identified three clusters ("good performance", "poor performance", and "false alarm") of stimuli with similar cognitive response profiles. Results showed that the three clusters differed in terms of arousal and database membership, but not in terms of valence. The new database, with accompanying ratings and image parameters, allows researchers to select visual stimuli independent from dimensional/discrete-categories, and provides information on the implicit effects triggered by such stimuli.

Keywords: emotion, attention, International affective picture system, Geneva affective picture database, Nencki affective picture system

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INTRODUCTION

There is unanimous agreement that the complexity of human feelings and the concept of emotion are complex neural and psychological phenomena, central to the organization of human behavior. Accordingly, emotion has been widely investigated and psychologists have advanced more than a single definition aimed to highlight specific aspects. A recent review

(Izard, 2010) focusing on the commonalities among the diverse definitions, defined emotion as the result of subjective experience, variations in physiological state and behavioral outcomes, and strengthening the idea that emotion prompts an organism to act in response to and consistent with environmental demands (Inzlicht et al., 2015). This definition clearly links emotion to cognition and cognitive control (i.e., the mental processes responsible for efficient adaptation of human behavior to the environment based on salient goals), suggesting that emotion and cognition are integrated and consequently can have reciprocal selective effects (Gray, 2004). Indeed, this strong connection has become the focus of a huge number of studies evaluating the reciprocal effects on different facets of emotion and cognition including memory, attention, and executive control, across a variety of tasks and different stimuli. In addition, the emotion cognitive interaction involves both bottom-up and top-down pathways of human information processing. For example, on the one hand, orienting spatial attention relies on top-down mechanisms initiated to select information for further processing according to individual goals and the task at hand. On the other, spatial attention can also be attracted by salient and/or potentially dangerous events *via* bottom-up mechanisms in response to unexpected but important events.

As a result, careful selection of controlled emotion stimuli is crucial for inducing and/or investigating the constructs under investigation. This study aims to classify emotion stimuli according to their effects in terms of hits, false alarms, and reaction times (RTs) on attention performance. This may allow researchers to select the best exemplars and to discriminate bottom-up mechanisms and clarify emotion-cognition interactions. In particular, although emotionally charged stimuli in different modalities (e.g., auditory, lexical, and visual) have been adopted in both behavioral and neuroimaging research (Zeelenberg and Bocanegra, 2010; Brooks et al., 2012; Sylvester et al., 2016), the visual channel is probably the most common. In the visual channel, emotional stimulation has been achieved through movie presentation (Gross and Levenson, 1993), complex images, or meaningful faces (Lang et al., 1993; Codispoti et al., 2001; Stark et al., 2004) and researchers can rely upon many sets of standardized items together with measures along various axes fundamental to emotion. Among these sets, the gold-standard of emotionally charged visual complex pictures is probably the International Affective Picture System (IAPS), developed by Lang and colleagues (Center for the Study of Emotion and Attention; Lang et al., 1988, 1997, 1999, 2001). In this database, each item is accompanied by a series of norms (means and standard deviation) along three dimensions: arousal (physiological activation evoked by the image), valence (pleasantness and pleasure), and dominance (the degree to which the emotional state is under subject's control). This set has also been standardized according to the dimensional-category theory of emotion which holds that affective experiences can be characterized by the above-mentioned dimensions as well as the approach-avoidance dimension (Mauss and Robinson, 2009). More recently, the IAPS has been standardized according to a discrete-category theory of emotion that proposes at least five basic universal emotions. Indeed, discrete-category theories of emotion assume that traditional dimensions are too simple and therefore, do not accurately reflect the complex neural system underlying emotional responses (Darwin and Prodger, 1998; Mauss and Robinson, 2009).

In line with discrete-category theories of emotion, other affective static image databases with various content and validated normative ratings have been developed. To date, the most internationally recognized databases are the Geneva Affective Picture Database (GAPED; Dan-Glauser and Scherer, 2011) and the Nencki Affective Picture System (NAPS; Marchewka et al., 2014). The former includes negative pictures depicting four specific categories (i.e., spiders, snakes, and scenes that induce emotions related to human rights violations or animal mistreatment), neutral pictures that mainly represent objects, and positive pictures that mainly depict human and animal babies and natural scenery. Valence, arousal, internal (moral), and external (legal) norms have been collected for the images in this discrete-category organization. The latter, instead, provides high-quality images organized in five discrete categories (i.e., people, faces, animals, objects, and landscapes) that have been evaluated, using semantic bipolar scales, for arousal, valence, and motivational direction (i.e., approach-avoidance dimension).

However, when individuals are asked to judge stimuli from a database, they must deeply elaborate each stimulus in order to formulate an appropriate affective judgment. In this manner, they rely on top-down controlled cognitive resources that are crucial for making affective judgments. Yet, it is widely recognized that brain structures linked to the processing of affective information are often subcortical (e.g., amygdala, ventral striatum, and hypothalamus). Moreover, these structures are considered primitive and operate in a fast and automatic fashion. It follows that certain "trigger" features are relatively unfiltered and evoke responses that might be important for survival. Indeed, an individual need not be conscious of the trigger stimulus (e.g., the white of eyes in a fearful expression) that elicited activation in an affective brain region.

Extensive literature has examined the link between affective information and cognition and has shown how affective stimuli can directly modulate cognitive performance through bottom-up processes such as attention orientating, and consequently memory (Murphy and Isaacowitz, 2008; Talmi et al., 2008; Brenner et al., 2014; Padulo et al., 2020). More specifically, the boost in sensory processing for emotionally salient events (Vuilleumier, 2002, 2005), enhances attention toward them and/or alters attention toward other concomitant stimuli (Dennis and Chen, 2007; Bocanegra and Zeelenberg, 2009; Vuilleumier and Huang, 2009) and ultimately leads to more efficient encoding and consolidation in memory. In this manner, bottom-up processing of affective stimuli orients attention and subsequently engages emotional processing mechanisms that rely on more top-down cognitive processes.

Here, we aimed to provide an additional bottom-up validation of the above-mentioned picture databases that can be consulted when choosing affective stimuli for an experimental paradigm. We used existing norms to select the best exemplars from each database with the intent to cover all the emotional dimensions. To elicit implicit effects linked to the interaction

between emotion and attention orienting, we used the dot-probe task, in which attention is modulated by the presentation of two task-irrelevant cues before probe presentation. In this task, attention is automatically captured by one of the formers based on both the relative salience and the congruency between attended cue and probe locations, leading to differential behavioral responses (Bradley and Lang, 1999, 2000; Carrasco et al., 2004; Bradley, 2009). We postulated at least three main advantages of our bottom-up validation: (1) it should be independent from cognitive processing and control mechanisms necessary when formulating appropriate affective judgments, (2) it should be closely related to the implicit relevance and evolutionistic significance of stimuli, and (3) it should be independent from dimensional-category and discrete-category theoretical background, and provide information on the implicit effects triggered by such stimuli.

MATERIALS AND METHODS

Participants

Participants included 199 young adults (33 males), with a mean age of 21.28 (*SD* = 4.47; range: 19–27) years and with a mean education of 14.89 (*SD* = 1.35) years. All volunteers were recruited from the University of Chieti-Pescara and compensated with class credit. All participants were right-handed, native Italian speakers, had normal or corrected normal vision, with no reports of psychiatric or neurological disorders, use of psychiatric drugs, or any medication that could potentially interfere with their mental processing. Participants signed informed consent forms approved by the Department of Psychological Sciences, Health and Territory, University of Chieti, Italy, Review Board before taking part in the experimental session. Participants were randomly sorted into three different groups. Each group executed the same attentional task but with a different set of affective images drawn from one of three databases described above (IAPS, NAPS, and GAPED). Before beginning the experimental task, all participants underwent cognitive, mood, and personality evaluations. General cognition was assessed with the Culture Fair Intelligence Test (CFIT) Scale 3 (Cattell and Cattell, 1959). We administered the "State Trait Inventory of Cognitive and Somatic Anxiety" (STICSA) for mood (Balsamo et al., 2015; Carlucci et al., 2018) to assess cognitive and somatic anxiety symptoms and consisting of both trait and state versions; and the "Teate Depression Inventory" (TDI; Balsamo and Saggino, 2013) to detect major depressive disorder as specified by the latest edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-V). We evaluated personality traits with the short form of the "Big Five Questionnaire" (BFQ; Caprara et al., 1993) with five general domain scales (energy, agreeableness, conscientiousness, emotional stability, and openness).

All questionnaires were given *via* web (Qualtrics software; Qualtrics, Provo, UT). The cognitive, mood, personality and demographic variables are reported in **Table 1** for the three groups separately along with the statistics testing possible differences among samples.

Images Selection

We selected a total of 360 images from the IAPS and NAPS datasets (180 stimuli each; 60 negative, 60 neutral, and 60 positive) and 168 items from the GAPED (56 negative, 56 neutral, and 56 positive). Image selection was based on specific criteria taking into consideration both the dimensional (valence

TABLE 1 | Descriptive statistics of cognitive, mood, personality, and demographic variables.

	Group			ANOVA	
	IAPS (*N* = 67) mean (SD)	GAPED (*N* = 66) mean (SD)	NAPS (*N* = 66) mean (SD)	*F*	Sig.
Age	21.25 (1.90)	20.74 (1.88)	20.64 (1.63)	2.22	0.11
School	15.16 (1.24)	14.86 (1.47)	14.64 (1.31)	2.60	0.08
Culture fair	24.66 (4.21)	24.72 (4.19)	24.65 (4.11)	0.01	0.99
TDI	2.43 (0.52)	2.52 (0.46)	2.46 (0.53)	0.52	0.60
STICSA-trait	35.81 (8.13)	35.70 (7.35)	35.82 (7.03)	0.01	0.99
STICSA-state	31.45 (6.92)	32.68 (6.91)	32.45 (7.18)	0.58	0.56
BFQ-extraversion	78.18 (12.62)	75.64 (12.89)	75.42 (12.41)	0.98	0.38
BFQ-consciousness	90.84 (14.28)	91.79 (13.63)	89.79 (14.62)	0.33	0.72
BFQ-neuroticism	64.78 (16.91)	62.85 (17.49)	64.06 (16.75)	0.22	0.81
BFQ-agreeableness	85.70 (13.41)	83.52 (10.74)	83.06 (9.59)	1.03	0.36
BFQ-openness	90.96 (11.24)	86.88 (12.8)	87.82 (13.64)	1.91	0.15
			Group		
		IAPS	NAPS	GAPED	Total
Gender	F	57	55	54	166
	M	10	11	12	33
	Total	67	66	66	199

STICSA, State Trait Inventory for Cognitive and Somatic Anxiety; BFQ, Big Five Questionnaire.

and arousal) and discrete (i.e., happiness, anger, fear, etc.) ratings available for the sets intended to maximize the differences among the three affective categories (negative, neutral, and positive). Specific details for each database are as follows.

Images for the IAPS were selected on the original norms and their updates (Lang et al., 1997, 2008; Libkuman et al., 2007). Briefly, the criteria for including pictures in the current study were: (1) mean valence ratings for unpleasant stimuli <25th percentile on both datasets and >75th percentile on the "anger and fear" dimension; mean standard deviation scores for negative between 25 and 75th percentile on both norms; (2) valence ratings for the pleasant images >75th percentile on both datasets and scores on the "happiness" dimension >75th percentile; mean standard deviation scores for positive stimuli between 25 and 75th percentile on both norms; and (3) neutral stimuli within the range of mean ± 1/3 SD in both datasets. In order to keep the image number within the pre-established range, further selection was based on valence: we selected the first 60 images with lowest ratings for the unpleasant category, the first 60 pictures with the highest scores for the pleasant category and the 60 images closest to the mean for the neutral category, respectively.

In addition, to maximize differentiation between stimuli, we used an important characteristic of the GAPED dataset. This dataset adopts a topic-oriented approach, with selection of the pictures mainly driven by their affective content, yielding a range of images with high biological, evolutionary, and social relevance. In this study, we selected 168 images from the original GAPED norms (Dan-Glauser and Scherer, 2011) based on the following criteria: (1) mean valence ratings for unpleasant stimuli <25th and mean standard deviation scores between 25 and 75th percentile. This yielded a set of 74 items drawn from the human rights violation and animal mistreatment categories; (2) based upon authors' considerations (Dan-Glauser and Scherer, 2011) and on electrophysiological data showing attention-orienting responses driven by positive nurturance-relevant stimuli, we decided to select the positive pictures from the set of images representing human babies and young animals. Selection resulted in a set of 56 images. (3) Neutral stimuli within the range of mean ± 1/2 SD resulting in 63 items. In order to have consistency among the positive, negative and neutral categories in terms of set size, we limited the number of images to the minimum size obtained by our selection. Hence, 56 positive and 56 neutral pictures were randomly drawn from our selection.

Selection of the 180 images from the NAPS followed the criteria already reported for the IAPS. First, mean valence ratings under the 25th percentile and above the 75th for negative and positive items, respectively. In addition, positive and negative items were included between the 25 and 75th percentile on the distribution of valence standard deviation. Interestingly, the selection on valence ratings resulted in a pool of negative items equally distributed among fear, sadness, and disgust categories, while positive items had high score on happiness and surprise categories. Finally, neutral stimuli had mean valence scores between the mean and ±1/3 SD.

Experimental Setting

An Intel-based computer running E-Prime 2 (Psychology Software Tools, Pittsburgh, PA) controlled stimuli presentation and data acquisition. Stimuli were presented visually on a 15.2-inch computer screen. During the entire experiment, a white fixation cross (0.5° of visual angle) and two white rectangular frames (4° × 5.17° visual angle; 7 × 10 cm) appeared on a gray background. Fixation was located at the center of the screen while the two rectangular frames were presented in the left and right upper visual fields. Inner edges of the latter were 6°- horizontally and 3°-visual angles vertically apart from the fixation cross. Affective colored images and target stimuli were presented inside the white frames. Target stimuli consisted of circular Gabor patterns modulated either horizontally or vertically in black and white that had a diameter of 4° visual angle and a spatial frequency of 4 cycles per degree. Responses to targets were acquired through a computer keyboard. Participants were seated approximately 100 cm from the screen.

Experimental Task and Procedures

Each group of participants executed the same attentional task but with a different set of affective images from one of the three databases (IAPS, NAPS, and GAPED). We adopted a modified version of the dot-probe task to evaluate the orienting of attention as a function of the emotional valence. Specifically, we presented three types of image pairs: negative-neutral, positive-neutral, and negative-positive. An example of a trial is presented in **Figure 1**. Each trial started with a fixation cross and the two rectangular frames, one in the left and one in the right visual field (LVF and RVF, respectively) presented randomly between 1,200 and 1,400 ms (in 50 ms steps). Immediately after, two affective images were presented simultaneously inside the two frames for 100 ms followed by a variable interval (100, 150, 200, 250, and 300 ms).

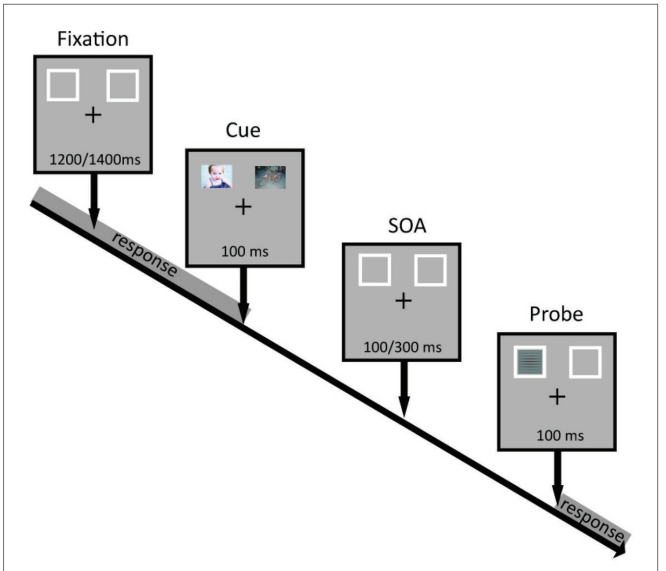

FIGURE 1 | Visualization of the experimental stimuli and procedure.

After the delay, a target stimulus appeared in either the left or right rectangular frame for 100 ms. The experimental session consisted of six blocks for a total of 720 trials. Participants were instructed to respond only to targets having either horizontal or vertical orientation (depending on the initial instructions) as quickly as possible by pressing the space bar with their right index finger. Of note, we manipulated the shape of the fixation cross so that either the horizontal or vertical branch was thicker than the other. In this manner participants were reminded of which judgment to make to avoid confusion between blocks. We asked participants to fix on the central cross throughout the whole experimental session, and to covertly pay attention to the visual stimuli presented laterally. In addition, participants were explicitly told that the images preceding the target were not informative of its location.

All participants completed a practice session consisting of a total of 20 trials to familiarize with the task. Only participants who completed at least 90% of trials correctly took part in the experimental session. We manipulated emotional attention by presenting image pairs according to three different experimental conditions: negative-neutral, positive-neutral, and negative-positive. Each block consisted of 40 image pairs per condition (20 in the RVF and 20 in the LVF). Half of the targets appeared in the RVF. For these 10 items, five corresponded to the judgment to make (for example vertical; valid) while the other five did not correspond to the judgment for that block (for example horizontal; invalid). The other half of the targets appeared in the LVF. For these 10 items, five again corresponded to the judgment to make (for example vertical; valid) while the other five did not correspond to the judgment for that block (for example horizontal; invalid). Each stimulus appeared four times within the entire task.

For each image pair we collected RTs, Hits (the correct detection of a target), and False Alarms (yes-response to non-targets). These were computed by averaging the indices among subjects within each group (IAPS, GAPED, and NAPS), and separately for image pair (i.e., neutral-negative, neutral-positive, and negative-positive) and target type (valid and invalid). Given the aim of the study (characterization of a subset of images based on their capability to capture attention resources), we focused only on valid trials.

Analysis

Data analysis was carried out in two steps. First, we explored possible differences between images from the three databases to identify potential confounding variables that might have biased performance on the attention task. Specifically, we portrayed the distribution of the items in the affective space and tested variation in item valence and arousal scores as a function of database (IAPS, GAPED, and NAPS). Moreover, we evaluated how item luminance influenced task performance and verified whether images selected from the three datasets were associated with specific performance patterns on the attentional task. Second, we classified selected items based on the ability to modulate automatic attention in line with the hypothesis that similar patterns of performance maybe associated with groups of items that share some commonalities. To this end, attention indices associated with each item were entered in multivariate classification methods to obtained groups of stimuli able to elicit comparable cognitive patterns.

RESULTS

Items Description

Figure 2 reports a scatterplot of the affective space for the selected items as a function of the original dataset. Valence and arousal scores were first standardized on their original norms. In line with previous studies (Lang et al., 2001; Libkuman et al., 2007), we observed a C shape distribution of the data. However, we obtained a more defined pooling of the items as a result of the selection procedure (maximizing the differences between items valence). At a first glance, items distribution in the affective space seems analogous among the three datasets. This was confirmed statistically by entering valence and arousal z scores into a 3 × 3 General Linear Model with Dataset (IAPS, GAPED, and NAPS) and item affective categories (neutral, negative, and positive) as factors. As expected, we found a significant effect of item affective category on valence ($F_{(2,520)}$ = 6643.965; p < 0.001; η_p^2 = 0.963) and arousal ($F_{(2,520)}$ = 673.820; p < 0.001; η_p^2 = 0.723). Most importantly, we did not find any reliable difference between datasets (valence, $F_{(2,520)}$ = 0.011; p = 0.989; η_p^2 = 0.0; arousal, $F_{(2,520)}$ = 0.001; p = 0.999 η_p^2 = 0.0).

In line with our aim to differentiate stimuli for bottom-up characteristics that can influence affective information processing, we investigated item luminance, a characteristic known to influence task performance. Indeed, visual attention is biased by visual luminance (Maunsell and McAdams, 2000;

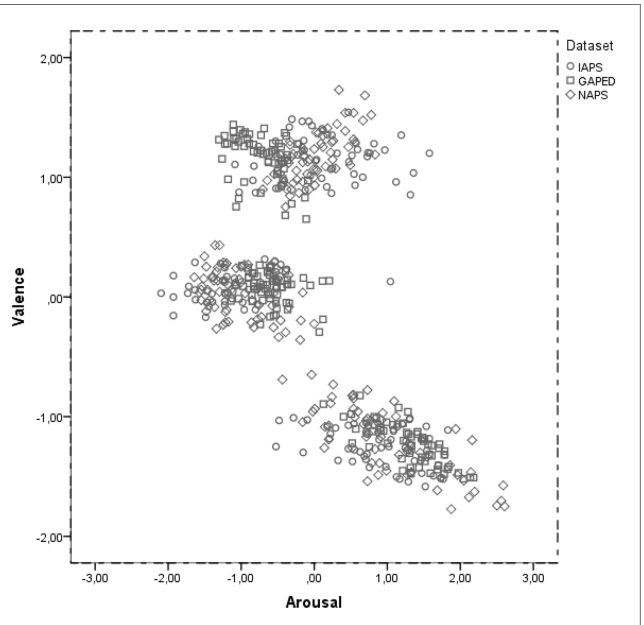

FIGURE 2 | Scatterplot of the affective space for the selected items.

Reynolds and Desimone, 2003), and the three datasets differed along this dimension. We first computed luminance for each image by using an *ad hoc* MATLAB function (Math-Works; MA, United States), and then entered the values in a between-group ANOVA. We found that IAPS images had significant lower luminance values compared to both GAPED and NAPS (main factor effect - $F_{(2,520)} = 55.893$; $p < 0.001$; $\eta_p^2 = 0.178$; *Post hoc* $p < 0.001$, Bonferroni corrected). However, when we evaluated the relation between luminance and the other variables of interest (item arousal and valence as well as the performance indices at the attention task), we observed small r correlations (Pearson's) ranging from −0.114 to 0.123.

After, we proceeded by verifying whether IAPS, GAPED, and NAPS images had some intrinsic characteristics that might capture attention resources differently. To partialize out the contribution of item luminance on performance, we first ran a series of regression procedures between luminance and the behavioral task outcomes (RTs, False Alarms, and Hits) to obtain residual scores that were further entered in a 3 × 3 General Linear Model with Dataset (IAPS, GAPED, and NAPS) and Item Affective Categories as factors (neutral, negative, and positive). The only significant finding was a differences across datasets for all the three tested variables (Hits: $F_{(2,945)} = 16.814$; $p < 0.001$; $\eta_p^2 = 0.035$; False Alarm: $F_{(2,945)} = 65.848$; $p < 0.001$; $\eta_p^2 = 0.123$; RTs: $F_{(2,945)} = 34.463$; $p < 0.001$; $\eta_p^2 = 0.069$). **Figure 3** reports findings. NAPS items were associated with less accuracy in target detection as well as faster responses compared to GAPED and IAPS. The three datasets all differed in eliciting false alarms since NAPS produced more false alarms than GAPED and IAPS, and GAPED more than IAPS.

Cluster Analysis

We also carried out a further analysis on mean Hits, False Alarms, and RTs cognitive dimensions, a dual process clustering procedure (using hierarchical and non-hierarchical methods; see Hair et al., 1995; Bigné and Andreu, 2004), in order to identify subgroups of stimuli with similar cognitive responses profile. Thus, no a-priori number of clusters was specified. Of note, as for the previous analysis, we used z-scores ($M = 0$ and $SD = 1$) to yield equal metrics and equal weighting.

We performed the hierarchical clustering analysis in exploratory way, using the squared Euclidean distance matrix with Ward's linkage method (Everitt et al., 1993) for forming clusters. Since there is no formal stopping rule for hierarchical cluster analysis, a cut-off point was determined according to the dendrogram to signify when the clustering process should be stopped (Bratchell, 1989). Next, in order to determine the number of clusters, information from both the agglomeration table and the dendrogram were incorporated. Results suggested a four-cluster and a three-cluster solutions, respectively. Next, the K-means cluster algorithm was applied to improve results from the hierarchical procedures and to provide more accurate cluster membership.

Using the initial seed points from the results in the hierarchical cluster, the K-means cluster defined three groups. **Table 2** shows the final cluster centers. For each cluster, the mean value (centroid) is provided. In absolute terms, clusters were dissimilar, ranging from 2.44 (cluster 1 vs. 2) to 1.83 (cluster 2 vs. 3). The greater the distance between two clusters, the greater the differences in these clusters. The first cluster contained $N = 197$ images, the second $N = 296$, whereas the third $N = 452$.

In detail, the first cluster contained images with negative values of accuracy, positive values of response time as well as false alarms close to the mean. This cluster was characterized by stimuli associated with "poor performance" (i.e., low rates of accuracy and longer time to target detections). The second cluster contained images with high rate of "false alarms" and fast reaction time. Finally, the third cluster contained images that prompt "good performance," fair accuracy, few false alarms and average response times. Results suggest that it is feasible to group affective stimuli based on patterns of cognitive performance. **Figure 4** shows the distance of the items from the center of the cluster for Hits, FAs, and RTs.

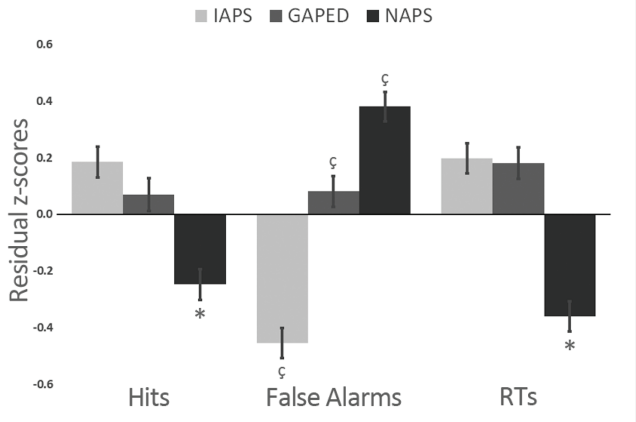

FIGURE 3 | Differences between Nencki affective picture system (NAPS), Geneva affective picture database (GAPED), and International affective picture system (IAPS) dataset on Hits, False Alarms, and reaction times (RTs).

Clusters Description

After pooling items for cluster membership, we ran a set of analyses aiming at exploring the new classification. First, we investigated the affective nature of the three clusters by entering item valence and arousal scores in a Multivariate ANOVA (MANOVA) with cluster membership as factor. We found a slight effect of valence ($F_{(2,945)} = 3.021$; $p = 0.049$; $\eta_p^2 = 0.006$) that did not survive to *post hoc* procedures (all

TABLE 2 | Composition of the final cluster centers solution.

	Cluster		
	1	2	3
Hits	−1.237	0.187	0.444
False alarm	−0.005	1.072	−0.672
RTs	1.065	−0.595	−0.093
N images	197	296	452

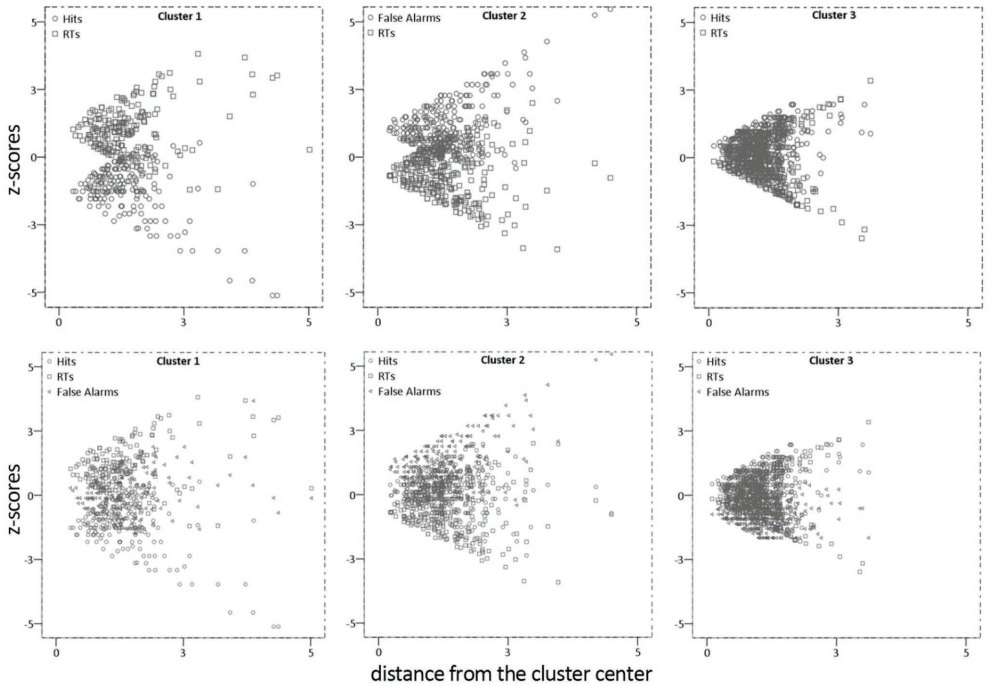

FIGURE 4 | Scatterplot of distance from the center of the clusters.

$p > 0.05$, Bonferroni corrected). The non-parametric procedure testing differences in the distribution of neutral, negative, and positive items among the three clusters found revealed no significant effect (Pearson $\chi^2 = 6.081$, $p = 0.193$). On the contrary, the three clusters differed in terms of arousal ($F_{(2,945)} = 3.634$; $p = 0.027$; $\eta_p^2 = 0.008$). Images belonging to the "poor performance" cluster were more arousing than the images in the "false alarm" cluster ($p = 0.023$, Bonferroni corrected). No statistical differences were found between images belonging to the "good performance" cluster compared to the remaining clusters ("poor performance," $p = 0.433$; "false alarm", $p = 0.318$). The average value close to zero displayed by the "good performance" cluster images (mean = 0.009) suggested the non-arousing effect of these images.

Second, we verified a possible association among clusters and databases. We found an unequal item distribution (Pearson $\chi^2 = 6118.48$, $p < 0.001$). Specifically, the first cluster contained images drawn equally from the IAPS, GAPED, and NAPS databases. The second cluster consisted mainly of NAPS images (54.4%): The third cluster pooled a great number of IAPS images (67.1%).

Third, we verified whether clusters could be explained by the experimental condition in which the image was presented (neutral-negative, neutral-positive, and negative-positive). As expected, we did not find any significant result (Pearson $\chi^2 = 3.637$, $p = 0.457$).

Finally, for each cluster we identified the best images based on the distance from the centroids. Quartiles were identified for the three clusters and items labeled accordingly.

Appendix 1 provides cluster membership along with its corresponding quartile, all the indices extrapolated from the attention task, the standardized valence and arousal ratings (mean and SD) obtained from the original norms, and the task condition in which it was presented for each image.

Of note, we ran the very similar cluster analysis on the same behavioral variables after removing the contribution of item luminance. The results were comparable with those reported above as for cluster membership and composition. However, we found that the small differences reported in arousal and valence across clusters disappeared, suggesting that luminance might have contributed to the findings.

DISCUSSION

Emotion cognition interactions are crucial for the organization of human behavior and have reciprocal effects on memory, attention, and executive control. Moreover, these interactions vary across a variety of tasks and stimuli and can be linked to both bottom-up and top-down pathways of information processing. In addition, these strategies could be biased by the individual's affective state. For example, depressed subjects exhibited a bottom-up impairment in emotional processing (Fales et al., 2008).

Accordingly, careful stimuli selection is crucial when selecting stimuli to be used in an experimental situation or training sessions of cognitive rehabilitation with special populations. The principal aim of our study was to provide new image indexes that rely upon emotional relevance and saliency.

As postulated, our analyses demonstrated that IAPS, GAPED, and NAPS images can be categorized and selected based on three main categories: (1) a cluster of "poor performance," constituted by pictures associated mainly with low rates of accuracy and longer time to target detections, (2) a cluster of "false alarm," composed of pictures associated mainly with high rate of false alarms and fast RTs, and (3) a cluster of "good performance" constituted by pictures associated mainly with fair accuracy rates, low false alarms and an average response time. In this way, we produced an empirical bottom-up validation of the three picture databases, already validated for valence and arousal that can be consulted along with valence and arousal ratings when choosing affective stimuli for an experimental paradigm.

Although our image section considered both dimensional (valence and arousal) and discrete (i.e., happiness, anger, fear, etc.) ratings available for the sets, so as to maximize the differences among the three affective categories (negative, neutral, and positive), we found that cluster nature is independent from valence and experimental conditions. Moreover, we found no differences in the distribution of neutral, negative, and positive items among the three clusters, so that the three picture types are well distributed among all clusters. Thus, we could argue that this new validation approach is effective in adding new and useful information for the selection of the best exemplars, considering their capability to capture and direct attention.

Regarding arousal, we found arousal was higher in the "poor performance" cluster. According to the arousal-biased competition (ABC) model (Mather and Sutherland, 2011), emotional arousal of both positive and negative stimuli amplifies the effects of bottom-up salience during visual encoding, increasing selective attention to salient stimuli. This interaction of arousal and salience may underlie the poorer performance of our sample in the dot-probe task. This may seem to be in contradiction to the ABC model, but relation between arousal and saliency and their effects on cognitive tasks are more complex. In fact, Lee et al. (2015) indicated that the arousal enhancement of cognitive functions, such as memory for previously encoded items, depends on the goal relevance initially assigned to those items. In our study, the emotional pictures were task-irrelevant cues (i.e., they were not predictors of target positions); indeed, as the level of arousal increased, and consequently salience, attention was automatically captured by pictures, leading to poorer performance in the dot-probe task. This outcome suggests that the effects that these emotional pictures can exert could be related to their implicit relevance and significance in influencing allocation of attention (Gable and Harmon-Jones, 2008, 2010; Becker, 2009; Padulo et al., 2020). Such findings corroborated the usefulness of our pictures categorization as an additional guide allows researchers to select affective images not only on affective dimensions, but also considering the effects arising from their bottom-up implicit features.

Surprisingly, although we did not find differences in the distribution of neutral, negative, and positive items among the three clusters, we found disparities in the distribution of pictures of each database among clusters. In fact, results evidenced that the "good performance" cluster consisted mainly of IAPS images whereas the "false alarm" cluster is composed mainly of NAPS images.

Despite the drawbacks, evidence in the neuroscience literature supported the high impact of IAPS images into manipulated emotional states (Liberzon et al., 2003; Hajcak et al., 2010; Beatty et al., 2014), as well as an high rate of accuracy (Britton et al., 2006). In addition, the IAPS database included a wide range of scene categories (landscapes, sexual interactions, peoples, etc.) that statistically increase the chance of detecting stimuli with good performance characteristics.

Next, a high number of the negative NAPS (N = 51) images were located in the "false alarm" cluster, compared to GAPED (N = 28), and IAPS database (N = 10). This datum also replicated the findings according to which negative stimuli results more frequently induced false memories than neutral and positive stimuli (Brainerd et al., 2008; Norris et al., 2019), and consequently resulted in higher rates of false alarms (Bisby and Burgess, 2014). Hypothetically, negative stimuli were encoded with gist compared to verbatim representations. This could increase the false alarm rates (Matsumoto and Kawaguchi, 2020).

It is widely known how visual attention can also be biased by visual luminance, as well as luminosity may influence image processing and subsequent memory performance (Einhäuser and König, 2003; Proulx and Egeth, 2008; Keil et al., 2013). The presence of a luminance effect on IAPS images (low luminance values) is in line with the current literature (Meiselman, 2016). IAPS images has been labeled as outdated compared the modern standards of pictures quality (i.e., brightness, contrast, and color composition; Lakens et al., 2013; Meiselman, 2016).

Unexpectedly, the luminance effect was found not to directly affect performance indices as rated by subjects in the present attention task. To date, based on the previous similar studies (Sterzer et al., 2005; Attar et al., 2010), and in order to provide a reliable and valid database norm, the contribution of item luminance on performance has been partialized out through a series of regression procedures between luminance and the behavioral task outcomes.

Limitations of this study concern statistical approach applied to select affective stimuli, sample characteristics, and stimuli characteristics considered. Despite clusters models approach represent a consolidated approach to detect similarity and dissimilarity among latent constructs in psychological literature, this does not always seem to be the case in the applied psychology and with other databases (Constantinescu et al., 2017). Due to the large variety of algorithms available that can lead to substantial variations in clustering solutions, we applied a double clustering strategy (explorative and confirmatory) to detect which solution was more appropriate for our data. Furthermore, participants in the present study were young students, mainly females, and highly educated. These sample characteristics potentially threat the generalizability of our findings. Further studies need to explore the presence of age and sex-related effects, (as well as cognitive styles; Carlucci et al., 2015, 2020) in ratings affective images as clustered in the present database (Fairfield et al., 2017).

In addition, the overall selection of our clusters was constrained by the valence of images selected (negative, positive, and neutral). Undoubtedly, future studies need to take into consideration arousal as well. Here, we considered arousal in our analyses but did not use it as a criterion for image selection. However, z-scores for image arousal and valence by cluster are available for use by researchers when choosing affective stimuli. These concerns could be addressed by new pictures to be included in future studies.

CONCLUSION

To date, the present study represents a first attempt to provide a common stimuli metrics to which researchers could gain comparable results, since a unique and standardized database of affective stimuli based on a series of objective criteria and rigorous data analysis process were proposed. The present database, with accompanying ratings and image parameters, allows researchers to select visual stimulus materials that are independent from dimensional/discrete-category theoretical background, and to provide information on the implicit effects triggered by such stimuli.

Further studies will need to confirm the influence of cluster membership on performance and extend results to other material and cognitive tasks aimed to facilitate the sharing of a common methodology and study comparisons in aging and emotion literature. For instance, future cross-cultural studies could address the presence of common cognitive patterns or cultural differences to assess bottom-up cognitive functions.

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 Department of Psychological Sciences, Health and Territory, University of Chieti, Italy, Review Board. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

BF, BP, CP, and MB conceived and designed the experiments. BP and CP performed the experiments. BP and LC analyzed data. BF, BP, and LC wrote the article. All authors discussed the results and provided comments. All authors contributed to the article and approved the submitted version.

SUPPLEMENTARY MATERIAL

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Complexity Thinking as a Tool to Understand the Didactics of Psychology

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The need to establish a research field within psychology didactics at secondary level has recently been voiced by several researchers internationally. An analysis of a Swedish case coming out of secondary level education in psychology presented here provides an illustration that complexity thinking—derived from complexity theory—is uniquely placed to consider and indicate possible solutions to challenges, described by researchers as central to the foundation of a new field. Subject matter didactics is defined for the purpose of this paper as a combination of general didactics and subject matter content, and considering the international nature of research traditions coming out of psychology, the implications of the results presented here cannot be regarded as limited solely to national concerns. An online survey was sent to secondary schools in Sweden. Discussions and lectures along with teaching to the book—alternatively used as inspiration—emerged as central from the thematic analysis of the results, providing the first mapping of teaching practices secondary level psychology in Sweden. An analysis, founded on complexity thinking—combined with a model enabling a delimitation of the scope of study—focused on time use and the importance placed on self-knowledge, along with the transformation of theory into practice. The former pointed to a teacher-centered nested subsystem (e.g., asymmetric relations between teachers and students), whereas the latter pointed to student-centered nested subsystems coming out of embodied knowledge (e.g., students as node) where psychological perspectives are learnt through self-reflection, case studies, and everyday life experiences (turning theory to practice), implying a holistic approach. The analysis applied to the Swedish case provides an illustration of how complexity theory has the potential to address challenges at the micro and the macro levels to the establishment of a new research field in psychology didactics and to indicate possible solutions (drawing among other things upon teaching experiences coming out of the Swedish case study). Psychology's high relevance to everyday life, multi-causality, perspective pluralism, dynamic systems character, and scientific character make complexity thinking a relevant approach in the consideration of challenges to the establishment of a research field in didactics of psychology.

Keywords: complexity theory, complexity thinking, education, didactics of psychology, learning, psychology teaching

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INTRODUCTION

Subject matter didactics has developed out of general didactics and covers a variety of traditions, some aiming at methodology and teacher practices and others coming out of empirical investigations of student learning. Subject matter didactics developed historically as both teaching practice and normative theory (Sandfuchs, 1990; Tenorth, 2006), optimizing discipline-related learning processes, remain as pivotal features to this day (Cramer and Schreiber, 2018). However, the term is seldom used within Anglo Saxon traditions of research (Hudson, 2007; Kansanen, 2009) as is the case with general didactics (Kansanen, 1995, 1999, 2002; Hopmann and Riquarts, 2000; Westbury, 2000; Hudson, 2007). The term didactics is often considered to have negative connotations in the Anglo Saxon world (Kansanen, 2009) and, in an attempt to avoid this, a new way of spelling didactics has been introduced, *didaktik* (Hudson, 2007; Kansanen, 2009), along with subject matter *didaktik* (Kansanen, 2009). Didactics will, however, be used for the purpose of this paper; furthermore, subject matter didactics and subject didactics will be taken to have the same meaning (and psychology didactics will be used alternatively with didactics of psychology). The core of subject matter didactics has been described as "how to combine subject matter or content with general didactics and arriving at an optimal way to teach and study" (Kansanen, 2009, p. 32), an approach which will be adopted for the purpose of this paper. General didactics then is an important part of subject matter didactics.

Uljens (1997, p. 49) suggested that "the aim of didactics is to understand and structure the overall educational situation with intentionality as one of the fundamental notions in contrast to methodik—the object of instructional method"—which Uljens goes on to describe as concerned with "activities . . . required in order to support an individual's learning" (Uljens, 1997, p. 49). In research, general didactics is often referred to as the science of teaching and learning, the science or theory of teaching, the theory of the contents of formation, the theory of the steering and learning process, and finally the application of psychological teaching and learning theories (Gundem, 2000, 2011). General didactics then covers a great variety of different fields; the same is true of subject matter didactics. A plethora of different research traditions and approaches have emerged, varying both between countries, within countries, across subjects, and within subjects (Englund, 2007; Buchardt and Osbeck, 2017).

The need to establish a new field of research—didactics of psychology—has been voiced recently by several researchers internationally, along with a description of the challenges to the project (Spinath et al., 2018; Tulis, 2018). Tulis' proposal will be presented at the outset of this article. The challenges described are related both to general didactics and to the generic aspects of the subject, pointing to the possibility of establishing a meta-level of psychology didactics (e.g., not only applicable to German secondary education). The international nature of research traditions coming out of various perspectives within psychology (taught at school) makes the combination of general didactics and subject content well placed to provide an approach not solely limited to national concerns, e.g., a meta-level of subject didactics. These challenges proposed will therefore be considered pertinent to the establishment of secondary level psychology didactics in Sweden. A mapping of Swedish secondary level psychology education will be carried out for the purpose of this article and is the first of its kind. There has, however, been a discussion in Scandinavia regarding the possibility of presenting different meta-levels of subject didactics, what these might be, and how they differ to general didactics.

Coming out of Sweden, for instance, Brante (2016) argues that Klafki's model of general didactics presents a framework for delimiting levels—including any problems or perspectives of interest to subject matter didactics—rendering subject matter didactics superfluous. Brante (2016) presents a review of a whole range of papers in different subject matter didactics to support this claim. Kansanen (2009) suggests that there may be a high level of similarity between school subjects in regards to didactics, and it may therefore be more propitious in certain instances to group didactics coming out of these subjects into fields such as subject didactics of arts, subject didactics of natural science, and subject didactics of practical subjects, providing a meta-level of didactics common to each group. Kansanen (2009), however, also argues that the best means of defining subject matter didactics is through a combination of didactics and subject matter and in so doing claims that there is always a field of general didactics within each subject matter didactic. Sjöström (2018) criticizes Brante's position and presents a model for a meta-perspective within subject didactics partially inspired by Klafki's theory of general didactics.

A search of scholarly articles shows no published research papers on subject didactics of psychology other than through references to educational psychology in Scandinavia and in Sweden. One chapter describing changes to the national curriculum in Sweden has been presented by Blåvarg (2018). Both Gundem and Hopmann (2002) and Hudson (2007) argue that there are significant differences between didactics and curriculum studies; the same approach will be adopted here (e.g., these cannot be considered interchangeable). However, subject matter didactics can include curriculum analysis as important to the development of teacher practices and facilitation of the delimitation of the subject matter to be taught in the classroom. For these reasons, Blåvarg's chapter will be considered.

Davis and Sumara (2006) have suggested that complexity thinking coming out of complexity theory is a powerful conceptual framework when applied to education. The aim of the investigation proposed here is to discover if complexity thinking can provide possible solutions to challenges, described as central to the foundation of a new field when applied to a case study coming out of Swedish secondary level. Teacher practices will be considered more specifically—coming out of Nilholm's (2016) proposals for *gestaltande didaktik*—as pertinent to a meta-level of subject matter didactics. Teachers in Sweden arguably face challenges similar to those described by Tulis (2018) if these indeed are pertinent to a meta-level of subject didactics, and any insights coming out of the Swedish case study should also be applicable to the German situation in return. For the purposes of the investigation at hand, a model inspired by complexity theory and Klafki's theory of general didactics (Klafki, 2000)

combined with complexity thinking will be used to facilitate for the delimitation of the study (e.g., micro and macro levels) and to consider dynamic interactions between and within levels. Tulis' (2018) proposal concerning German psychology education will be considered at the outset of this article; a presentation of Swedish psychology education will follow, after which complexity thinking will be discussed, followed by a presentation of the model developed for the delimitation of this study. A methods section describing the collection of material for this case study based on an online survey sent to psychology teachers at secondary level in Sweden will be presented, along with a results section coming out of a thematic analysis. Complexity thinking will be applied to the case study at hand in the discussion so as to facilitate the multilevel analysis and to deal with not only different levels but also perspective pluralism in psychology. The complexity of interactions between factors affecting the teaching and learning relationship, such as the dynamic interaction of various systems at societal, organizational, and individual level, and also environmental factors are considered, followed by a section presenting conclusions.

Subject Didactics of Psychology

Psychology is characterized by perspective pluralism, involving a variety of fields with different research traditions and cultures. In countries such as Germany, researchers have expressed an interest in developing subject didactics within psychology. Tulis (2018) cites the German Society of Psychology as having pointed to the "necessity to establish subject didactics psychology". Spinath et al. (2018) claim that "There is no sound subject didactics either for psychology at universities or for psychology lessons in schools in Germany" and recommend that "Psychology should establish its own subject didactics" (Spinath et al., 2018, p. 12).

Tulis' (2018) proposal for how a field might be developed includes *paradigm-oriented psychology didactics*, *integrative psychology didactics*, and *action-oriented psychology didactics*. In paradigm-oriented psychology didactics, the thinking concerning subject psychology and the respective explanatory patterns of different paradigms are clearly and didactically reduced and compared (Sämmer, 1999; Glassman and Hadad, 2013). Nolting and Paulus (2016) suggested an approach for integrative psychology didactics, which considers multiplicity and complex interactions. Their basic idea is the classification of psychic phenomena into a heuristic frame of reference, which constantly directs the view "to the whole" focusing on, namely, the interplay of personal and environmental factors influencing human experience and behavior. The action-oriented approach in psychology didactics is introduced by Ruthemann (2007), with its focus on student activity in the classroom and the competent application of specialist knowledge and methods in practice. Action-oriented psychology didactics also aims to restructure inadequate mental models, information coming from the "knowledge of everyday psychology". These three approaches—normally applied within the field of educational psychology (both secondary level and tertiary level)—are brought in to deal with, among other things, pupils' faulty application of concepts used in psychology education.

The main characteristic of subject psychology is arguably *perspective pluralism.* Thus, psychological issues can best be described, explained, predicted, or influenced when viewed or treated from different perspectives (e.g., from a behavioral, cognitive, and systemic point of view). Perspective pluralism is put forward as one of the central challenges of psychology teaching by Tulis (2018). Tulis also points to another challenge facing psychology didactics—in so far that psychology is a "soft science"—there is no "right or wrong," only a collection of different perspectives and opinions as compared to perspective pluralism within the natural sciences, which does not invite to personal speculation in regards to epistemology or knowledge. Based on the main characteristics of the subject, Tulis (2018) proposed four fundamental challenges for psychology didactics:

(1) How is it possible to teach psychology in such a way that pupils do not consolidate "everyday/lay psychology" or "sluggish knowledge"?
(2) How can human experience and behavior as well as the associated approaches of the different sub-disciplines and theoretical streams of psychology be conveyed without losing sight of the whole?
(3) How can scientific psychological insights (i.e., the understanding of a specific cause and effect within a specific context) and specialized methods be acquired in an action-oriented way so that they can also be used or implemented in extra-curricular situations?
(4) How can theories, approaches, and procedures of different paradigms lead to learning psychology by example, through a comparison and through integration into the existing knowledge structures?

In consideration of the first challenge—the revision of existing everyday psychological assumptions—Hughes et al. (2013) argue that psychological misconceptions are relatively resistant to change. Empirical evidence of discrepancies or disagreements are not always sufficient to revise the idea of everyday experience (Duit, 1995). Considering the second challenge—e.g., difficulties in dealing with the integration of sub-disciplines and theoretical streams of psychology—Nolting and Paulus (2016) argue for the classification of psychic phenomena into a heuristic frame of reference. According to this approach, not only different phenomena but also the basics and the applications of psychology can be integrated into a superordinate model and networked with each other (Nolting and Paulus, 2016). In relation to the third and the fourth challenges, Seiffge-Krenke (1981) outlines three steps for the initiation and the control of learning processes in psychology lessons (p. 312). These include consistent attachment to the naive-psychological assumptions of the pupil's awareness and reflection of these everyday psychological theories and their limits through the didactic principle of alienation and cognitive conflict—and learning goal-related restructuring through the use of specific teaching methods to modify existing assumptions.

Psychology didactics emerges as a complex phenomenon according to Tulis' description of challenges to the field. The specific characteristics of psychology includes high relevance

to everyday life, multi-causality or dynamic system character, scientific character, and perspective pluralism (Nolting and Paulus, 2016). Comprehension of psychology goes through an evaluative epistemological perspective, namely, that psychological findings must be critically reflected, weighed against each other, and evaluated or justified in terms of context and situation (Birke et al., 2016). Thus, what is central to describing or understanding (psychology) education as a complex system is the identification of the components, their interactions, and what emerges from the complex system. To address the challenges put forward by Tulis and the recommendations made by Spinath et al. (2018), an analysis using complexity thinking as an approach is presented.

Psychology Education at the Secondary Level in Sweden

Psychology became a separate curriculum subject in Sweden in 1965 after the national revision which took place in the 1960s (Blåvarg, 2018). Previous to this, the subject had been present in various curricula and various contexts (e.g., part of philosophy, anthropology, and the subject of religion). However, after an extensive revision of the curriculum in 1994 (Skolverket, 1994), the subject of psychology became mandatory only for some programs such as health education and social science in Swedish secondary schools (Blåvarg, 2018). At the same time, the syllabus was divided into different courses: "psychology A" and "psychology B." "Psychology A" focused on the basic theories of psychology and their everyday application; "psychology B" contained applied perspectives—i.e., psychology applied to societal and psychiatric perspectives (Blåvarg, 2018). In 2011, there was a complete revision of the Swedish secondary school system (Skolverket, 2011b). The subject of psychology was also revised and became mandatory in social science, health education, and economics programs. Three new courses were proposed by Skolverket (2011a), "Psychology 1" covering the basics of psychology, and "Psychology 2a" and "Psychology 2b," adding advanced and applied approaches building on one another. Seven out of 18 national programs offer psychology as a subject in Sweden (Skolverket, 2020). Pupils are instructed to read a minimum of 50 points where the subject is optional or obligatory; it is, however, possible to read 150 points. Points roughly correspond to lecture hours in terms of time spent by teachers working with pupils on the subject, but allocated time to any subject varies between schools and is the prerogative of the principal. In total, pupils take around 2,500 points to become eligible to apply for tertiary education (Skolverket, 2020). In the context of a program then, the subject of psychology is fairly small. However, core subjects are often no more than 100 points per course, and pupils read a wide variety of different courses. For the social science program, which is one of the largest and most popular programs in Sweden, psychology is mandatory in all specializations (Skolverket, 2020). Approximately 40% of all pupils graduating from upper secondary schools have grades from "Psychology 1" according to Statistics Sweden (SCB, 2018), coming out of programs where the subject is either mandatory or voluntary due to the various tracks.

Psychology courses include an introduction of the history of psychology, including the emergence of psychoanalysis and behaviorism, as these are requirements coming out of the national curriculum (Skolverket, 2011a,b). Pupils go on to read biological psychology, cognitive psychology, social psychology, and health in the first semester, followed by personality, developmental psychology, clinical psychology as well as studying the influence of media and culture on human behavior in the second semester (as part of "Psychology 2b" for those who opt to take a more advanced course). The third and the final course, "Psychology 2b," enables pupils to apply their knowledge and specialize.

According to descriptions posted on the National Agency for Education's homepage, the subject of psychology is intended to help pupils develop knowledge of factors influencing behavior, cognition, and emotion, both at an individual level and at a collective level (Skolverket, 2020). The course aims to increase self-knowledge through self-reflection, and teachers are directed to give pupils the opportunity to reflect on various psychological phenomena and perspectives. Psychology is also set to promote tolerance of difference by comparing people's way of life, behaviors, and values and to develop critical approaches to different psychological perspectives and explanatory models. Theories are promoted as important in the description of the course's specific content. It is emphasized that pupils must learn to use and evaluate different psychological theories and models and to merge different perspectives into a holistic view. Thereby, the assumptions expressed through the curricula seemingly promotes that different approaches taught in psychology can, to a degree, be considered complementary (e.g., do not present so fundamentally different views of human nature that these could not be merged into parts of a whole). The grading criteria are largely based on descriptive propositions, such as for the grade C in "Psychology 2b" where the student must describe and/or give a detailed account of different perspectives within personality psychology. Descriptive grading criteria give teachers a wide birth to define different kinds of examinations. Methods such as experiments and observations are only recommended in "Psychology 2b". The subject then can, to a large extent, be covered by lectures and group assignments along with written examinations as directed by the curriculum (Skolverket, 2020).

The diversity of the set of relations described here implies that the didactic relation could not be organized universally or according to technical rules. One of the approaches which might help us to overcome the limits of the causal–effect explanation of some phenomenon in education research is complexity thinking (Davis and Sumara, 2006).

Complexity Thinking and Education

Complexity thinking—derived from complexity theory—is a mindset used to frame a problematic situation, which can be identified as a complex system of interactions (Davis and Simmt, 2006; Davis and Sumara, 2006; Forsman, 2011). Complexity thinking has been applied in educational research, and it aims to describe and understand complex systems and their capacity to show order, patterns, and structure in educational activities (Davis and Sumara, 2006). Complexity thinking is not characterized by a particular research method but by a

methodological perspective (i.e., a way of thinking) that employs a range of methods to study complex phenomena (Davis and Sumara, 2006). This approach is mostly used in research pertinent to higher education; however, the relevance of the approach may be useful in all educational settings to describe dissipative structures, the holistic and non-linear nature of learning processes, and the dynamical relations between agents taking part in the educational system (Morrison, 2002; Forsman, 2011; Forsman et al., 2014). Complexity thinking is a powerful alternative to reductionist approaches to educational science. Complexity thinking is an approach where deep similarities can be recognized among the structures and the dynamics of several disparate phenomena and can provide a useful tool to describe interpersonal dynamics involving teachers and their pupils in the classroom. Learning can, for instance, be interpreted in terms of recursive and elaborative interactive processes as opposed to cause–effect interpretations (Davis and Sumara, 2006). Doll (2008) discusses complexity theory and the culture of the curriculum pointing to how the aim of recursiveness often results in difference (the-yet-to-be-seen), especially if a curriculum is complex. However, according to some theorists such as Deleuze, repetition always leads to difference (Deleuze, 1968), so no classroom will produce the same behaviors and interactions in response to a set curriculum.

In general, complex systems are neither homogenous nor chaotic. They have structure embodied in the patterns of interactions between the components (Forsman et al., 2014). Some of these structures can be stable and long-lived (and are therefore easier to model), while others can be volatile and ephemeral. These structures are also intertwined in a complex way (Cilliers, 1998, p. 3). They can include neural networks, which are organic (Buzsáki, 2006, 2019), although there are certain advantages with structurally set networks. The term "complex" does not simply mean complicated but implies a non-linear relationship between components or agents and blurry boundaries between them (Buzsáki, 2006). Complex systems are open and information can be exchanged across boundaries, and small changes can cause large effects or no effects at all. For example, individuals who participate in education become active members of society, and some employ their influence on political decisions and culture, which, in turn, may effect changes in the educational system (Herbert, 2018). In this way, micro levels affect macro levels, and small scale affects large scale. Modern complexity science recognizes this as a *circular causality*, which may include multidirectional interactions across different levels of organizations (Nunez, 2016).

Stable structures can exist *a priori*, such as those of an organization with recursive activities as is seen in schools, where work is connected to the national curriculum (Carlgren and Kallos, 1997). The latter is recursive. These recursive systems can be described as nested, affecting subsystems, and can affect the structure on a lower level of nested systems such as those seen in a classroom. If a teacher, for instance, is working with a demanding curriculum (with many diverse goals and fields of study) and the time allocated for work is limited—there is a risk that the structure will be centralized and hierarchical, with the teacher at the helm of all activities (Herbert, 2018) to maximize production and the output of work (essays and examinations)—a teacher-centered network. If, however, a curriculum is less demanding and time is relatively liberal—decentralized networks with flat organizations allowing pupils to interact and direct activities can develop as a nested system—a student-centered network. These differences in systems and networks allow for different kinds of knowledge to develop. In this case, complexity theory emphasizes knowledge as emergent.

Phenomenon *emergence* means that new features arise through actions of smaller entities that do not possess these features in isolation. Emergence refers to novel or global properties that arise in complex systems from relatively simple interactions within a smaller system. *Knowledge* can also be described as embodied (Haraway, 1991), in which case pupils can be seen as nodes embodying knowledge. Embodied knowledge can also be seen to emerge from a network of neurons in interaction with the environment at both the micro and the macro levels. In so far that cognitive psychology and neuropsychology will be included in the understanding and learning about the brain, it can be argued that "knowledge" is emergent. Gazzaniga (2011) describes this form of "emergent knowledge" in his book, "Who Is in Charge: Free Will and the Science of the Brain." Different sets of knowledge and thoughts "rise" to consciousness in competition with each other, and what any pupil/student remembers is the result of this competition, where certain sets of knowledge and memories gain precedence over others. This approach is also sympathetic with complexity thinking and the theory on which it is founded (complexity theory and network theory). Knowledge can also be *embodied* in things. Juelskjaer et al. (2013) describe, for instance, how the interaction between pupils, parents, and principals is affected by the couch placed in the principal's office, requiring confessional practices of wrongdoing from absconding pupils called to meetings along with their parents. The microscope is, for instance, the result of knowledge developed over many generations, and pupils may learn about the history and the skills necessary to create it before using it. By handling a microscope and learning about a microscope, knowledge emerges and can be considered both in terms of behaviors (a laboratory examination) as well as cognitive capacity in finding new fields and new ways to use the microscope applied to the environment.

The Complex System Model

While models are not ideal in the context of complexity science, they are often necessary (Cilliers, 1998). A combination of network theory and complex theory has been proposed by several researchers in the field (Cilliers, 1998; Morçöl and Wachhaus, 2009) and is considered of importance for public systems where both non-linear and linear processes are evident. In educational research, network theory has been used, for example, to characterize pupils' interactions in small group discussions (Bruun, 2011) or to describe pupils' retention from the school system (Forsman, 2011; Forsman et al., 2014). *Network theory* can be applied to explore, understand, and characterize structure connectivity in complex systems (Newman, 2018). Cilliers (1998) argues that the advantages of considering linearity in network models as constituting a part of a complex system is the possibility

to describe both *stability* and *volatility* in structures. To be useful, these must have "some *a priori* constraints which will have to form a part of the interpretation of the results" (Cilliers, 1998, p. 8). Furthermore, a network must be "engineered in such a way that we know what it does. . .however, a model of the system would have had to exist beforehand in order to make the engineering possible" (Cilliers, 1998, p. 8). The linear model proposed here unfolds out of didactical traditions where the interrelation between student, teacher, and subject content playing out in the classroom is of central importance—as described in Klafki's model of general didactics (Klafki, 2000; Hudson, 2007). Klakfi's model is well established (Hopmann, 1997; Brante, 2016; Sjöström, 2018) and can be considered as *a priori*. The interactions between teachers, pupils, and the content (Hudson, 2003)—which can include the reader describing the topic or the technology facilitating access to information about the topic or subject—are depicted by a triangle with three points, with the sides describing different kinds of interactions which serve the purpose of this investigation where the classroom can be considered a complex system encompassing different kinds of nested systems (combinations between pupils, teachers, and technologies). Knowledge can be seen as emergent from the interactions (Gazzaniga, 2011). The nested subsystems can be of linear nature, and the interactions can correspond to the relations described in the didactical triangle. Complexity thinking is considered here to enable a better understanding of processes describing the interrelational dimensions of micro and macro levels, separately or otherwise, and Klafki's interrelational model of general didactics has therefore been expanded with macro perspectives (**Figure 1**). The interactions between micro and macro perspectives are important in so far that the level at which psychology didactics should be developed is currently at issue. This model then aims to enable the consideration of a meta-level of general didactics, a meta-level general subject didactics as proposed by Tulis (2018), and micro levels of subject didactics—these perspectives are considered through an adjustment of the lens of delimitation enabled by complexity thinking in combination with the model, allowing for the possibility to scale up or down (from macro to micro and *vice versa*).

The model then has been developed for the purpose of describing and delimiting the field or scope of investigation—to a certain set of interactions—considered to be of importance, which have been descriptive and prescriptive, unlike complexity models, but can be used in conjunction with some linear perspectives as, for instance, those coming out of network theory. The structural dimension of the model corresponds to aspects of importance for an understanding of the structural and the logical relations between the agents. The temporal dimension corresponds to the time order of different types of activities—and interactions among agents at the macro and the micro levels—because most of the interrelations between the agents depend on "live interactions" within and between levels. Complexity thinking—coming out of complexity theory—presents a mindset used to problematize and consider solutions to the challenges described by Tulis. Primarily, complexity theory does, however, underscore "the importance of contingent factors of considering the specific conditions in a specific context at a specific time" (Larsen-Freeman and Cameron, 2008, p. 63) and, referring to historical examples, should therefore be seen as a means, whereby it is possible to understand a "humanitarian task of the present" (Klafki, 2000, p. 94), including education.

Complex systems are networked with other complex systems (Davis and Sumara, 2006). Moreover, components within a complex system can be considered to be complex systems themselves; thus, complex systems are nested. Nested systems have similar structure and dynamics but operate on different scales (time, size, and so forth) (Davis and Sumara, 2006). It is possible to consider society and organizations within education

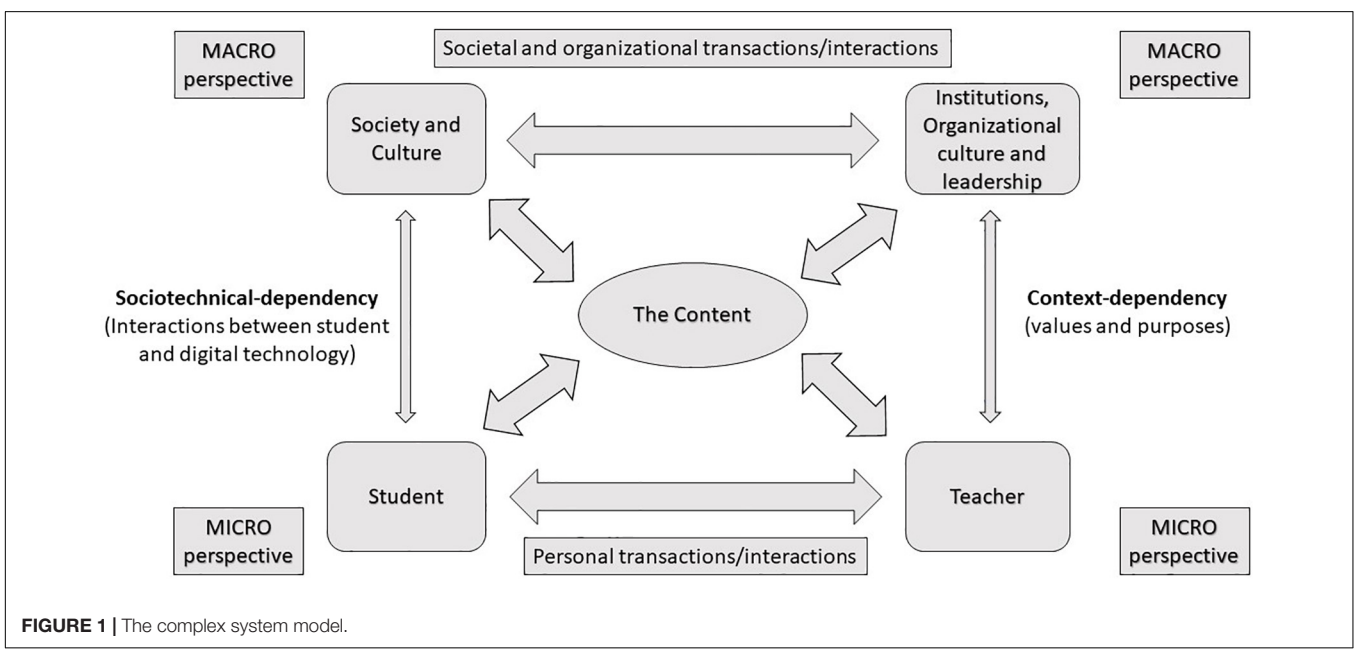

FIGURE 1 | The complex system model.

(i.e., schools) as two nested systems (at a macro level), which may have similar structures and dynamics. However, organizations in education are subsystems of the society, and these have been presented at the same level in order to describe the dynamic relationships with another, micro, level. The interactions on the micro and the macro levels may differ, considering their timescale (see above). Significant transformations at the macro level may take decades (e.g., changes in the curriculum), while significant transformations can take place over a few seconds at the micro level (e.g., discussions in the classroom). Hence, it is necessary to find relevant methods to measure the interactions on multiple levels in order to understand the interrelations between the macro and the micro levels from a dynamic perspective.

It is possible to describe the model proposed here of classroom interactions as a *self-organizing system* according to the sociological application of self-organization theory introduced by Luhmann (1995) (self-referential theory). For Luhmann, the elements of a social system are self-producing, i.e., "a communication produces further communications and hence a social system can reproduce itself as long as there is dynamic communication." Self-organizing systems involving classroom interactions (four different discourses) have been described mathematically using the Scale Invariant theory (Herbert, 2018). The model above (**Figure 1**) can also be considered to be an assemblage. The assemblage theory provides a bottom-up framework for analyzing social complexity by emphasizing fluidity, exchangeability, and multiple functionalities (Deleuze and Guattary, 1987; De Landa, 2006). "Interpersonal networks may give rise to larger assemblages like the coalitions of communities that form the backbone of many social justice movements . . . social movements are a hybrid of interpersonal networks" (De Landa, 2006, p. 33) and "assemblages should be given the ontological status of individual entities: individual networks . . . individual cities and nation states" (De Landa, 2006, p. 40). However, emergence through self-organization has two directions: global-to-local and/or local-to-global determination [Haken's system of synergetics referenced by Buzsáki (2006), p. 14]. In the system described here, we can find a dominance of the global-to-local determination. Global-order parameters (e.g., the curriculum and content, collective values, and purposes) may govern local interactions in the classroom, an interrelation described as *context dependent.* On other hand, factors which are *socio-technologically dependent* may also be evident, such as govern local interactions.

Complexity thinking can be applied together with the model described here (**Figure 1**) as a lens, which can be adjusted to delimit the field of study (from micro to macro and *vice versa*) to discuss the results of a mapping carried out for the purpose of this study in psychology didactics.

MATERIALS AND METHODS

Contextual Information

Contextual information regarding the subject of psychology, the size of the topic—points given to the topic along with the number of pupils graduating with grades in the topic—was considered. An analysis of the national curriculum served as a preparation for the online survey.

The Survey Content

Respondents were required to answer background questions related to age, gender, place of work, and educational background at the outset of the anonymous survey. These were followed by open-ended questions and multiple-choice questions (five-step Likert scale). The respondents were further requested to suggest ways in which psychology didactics at secondary level differs from other subjects. Questions designed to gauge respondents' experiences of teaching were included in the first part of the survey. In the second part of the survey, the psychology teachers were queried in regards to common methods used in teaching practices as well as the technology used in the classroom (five-step Likert scale, ranging from 1, "not at all," to 5, "very often"). Questions were presented separately for different levels of the subject (Psychology 1, Psychology 2a, and Psychology 2b.) The original survey was formulated in Swedish (see the English translation in **Tables 1–6**).

Data Collection

A survey link was shared *via* email (Survey and Report, Linnaeus University). The public survey was sent out to 960 secondary schools in Sweden. While approximately 50% of these have social science programs, the subject is also taught on several other programs nationally in accordance with demand. This demand varies from year to year, warranting the choice of sending out the survey to a large group of secondary schools. Principals were charged with distributing the survey link to the psychology teachers responsible for teaching the subject. In addition, the survey link was shared with a special Facebook group which included 110 secondary school teachers in psychology in Sweden at the time of data collection. A reminder was sent out after 2 weeks of the first call. The participants' answers were saved on a server maintained by Linnaeus University (Survey and Report). The written texts from the open-ended questions served as the basis for a thematic analysis of the survey content (Braun and Clarke, 2008).

Data Analyses

A thematic analysis was applied to open-ended questions (Leininger, 1985; Aronson, 1994; Braun and Clarke, 2008). The application of thematic analysis demands that a sample population can be considered to be part of a community with shared concepts (Braun and Clarke, 2008), e.g., concepts used by the participants are understood and used in roughly the same way. The participants in the study are teachers with similar educational backgrounds working in school organizations and are therefore considered to fill the requirements for being part of a community with shared concepts and with shared meaning (roughly similar) given to these concepts. The responses to the open-ended questions of the survey were analyzed in order to identify categories or themes emerging from the material. A list of basic categories coming out of the text of each open-ended

question in the survey (e.g., the responses to questions) was collated by one researcher. The list of basic categories from each open-ended question was then given to another researcher, who repeatedly compared the original list with text from the survey. These lists were repeatedly compared with the answers from the participants for these questions, until the two researchers agreed regarding the basic categories (**Tables 1–4**). In addition, the raw score for each participant's answers on the five-point Likert scale was calculated. The raw scores from the five-point Likert scales were standardized in each question into the percentage of the maximum possible (POMP) scores which express the raw scores in terms of possible rating scores (Fischer and Milfont, 2010) (**Tables 5**, **6**). The statements collected to open-ended questions are considered to be speech acts, where meaning can be inferred without considering the characteristics of the subject who utters the statement. The results coming out of this analysis act as a mapping or case study describing how psychology is taught and how subject matter didactics is conceptualized by 61 teachers in the field at the secondary level. Complexity thinking founded on the model prepared specifically to enable a delimitation of this study is then applied to the case created from the survey.

Participants

Sixty-one psychology teachers (M = 44.5 ± 9.2 years old, 40 females, 20 males, one other) from schools in Sweden, who were responsible for teaching the subject at the secondary level, took part in the survey. The respondents had reliable educational background—teacher training at a tertiary level with a psychology major or a major in a related subject—along with extensive teaching experience in the subject (M = 11.6 ± 7.7 years of teaching expertise). There is no collated documentation as to how many teachers work with psychology at the secondary level, but given the size of the subject and the distribution of the social science program nationally, there are good grounds for treating this sample as representative (keeping in mind the limitations of the study).

RESULTS

Open Questions About Psychology Didactics and Teaching of the Subject

Following background questions including age, gender, place of work, and educational background, questions regarding experience of education practices (see **Tables 1–4**) were asked. Coming out of the first question "What is psychology didactics for you?", four response categories were found along with an additional category of "short answers" (e.g., named short answers). The first four categories can be interpreted as representing aims described in the curriculum such as the elaboration of pupils' self-knowledge and critical thinking, the explanation of different theories, *etc*. Following on—from the question asking the respondents about the perceived difference between psychology didactics and other subject matter didactics—four categories emerged. These themes referred to the transformation of the curriculum into practice—i.e., a focus on theories and concepts, the aim to increase a student's self-knowledge through self-reflection, a focus on connecting theory and practice—different approaches seemingly pointing to the necessity of developing teaching methods which differ from those of other subjects taught at the secondary level. The last category was defined as short answers (e.g., no difference). A third question investigated the

TABLE 1 | What is psychology didactics for you?

Response category	Detailed description	Example
How to apply theories in practice	The teachers claimed that psychology didactic is a subject that helps a lot on how to apply theories in practice and how to teach their students to use these theories in their everyday life.	"The ability to turn theory into practice." "That pupils see the impact of psychology on us in all aspects of our everyday lives. That pupils get to carry out practical exercises to reduce stress and performance anxiety and to manage groups."
Elaborating pupils' self-knowledge	The teachers described that subject didactic is helpful to them to find the proper method on how the pupils understand better one's own and others' emotions, thinking, and behavior.	"Getting pupils to better understand why they behave the way they do and why others do it." "What influences us, how we think, behave, and learn, and how we become emotionally involved in different environments (e.g., learning environments and learning) and from the vantage point of different methods/perspectives."
Explaining different psychological theories and concepts in a meaningful way	The teachers mentioned that subject didactic helps on how to explain different psychological theories and concepts sufficiently to their pupils.	"To approach different theories about man. To be able to work from the view that the various theories complement each other rather than provide complete truths." "To test psychological theories and models together on real cases. By problematizing and discussing real cases, it becomes clear why there are several different theories and models."
Elaborating the critical thinking of pupils	The teachers claimed that didactical methods are useful to problematize the knowledge in psychology in order to improve their pupils' skills about critical thinking.	"Open the eyes of the pupils to be critical in their thinking."
Short answers	The teachers gave just a simple answer and mentioned that they have never been thinking about this question.	"How to teach pupils in psychology." "A pseudoscience like all didactics." "Great question that I have not reflected on . . ."

TABLE 2 | What is the difference between psychology didactics and the didactics in other subjects?

Response category	Detailed description	Example
More focus on theories and concepts	The teachers suggested that the subject contains more theories and concepts than other subjects deal with that.	"More focus on concepts and terms. Narrative, illuminating, *etc*." "I think that, above all, Psychology 1 is very much tied to lecturing, but it does not have to be bad. There are many difficult theories and concepts that can be used as a teacher."
Aim to increase pupils' self-knowledge through self-reflections	The teachers claimed that, based on the curriculum, teaching psychology should give the opportunity to develop pupils' ability to reflect on their own behavior and experiences.	"In the field of psychology, the purpose is to understand oneself and others and to reflect on one's own behaviors and thoughts as well as their own feelings and thoughts, so didactically. I think it is important to have conversations, discussions, experiences, and not just have theoretical knowledge."
More focus on connecting theory and practice	The teachers mentioned it is different in psychology teaching compared to other subject didactics, how to connect theoretical knowledge with practical knowledge.	"Psychology is very theoretical; my other subjects are more able to combine theory and practice." "Maybe what is mentioned above with more focus on linking theory and practice. Which contributes to more experimental/laboratory-based means of teaching."
Psychology teaching requires a special kind of methodology	The teachers claimed that special kinds of didactical methods are needed to problematize the knowledge in psychology.	"Trying to explain emotions, thoughts, and behaviors is different because it is so subjective and is close to people's nature; it requires a certain kind of didactics/methodology."
No difference (short answers)	The teachers claimed that there are no differences.	"Do not think that didactics differs very much from other theoretical humanistic subjects."

TABLE 3 | How the course books make an impact on your work with subject didactics?

Response category	Detailed description	Example
Inspirations for ideas	The teachers claimed that they get lots of inspiration on how to teach the subject in practice.	"They give me inspiration. Sometimes also a quick help for unplanned situations, such as completed study questions or reflecting/ discussing/finding out assignments." "They are important! They follow the central content of Psychology 1, 2a, and 2b. They address the central concepts in a good way and they provide inspiration for exercises and assignments in the course."
Structure for teaching the subject	The teachers described that the books give the basic structure on how to present the material for their subjects.	"Good guidance." "Use it mostly for reference in relation to the general course structure to create a basic structure."
Support for methods and case studies	The books give support on how to implement different methods for teaching of the subject, and they can find useful case studies.	"It gives support to the areas we work with, discussion paper." "Used as preparation for among other things, case histories."
Support for teaching in general	The teachers just gave a simple answer about course books to support their teaching in general.	"The textbook supports teaching." "They supplement with in-depth texts on different subject areas."

impact of course literature (the reader) on teaching practices and work. The response indicates that teachers mainly use course books as a support to prepare for lessons—i.e., as an inspiration, a structure for teaching the subject, a support regarding methods and to provide case studies—as well as a more general support for education praxis in the classroom. A fourth question required the respondents to cite/describe challenges in regards to teaching practices. "What is the biggest challenge for psychology teachers when the syllabus is to be transformed into didactic work in the classroom?" One response category—emerging from the material—related to problems regarding time allocation. Teachers were challenged by having to teach complex material in the time allocated to the subject in the schedule, e.g., 45 lecture hours (Psychology 1). Other response categories were similar to those coming out of the second question (i.e., applying psychological theories into practice, explaining the connection between different theories, helping the pupils to increase their self-knowledge).

Questions About Methods

In the third part of the survey, an inquiry was made into common methods used in the classroom. The sums of the rating scores on the five-point Likert scales in each method were turned into the percentage of the POMP scores, which express raw scores in terms of possible rating scores (Fischer and Milfont, 2010) (**Tables 5**, **6**). The respondents were asked about teaching practices. Discussions, lectures, and individual work were listed as common classroom methods, and less frequent methods included study visit, laboratory session, and recorded lecture (**Table 5**). We also asked teachers how often they use other types of teaching methods. We found that case studies, research articles, and digital tools are commonly used, and role plays, the flipped classroom, and logbooks are used quite rarely for the purpose of teaching psychology. In addition, the selection of methods more often takes place after a consultation with pupils and not so often after a consultation with colleagues (**Table 6**).

TABLE 4 | What is the biggest challenge for psychology teachers when the subject plan is to be transformed into didactic work in the classroom?

Response category	Detailed description	Example
Complain about time	The teachers complained that the time for their course is not enough to teach a complex subject with different concepts and their applications. They mentioned as the biggest challenge teaching psychology in Swedish secondary schools.	"The biggest challenge of all is that our courses are 50 points! With only 45 h, six different psychological perspectives must be covered (in Psychology 1)." "The fact that it is a 50-point course means that there is little time, which makes it difficult, for example, to give seminars and oral presentations when you also have large groups." "To find time to cover the curriculum in a good way so that the pupils really learn."
Applying psychological theories into practice	The teachers claimed that it is a challenge how to turn over psychological theories into practical knowledge in the classroom.	"Practical exercises. In-depth studies using only the textbook does not enable pupils to learn or understand. Getting more practical elements into education like experiments and labs." "Finding relevant examples from everyday life."
Explaining the connection between different theories	The teachers mentioned that it is a challenge how to make connections between the different subjects and theories in psychology.	"That the pupils' interest and curiosity regarding the subject can be disturbed by the subject's somewhat stilted division of perspectives (Psy1). At the same time, the subject plan is quite inexact/unclear regarding what theories to include." "To go through as many different perspectives as possible so that pupils get a broad sense of the subject's complexity."
How to help the pupils to increase their self-knowledge	The teachers mentioned as a challenge in teaching of the subject how to help pupils increase their self-knowledge by learning the subject.	"That the pupils should see the connection between theories and reality; so that it will not be too difficult, they must get the real picture in order to relate the subject to themselves, for example." "The problem is that it can be difficult to make space for the student's own development throughout the course."
Finding special methods to support the needs for individual differences and for the whole class	The teachers also mentioned that it is a challenge how to find the right method in the classroom to adjust the teaching material that follow the needs for the individuals and also for the whole class.	"To individually adapt everything to the pupils' needs: teaching methods, examination methods, content, language, *etc*."

DISCUSSION

Complexity thinking will be applied here as a means of enabling a dynamic approach for a better understanding of the relation between the micro and the macro levels. The combination of complexity thinking and the model developed specifically for this investigation (**Figure 1**) enables a delimitation of the field and scope of the investigation at hand. Further this combination facilitates for a discussion of the results of the mapping coming out of the thematic analysis which constitutes the case study. The first level analysed (micro level) involves a linear model which relies heavily on Klafki's theory of general didactics and is considered to describe nested systems which are a priori.

Micro Level

From the first mapping carried out of the results, it emerges that most combinations of methodologies favored by Swedish teachers are similar to combinations used in other subjects (e.g., lectures and discussion) and, in some instances, to certain groups of subjects such as natural sciences—experiments receive a mean score of 65%, observations receive 60%, and practical exercises. This gives some support to Kansanen's consideration of creating larger groupings of subjects (Kansanen, 2009). Teachers describe practices faithfully mirroring the intention of the curriculum, informed by the values expressed there. In accordance with the curriculum, pupils are encouraged to learn theories and concepts as well as achieve self-knowledge through self-reflection, and to these ends, discussions and lectures are primarily used (**Table 5**).

TABLE 5 | Which types of teaching methods do you use in the classroom?

	Psychology 1 (*n* = 61) %	Psychology 2a (*n* = 50) %	Psychology 2b (*n* = 21) %	Mean % (POMP)
Discussions	87	79	85	83
Lectures	79	84	71	78
Individual work	72	81	78	77
Written work	75	67	79	73
Practical exercises	78	74	64	72
Group work	62	67	63	64
Oral presentation	61	66	66	64
Seminaries	57	66	63	62
Workshop	42	36	54	44
Study visit	37	41	44	40
Laboratory session	34	34	45	37
Recorded lecture	32	37	42	37

The sum of the rating scores on the five-point Likert scale in each method and the percentage of the maximum possible (POMP) scores, which expresses raw scores in terms of possible rating scores. n, number of respondents; %, percentage of maximum possible scores.

Teachers prefer to engage with pupils when transforming the curriculum into practice through the selection of methods rather than consulting colleagues (**Table 6**).

TABLE 6 | How often do you use the following methods for your teaching?

	Psychology 1 (*n* = 61) %	Psychology 2a (*n* = 50) %	Psychology 2b (*n* = 21) %	Mean % (POMP)
Case studies	79	80	63	74
Research articles	64	76	77	72
Digital tools	71	70	66	69
Films	67	67	60	64
Experiments	56	58	66	60
Observations	53	60	66	59
UR	60	60	57	59
Interviews	48	57	61	55
Science channels	53	53	54	53
Journals	51	60	46	52
Fictions	45	46	46	46
PBL	40	42	41	41
Role play	40	41	33	38
The flipped classroom	28	31	37	32
Logbooks	28	30	36	31
Selection of the methods takes places				
In a consultation with the pupils	52	76	70	66
In a consultation with other teachers	54	62	57	57

The sum of the rating scores on the five-point Likert scale in each method and the percentage of the maximum possible (POMP) scores, which expresses raw scores in terms of possible rating scores. n, number of respondents; %, percentage of maximum possible scores; UR, Swedish Educational Broadcasting Company; PBL, problem-based learning.

A dialogic approach related to the student–teacher axis of the model is implied here. The dialogic approach refers to an interaction between student and teachers, while the emphasis placed on self-knowledge through self-reflection points to a student-centered nested network where an adjustment of the focus enables a consideration of intra-action. The development and the integration of these two practices (self-knowledge and self-care) in educational context originated in Ancient Greece (Foucault, 1995). Self-knowledge is often described as the aim of maieutic (dialogic method) but is also related to the understanding of how the three parts of the soul (read here as psyche) could be balanced. This intra-action between the animalistic, the idealistic, and the realistic/rational parts is described by Plato in the Phaedrus (Plato, 1997, p. 506) and the Republic (Plato, 1997, p. 971), a model which has arguably inspired Freud's topographical model (Freud, 1923), where the latter described as a chariot driver having to control two unruly horses can be conceptualized as a network (an "intra-action" coming out of a subject-specific approach when considering Freud's modern theories). In Klafki's model, self-care is integrated into formation or *bildung*. The subject of *bildung*, however, points only to conscious processes (e.g., precludes a consideration of intra-action between neurons, for instance, as enabled by the combination of network theory and complexity theory used for this analysis).

In regards to temporal factors, time is an issue according to teachers in the case study, especially where the transformation of theory into practice related to abstract models within psychology is concerned. An emphasis on lectures, as evident in this study, implies a more traditional uni-directive approach with asymmetric relations between students and teachers—(student–teacher axis of the model), which is common when logistical problems arise due to limited resources (Herbert, 2018). Fuite (2005) has hypothesized that the tendency of educators to perceive time as a limited resource may be one of the reasons for the emergence of centralized nested systems in the modern classroom where knowledge goes through the teacher (teacher-centered network).

The book is the primary technology through which both pupils and teachers achieve their goals and is depicted in the teacher–content axis. The book is mentioned as both enabling a foundation for teaching, an inspiration for teaching, and a means of teaching and is therefore yet another nested network of interactions describing classroom praxis, where the book becomes the central node. The centrality of the book, as indicated by the responses coming out of the survey, is likely to be a feature of many different subjects and cannot therefore be considered to characterize a meta-level of subject didactics.

Some of the books listed by Swedish teachers in this study, however, include case studies, and teachers often use these in classroom activities. Digital tools, practical exercises, and films are also used, but to a lesser extent than case studies (**Table 6**). The book in combination with methodologies promoting self-knowledge, including case studies, is one of the activities carried out to reach goals in the curriculum according to teacher statements, and case studies (as described in the psychology books listed by teachers) are particular to traditions coming out of psychology. Based on results coming out of the qualitative survey (**Table 3**) then, case studies are useful to elaborate a student's self-knowledge and transform theory into practical knowledge. Case studies coming out of the reader along with the aim of self-knowledge (described in the national curriculum) and coupled with self-reflection are combinations which could arguably present a potential for a subject-specific approach (interaction of several nodes describing a new nested system).

There is a tension described here between the two nested networks (i.e., student-centered networks and teacher-centered networks) which can emerge from interactions at the micro level. The findings of this analysis mainly describe practices related to general didactics. Issues involving time, for instance, are not specific to psychology education (Fuite, 2005). The same is true regarding challenges involved in the transformation of theory to practice, which is arguably common to all theory-laden subjects including philosophy, mathematics, and physics. However, the emphasis on a combination of self-knowledge and self-reflection put forward by teachers in the mapping carried out for the purposes of this investigation describes practices within psychology education facilitated by case studies coming out of the book, and these could potentially strengthen arguments for a meta-level of subject didactics. We will move on to consider what

complexity thinking enables in terms of a deeper understanding of interaction of networks described here as well as an interaction between the micro and the macro levels.

Interpretation of Interaction Between the Micro and the Macro Levels in Education As Two Nested Systems

It is assumed here (e.g., implicit to the model) that interrelations at the micro level are not separate from interrelations at the macro level. There is a reciprocal relationship between the parts and the whole, and there are multiple causes for the changes in the system. Some previous research has focused on interrelations at a micro level by describing interactions between teachers and pupils (e.g., Bruun, 2011; van Geert, 2014). In Sweden, curriculum studies have been included in didactics as part of an attempt to understand the development of subject didactics. Swedish curriculum research has also been related to the consideration of macro perspectives, where changes in the Swedish school system have been discussed as well as political, social, and economical changes covering the late 1960s to mid-1990s (Carlgren and Kallos, 1997). These authors analyzed which societal groups dominate and influence the development of the curriculum during a specific historical period as well as why a certain kind of curriculum becomes possible in relation to a specific set of described circumstances. The analysis of how a curriculum expresses educational policy over time and what changes/interactions take place over an extended time frame can be applied to research at a micro level, e.g., interactions between teachers and pupils. Changes to the curriculum have multiple causes, which cannot be understood as linear and are better described as an accumulation of different events, a pile (Davis and Sumara, 2006, p. 89). Complexity science is a useful approach for the analysis of interactions between micro and macro level coming out of such changes. The model proposed here (**Figure 1**) allows for an understanding of temporal and structural dimensions of didactics. At a micro level, pedagogical inter-action is a shared activity between two subjects (teacher and student) focused on a specific content aiming at reaching goals commonly agreed upon (Uljens, 1997, p. 54). However, interaction at the micro level needs to be interpreted in a societal, cultural, and historical context, e.g., considering interactions at a collective level.

One example, following the transformation of the curriculum of the subject of psychology in Sweden, will be described here. Blåvarg (2018) describes changes within the subject in regards to how the pupils were involved (or not) in the teaching of the subject, as seen over the past half century. Based on the first curriculum in 1964, when psychology became an independent subject in Swedish secondary schools, pupils' own life experience was taken as a starting point to learn the subject. After a change in the curricula (Skolverket, 1994, 2011a,b), focus was placed on abstract content in the subject matter (e.g., psychological). While a student's self-knowledge was retained as an important goal in the curriculum, student experiences were no longer treated as the main point of departure, which might possibly explain the teachers' perceived lack of time for teaching the subject as expressed in the responses to the online survey. The pressure to cover a broad curriculum in a limited time frame and the reduction of classroom autonomy may result in a system where all information is made to pass through a central hub (the teacher). It may also offer an explanation as to why the teachers in this study often use lectures or discussions (led by the teacher) as a method, instead of laboratory sessions or recorded lectures (**Table 5**).

During the late 1960s, most of the school system in Sweden was centralized by the state, but toward the end of the 1970s, a shift toward decentralization was carried out. Governance of schools was given to the municipalities or to private organizations. This transition from national to local governance of the schools in the 1980s was also in line with new ideological approaches such as neo-liberalism and neo-conservatism (Carlgren and Kallos, 1997). An emphasis on the individual's self-reflection and self-knowledge as opposed to understanding in terms of a collective experience and society may be understood in this context. In addition, Sweden became a member of the European Union in 1995, resulting in educational systems becoming increasingly globalized. All of these complex issues may have impacted the changes in the curriculum at a national level, affecting the subject of psychology as, for instance, can be seen in aims to promote tolerance, awareness of difference, and understanding of social change (Psychology b). Further societal changes impact working conditions, digitalization, and fluidity; new markets result in new demands on pupils—coming out of educational institutions looking for work—creating shifts in what might be called the concept of the model citizen. The national curriculum (Skolverket, 2011b) of psychology points to the education of a citizen accepting of change, adjusted to a multicultural society, and prepared to take part in democratic processes. However, the latter aim is also part of general didactics as described by Klafki (Herbert, 2018).

Emergence of Knowledge and Self-Knowledge

The classroom has been delimited as a complex system/network at the micro level and nested with in the macro level (**Figure 1**) in accordance with the model developed specifically for the purposes of this study. It is posited here that the macro level has top-down control on the micro level through the curriculum (context dependency) and through the implementation of technological and digital development (socio-technological dependency). Teachers must follow the updates of the actual curriculum, and all changes in the subject curriculum are set to act as triggers, with repercussions in the classroom affecting interaction and the emergence of knowledge (Gazzaniga, 2011).

Knowledge is considered to be *embodied*—in the model proposed here—in so far that the "self" is the central hub, which carries knowledge based on previous interactions with other nodes from which knowledge becomes an emergent property. Knowledge can be seen as an emergent property of complex interaction in bundles of neurons, expressed through language, for instance (Beckner et al., 2009), affected by the complexity of interactions which develop between teachers and pupils during lectures and discussions (Doll, 2008), which in turn can be

affected by changes to the curriculum which emerge from the societal level involving complex interaction within politics.

Self-knowledge refers to how individuals understand their own character, feelings, motives, and desires. Self-knowledge requires ongoing self-awareness and self-consciousness through self-reflection. Interactions between micro and macro perspectives can be seen in so far that the pupil, imbued with knowledge of the self, achieves this through different praxis involving lectures, discussions, and self-reflection—implying not only a student-centered network coming out of the interaction but also a consideration of intra-action, adjusting the lens of complexity thinking to focus on internal nodes—the self and the I in the case of Mead's models (Mead, 1934), the id, ego, and super ego coming out of Freud's theory (Freud, 1923)—alternatively, neurological networks with no central hub can be considered, where knowledge is seen to be emergent as is described by Gazzaniga (2011). The pupil is directed to integrate different fields of psychology into a holistic approach through their own experiences (turning theory into practice), enabling an understanding relating individual experiences to group experiences and further on to experience at the societal level. Furthermore, the pupil may integrate a variety of separate fields of psychology with their own traditions, expertise, and research methodologies into a whole. Self-knowledge through self-reflection implies that a pupil-centered network can co-exist, nested within a teacher-centralized network in so far that self-reflection can be taught as self-care or care of self (embodied knowledge). This combination originates from educational practices in Ancient Greece (Foucault, 1995; Herbert, 2018). Self-knowledge (enabled through self-reflection coming out of contemplation, meditation, and prayer) aimed, among other things, at facilitating a balance between the three levels of the psyche or soul and could therefore be considered a pedagogical approach. However, this particular means of achieving self-knowledge was not adopted by any pedagogic philosophers or applied to pedagogy; instead it was adapted to Freud's topographical model and can thereby be considered as subject specific (Freud, 1923).

The model presented here allows for complexity thinking to consider individual nodes (pupils) and embodied knowledge, describing this delimitation. Practices developed in the classroom to promote self-reflection are not limited by the classroom. Complexity thinking combined with the model developed for the purpose of this study merges both linear and non-linear, dissipative structures, allowing the analysis here to account for how self-reflection as a practice can carry over to other spaces. Self-knowledge then, developed through self-reflection, can be considered to translate into intra-action where pupils' embodied knowledge is central.

The complexity of the aims of psychology education indicates that not only is psychology charged with "producing" future citizens with the espoused correct values, tolerance, and understanding of fellow man [typical of general didactics described by Klafki (2000)] but also the pupil must also be capable of holistic thinking by integrating the whole of psychology with all of its major fields, and this is achieved through, among other things, self-knowledge facilitated by case studies coming out of traditions in psychology [which may offer insights and possible solutions to challenges 2 and 4 as proposed by Tulis (2018)]. Self-knowledge has been described as belonging to a meta-level subject didactics (Herbert, 2018). As suggested by Birke et al. (2016), Swedish pupils are encouraged to think critically as a means to facilitate for comprehension of psychology, whereby psychological perspectives can be compared and findings within these perspectives can be critically reflected (weighed against each other and evaluated in terms of context and situation). Furthermore, a critical approach in combination with self-knowledge can be a means of challenging and changing the establishment of popular and faulty use of psychology concepts and theories. However, Swedish teachers did not raise this particular challenge as an issue.

The Generalizability of the Study

A majority of Tulis' (2018) challenges seem to be applicable to other subjects—in so far that the challenges are general (transforming theory into practice, for instance, along with the focus on critical thinking), the didactical frame from which they originate may also be considered general in line with Brante's claims (Brante, 2016). However, subject didactics can be seen as a combination of subject matter considerations and general didactics (Kansanen, 2009). Subject matter content specific to psychology is evident in both Tulis' challenges and those described by Swedish teachers as, for instance, the consideration of behavior and human experience in challenge 2 and the importance of behavior, emotions, and cognition (thinking) mentioned by Swedish teachers in regards to what differentiates psychology didactics from other subjects. Self-knowledge through the practice of self-reflection facilitated by case studies offers a potential solution to several challenges and the potential for a subject-specific approach. Complexity thinking based on complex network theory suggests that phenomena must be looked at holistically, and this enables multiple causalities, multiple perspectives, and multiple effects to be charted. We argue that complexity thinking combined with the model (proposed here), which aims to delimit the field of investigation—enables an understanding of subject didactics of psychology. Complexity thinking coming out of the model proposed here then can be applied to general didactics (i.e., it can be relevant for any pedagogical situation) and subject didactics (at different levels) that deal with teaching different subjects in organizations/schools due to the possibility to adjust the focus and the field of delimitation.

Complexity thinking does not aim to fix a focus on either subject matter didactics or general didactics, but in this study, we have aimed to discuss the challenges, described by teachers, to the development of subject matter didactics at the secondary level in Swedish education and use this to consider possible solutions to challenges voiced by researchers concerned with establishing a research field and *vice versa*. The analysis carried out here does lend support for the possibility of establishing a meta-level of subject didactics as proposed in support of Sjöströms' proposal (2018) but does not definitely preclude Brante's proposal (2016), complexity thinking points to a variety of possible delimitations of levels. Swedish teachers experience similar challenges as those

described in Tulis' proposal. Furthermore, the way in which these challenges were met by Swedish teachers does bring insights of importance to the proposal set forward by Tulis (2018), pointing to the generalizability of the results of the investigation carried out here.

Complexity thinking combined with the model presented here can be applied to understand and discuss questions and challenges to the establishment of subject didactics at the micro levels as well as meta-levels along with challenges faced at different levels of education, including tertiary levels. However, one must assume that there is still no definite and widely accepted answer to the question of how subject matter didactics relates to neighboring disciplines like educational sciences and pedagogy; the sheer number and the diversity of models used to describe subject matter didactics make this point.

Suggestions for Future Research

Suggestions regarding possible fields for future research coming out of the model used for the analysis of the case of psychology teaching at the secondary level in Swedish schools will be presented here. It is proposed that complexity thinking is well placed to address several dimensions of psychology didactics which have emerged as important in the investigation carried out here, along with the challenges described by Tulis. Research can be carried out at the micro level (measuring classroom interactions, effectiveness of different teaching methods) and at the macro level (curriculum studies) separately. An emphasis is placed on the importance of taking a holistic approach (or understanding "the whole") in this article. Society is currently complex. It is a flexible fluid society (Bauman, 2003), and it is important for individuals to be able to adapt to quick changes and to learn until the end of life.

In this study, the necessity of establishing a research field within secondary level psychology didactics has been pointed to. However, the role of research is seen to relate to both informing development and underpinning professional practice in relation to two main aspects: firstly, educational work in general and, secondly, in specific subject matter didactics (Hudson, 2007). What characterizes psychology didactics, setting it apart from other subject didactics, according to the investigation presented here is, among other things, the focus on behaviors, emotions, cognition, and an emphasis on self-knowledge as coming out of the case study of Swedish teacher practices, the translation of curriculum goals involving the demand that pupils should learn, and transform theories within psychology into practice through self-reflections in order to increase their self-knowledge, which in turn requires special teaching methods (in order to reach the goals of the curriculum). It is suggested here that future research focus on the means of increasing pupils self-knowledge and consider what kind of environment, methods, equipment, and support determines the emergence of self-knowledge in the classroom?

Learning about different theories and approaches in psychology may have an important role in improving pupils' critical thinking. The question also arises regarding student-centeredness (decentralized control) as opposed to teacher-centeredness (centralized control) in the classroom (Davis and Simmt, 2006). If the classroom works as centralized hub (teacher-centered network), pupils may not have enough autonomy to think freely or share their experiences and different opinions with each other (it may even hamper critical thinking). Questions could be asked, such as: How is it possible to give more autonomy to pupils in secondary schools to learn the subject in a more decentralized way in the classroom but to avoid consolidating their "lay experiences"? How can teachers introduce complex theories in psychology and their relations to each other? What role might creativity have in a consolidation of this approach? How can concepts and approaches be interpreted by the teachers as related/or not related to the goals of the curriculum?

In response to Tulis' claims regarding challenges to the foundation of a new research field within secondary level psychology didactics, we suggest that future research should also take into consideration how the basics and the applications of psychology can be integrated into a superordinate model and networked with each other. This could be helpful not only for the pupils but also for their teachers. According to Davis and Simmt (2006), research must also consider teachers' knowledge about different concepts in psychology and their knowledge about how these concepts are developed and come to interact. In line with this aim, we suggest that future research also focuses on the complexity of the teachers' knowledge and their pedagogical content knowledge (PCK) (Shulman, 1986, 1987; Nilsson, 2013, 2014; Nilsson and Karlsson, 2019). PCK suggests that teachers need pedagogical content knowledge, a special kind of knowledge teachers develop about how to teach a particular content to particular pupils. Teachers need to find appropriate methods and facilitate interactions in the classroom in order to teach theories and deepen their pupils' self-knowledge through introspection, etc. PCK can supply or result in an important understanding of how teachers present and interpret these concepts to their pupils and how they relate that to their pupils' learning.

Finally, further research at the macro level should focus more on complex changes in society (educational policy) and how these transformations may determine changes in the curriculum (Carlgren and Kallos, 1997). However, research at the macro level should not be thought of as separate from that at the micro level. We also need to understand emergence at the micro level, i.e., in the classroom (subject didactics) in regard to changes at the macro level. As we suggested, the classroom works as a complex system/network itself and nested with the macro level. Macro level has top-down control on micro level through the curriculum (context dependency) and through implementing technological and digital development (socio-technological dependency). However, multilevel descriptions are required for understanding because the macro level influences on the micro level and *vice versa*, demonstrating the process of circular causality (Nunez, 2016, p. 72). In addition, the connection between socio-technological development and how digital pedagogy should be implemented into psychology teaching in the secondary schools and higher education levels are relevant issues (Goldman-Segall and Maxwell, 2003).

CONCLUSION

We interpreted the results coming out of a survey sent to psychology teachers in Swedish secondary schools (the first mapping of teacher practices within a secondary school of its kind) and the emergence of challenges in teaching the subject using thematic analysis.

Swedish teachers experience similar challenges as those described in Tulis' (2018) proposal. Furthermore, the way in which these challenges were met by Swedish teachers does bring insights of importance to the proposal set forward by Tulis (2018). Knowledge development is described here as emergent from interactions between teachers and pupils as well as important artifacts such as books and technology, even words (Dahlbom et al., 2002). Further knowledge is discussed as embodied. The Swedish curriculum is considered here along with a brief presentation of how Swedish teachers currently "translate" the curriculum into practice. Complexity thinking, combined with a model allowing for a delimitation of the field of study, was applied to a case study coming out of secondary level psychology education in Sweden, focusing on the importance of self-knowledge (subject specific) along with the transformation of theory to practice (general didactics). The former points to a teacher-centered nested subsystem with asymmetric relations with pupils, and the latter points to a student-centered nested subsystem coming out of embodied knowledge (e.g., pupils as nodes) where psychological perspectives are learnt through self-reflection, case studies, and everyday life experiences (turning theory into practice), thereby implying a holistic approach.

If a field specific to psychology didactics—a meta-level of subject didactics as suggested by Sjöström (2018)—the emphasis on behaviors (possibly also emotions and cognitions) as well as self-knowledge could be a possible way forward. The analysis applied to the case study at hand enabled a consideration of issues regarding both micro and macro levels of didactics (concerns regarding both subject content and general didactics were evident) and illustrated how complexity theory has the potential to address the challenges described by international researchers and indicate possible solutions.

In this study, challenges to the foundation of a new research field within secondary level psychology didactics have been considered—the results presented here point to possible solutions—providing some support for the proposal, along with possible ways forward, in regards to the development of the field, not solely limited to national concerns. There is a need for broad research in psychology didactics, where complex issues need to be taken into consideration at the micro and the macro levels in didactics presented in our model (**Figure 1**).

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request 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. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

LH and AH contributed to the conceptualization of this study, formal analysis of data, investigation/experiment design, methodology, visualization of tables and figure, and writing of the manuscript. LH took charge of data curation and project administration. Both authors contributed to the article and approved the submitted version.

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The Relevance of Online Social Relationships Among the Elderly: How Using the Web Could Enhance Quality of Life?

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This observational study analyzes the impact of Internet use on the quality of life and well-being of the elderly. Specifically, it seeks to understand and clarify the effects of Internet use on relationships in terms of self-esteem, life satisfaction, and Online and Offline Social Support in a sample of senior and elderly Italian people (over 60 years of age). A cohort of 271 elderly people (133 males and 138 females) aged between 60 and 94 years old participated in the study: 236 were Internet Users while the other 35 were Non-Internet Users. The results showed that the time elderly people spend online has a negative effect on their perception of Offline Social Support (Offline Emotional and Informational and Offline Affective Social Support) and a positive effect on their perception of Online Social Support (particularly on Online Positive Social Interactions). Surprisingly, Internet use among elderly people seems to positively affect the perception of Offline Social Support. Indeed, elderly Internet Users have a more positive perception of Offline Social Support (particularly Offline Positive Social Interactions and Offline Affective Social Support) than Non-Internet Users. A discussion of this finding is provided, positing that the Internet seems to represent the technological side of a functional organ that allows the elderly to stay in closer touch with their family and friends and in doing so to also overcome some age-related difficulties.

Keywords: elderly, Internet, quality of life, social support, well-being

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INTRODUCTION

In 2019, around 10% of the world's population was over 65 years old, and this percentage is expected to increase significantly by 2050. Currently, in the European Union, 18% of the approximately 750 million people are over 65 years, and the age group of the over 80s is increasing faster in Europe than in non-European countries.

The distinction between periods of life or stages of development such as "third age" and "fourth age" is fundamentally arbitrary, and there are no strict criteria that determine the transition from the former to the latter (Titmus, 2014). While in developed countries most "third age" (generally around 65 years) individuals have sufficiently good health conditions that allow them to live independently in private homes and participate actively in social

life, the "fourth age" (around the age of 85 years) refers to people who mainly experience difficulties in managing with independent living; they often need medical treatment and become fundamentally dependent on one or more caregivers (Stephens et al., 2015). Indeed, in developed countries, it is evident that people over the age of 85 are the most susceptible to disease and disability (Unger, 2012). Physiological aging impacts sensorial perception (hearing, vision, taste, and proprioception), the motor system (due to neuronal decay and/or loss of muscle tone), as well as cognitive abilities. This places an unavoidable economic burden on health services, a factor that should be appropriately considered when assessing the sustainability of social systems of the future (Sharkey and Sharkey, 2012). However, it should also be remembered that physical–cognitive decay through aging produces a spiraling process that makes it increasingly difficult for the elderly to remain physically mobile; given that they are already affected by the progressive thinning of social networks due to mortality, the elderly run the risk of progressive isolation from social life (Rosso et al., 2013).

For this reason, Stephens et al. (2015) affirm that in addition to the design of intervention programs aimed primarily at individual wellness, it is useful to deal with areas related to the management of the social and physical environment of reference of the elderly; this could help alleviate much loneliness and social exclusion. In this regard, caregivers need access to adequate tools and strategies for encouraging the maintenance and creation of social support. Among the principal aspects to consider for promoting good health in the elderly and planning useful prevention strategies to improve their quality of life (QoL), Foster and Walker (2015) suggest:

- The role and effectiveness of the network of social relationships in support of the elderly, and strategies for maintaining good levels of autonomy and independence even in advanced age;
- The role of technological aids in reducing disability and alleviating functional decline in the elderly, particularly via technological innovations aimed at improving communication, tecno-assistance, and home care.

Therefore, the individual's social and community context as part of a dynamic system plays a fundamental role in defining the general state of health of the person: well-being is a social construct and, as such, finds expression also in the capital of human relations (Marmot et al., 2012). As highlighted above, the maintenance and enhancement of social networks are relevant aspects for so-called Active Aging (Fernández-Ballesteros, 2008); with advancing age, the risk of progressive weakening and loss of contacts and bonds increases, and this can lead to situations of exclusion and social isolation. Given the growing interest in the potential of social relationships networks as a means for promoting the mental health and well-being of the elderly, the concept of social capital has become increasingly relevant (World Health Organization, 2013).

SOCIAL CAPITAL, SOCIAL SUPPORT, AND ICT FOR PROMOTING QoL AMONG THE ELDERLY

QoL is a multidimensional concept that embraces subjective and objective aspects of a person's life situation contextualized in a given socio-cultural and economic environment (Phillips et al., 2010), with particularly strong social connotations. Indeed, as widely documented in the literature, the concept of health is closely related to the social resources available to the individual. Therefore, social capital in advanced age can be considered a fundamental component in determining and defining the state of well-being and QoL (Nyqvist et al., 2013). The functional dimension of social capital is social support, which represents a fundamental element of QoL among the elderly, manifesting in emotional, instrumental, informative, and evaluation support (Phillips et al., 2010).

Bourdieu (1980) introduced the concept of social capital, defining it as the set of resources that are embedded in networks of relationships and which can be accessed in case of need.

The concept of social capital can be defined and measured through different dimensions, which include indicators such as the quantity and quality of social relations, and that determine different types of relations, e.g., bonding and bridging ties (Poortinga, 2012). Bonding social capital, like the relationships that characterize the family context, refers to strong intra-group bonds, while bridging social capital refers to the construction of weaker bonds between heterogeneous groups. Strong ties are not very diversified in terms of social extraction but offer relationships characterized by greater interpersonal closeness (Williams, 2006). Bridging ties include those between acquaintances and are established among more diverse and heterogeneous groups. These links are more cross-sectoral than strong ties and provide access to different and more varied resources (Granovetter, 1973, 1982) or other information that is not available in a close social network (typified by the sharing of largely common information, knowledge, and practices).

While in the past social capital was based on face-to-face interactions, phone calls, or postal correspondence, nowadays a large part of human intercommunications are conducted via ICT and Internet tools. Currently, these mostly involve the use of computers, tablets, and especially smartphones to access online meeting places and synchronous and asynchronous communication channels [e-mail, audio-video conferencing systems, chat systems, social networking sites (SNSs), etc.]. However, what possible role can digital devices play in creating or maintaining networks of relationships related to social support? Moreover, could the use of ICT, therefore, particularly in advanced age, contribute to the promotion of active and healthy aging?

In the case of bonding social capital and the Internet, few studies have examined the relationship between the Internet and bonding social capital (Williams, 2006). Although scholars have envisaged a probable net loss of social capital in face-to-face interactions as a result of growing usage of the Internet, Williams suggests that many studies have failed to focus on

the benefits that online interactions could yield in replacing, maintaining, or integrating strong networks. Indeed, most studies that investigate the effects of using the Internet focus on the associated risks (Mazzoni et al., 2016). Dwelling exclusively on the potentially harmful aspects deriving from the use of the Internet can however, be reductive and misleading. Instead, a positive approach to the study of the effects that technology has on real life allows us to consider the potential resources that Internet access can grant access to, even the case of quite elderly users. For example, an exploratory study of over-sixty Internet Users in Australia (Russell et al., 2008) has shown that although the Internet is not the only tool capable of maintaining social networks in advanced age, its use can bolster real social capital, preventing the loss of previously established contacts.

From the Vygotskian concept of the Zone of Proximal Development and that of functional artifacts developed by Leontev (1978), Internet tools could be seen as functional organs (Kaptelinin, 1996) that allow people to achieve better performance than they would without technological devices; in case of elderly people, they can compensate for weakness or loss of individual or structural capacities due to aging. However, in some cases, digital tools are used not for their primary function but rather to compensate for something lacking in real life, such as taking pictures not to record and share an event or experience but rather to capture general attention, receive likes, and enhance one's self-esteem. In such cases, there is a risk that instead of making constructive use of the tool, the user loses control of it and becomes subordinate to it, objectifying any potential active role. Ekbia and Nardi (2012) name this process *inverse instrumentality*, since the user risks losing control of the objectives of their actions this would happen, for example, if the user were to attend a cultural event, such as a concert, with the primary intent of taking pictures to upload online so as to boost self-esteem, rather than to appreciate the artists' performance. So, to understand if and how technologies can influence the creation and maintenance of social capital relationships, it is necessary to investigate what factors and conditions incline the user toward use of technology as a functional organ or instead in a condition of inverse instrumentality (Frozzi and Mazzoni, 2011).

Regarding the role that the use of technologies can play in maintaining or creating social networks, Zywica and Danowski (2008) have observed how people who have more well-developed social networks offline tend to grow and expand their network of relationships through online interactions, as a sort of enhancement of the former. Indeed, some studies (Lampe et al., 2006; Lenhart and Madden, 2007) suggest that SNSs are frequently used to stay in touch with people that are part of a person's offline, or real, social capital. Results from these studies show, for example, that Facebook users are also (or even more) interested in connecting with people they already know in the real world rather than exclusively online connections. Boyd and Ellison (2007) stressed that, prior to the diffusion of SNSs, offline and online communities were largely disconnected, with little of the overlap we see today. Although these results come from studies carried out with teenagers and young people, we can hypothesize that the same is even more evident for elderly people who, already having a structured social capital, do not have the same need to expand their existing social networks as they have more chances to stay in touch with them.

However, even people with weaker and less developed offline social networks tend to expand their online relationships, possibly as a compensatory effect. By following the "social compensation vs enhancement hypothesis" of Zywica and Danowski (2008); Mazzoni et al. (2016) showed how the Internet can be used as a functional organ in the creation and maintenance of the capital of relationships where there is already a good level of Offline Social Support in real life. When, on the other hand, offline social networks are weak or inexistent, a compensatory mechanism could be triggered to try online to fill this gap, thus running the risk of inverse instrumentality.

Unfortunately, the role of Information and Communication Technologies (ICT) in determining the QoL of elderly people through the creation and maintenance of social capital has generally been neglected in social gerontology, with existing studies mainly focusing on medical and care technologies (Xie, 2007).

An interesting review by Boz and Karatas (2015) considered 25 studies from the period 2000–2015, examining the impact of Internet use on elderly people's QoL. The review demonstrated that functional use of the computer and Internet can improve the life quality of the elderly with 15 of the 25 studies showing a significant relationship between Internet use and QoL for the elderly, whereas no relationship was found in other studies.

In one of the earliest studies investigating the effect of Internet use on social relations and QoL among the elderly, White et al. (1999) provided Internet and e-mail access to senior residents at a retirement center. A significant decrease in the loneliness and social isolation level of the elderly was found in the intervention group, while in the comparison group the same factors remained unchanged. In a more recent study (Osman et al., 2005), 50 elderly people were provided with a computer with Internet and access to a web portal specifically addressing the needs of the elderly; participants received thorough training on Internet use throughout the project. During the post-intervention interviews, the participants described Internet use as a potential "window on the outside world." During the course of the study, it was observed that access to the Internet and to e-mail reduced the social isolation of the elderly participants and strengthened their social interactions.

Even more recently, Sum et al. (2008) explored the impact of Internet use on the sense of belonging to a community in advanced age, showing that it facilitates the elderly's social interaction with family members and friends and extends their social network. The results of this study show the complex relationship between use of the Internet, social capital, and well-being; being connected online influences the social capital and well-being of elderly people in different ways, partly in relation to the average time spent on online activities. Going into detail, the authors observed that where the Internet is used to search for information and to communicate with others (as correlated with high levels of well-being and lower levels of perceived loneliness), a positive impact on social capital is generated. By contrast, Internet use to meet new people and pass the time (as related to lower levels of well-being and greater perception of

loneliness) has a significantly lower impact on the creation of social support networks. These results, therefore, underline that the use of technologies to compensate for the lack of satisfying and meaningful relationships in real life can lead to situations of inverse instrumentality, while the technological tool becomes a functional organ when it is a support for an existing network of offline relationships (Sum et al., 2008; Mazzoni et al., 2015).

An interesting study, based on the European Social Survey (ESS1), examined the impact of Internet use on social isolation and well-being of 11,000 Internet Users aged 65 from 26 countries (Lelkes, 2013). As the results indicate, the elderly's face-to-face interactions are not replaced by online communication, which, on the contrary, acts as a complementary and strengthening factor for the former. Indeed, even though the subjects communicated with their family and friends over the Internet, they reported that they still prefer to meet people face to face. Furthermore, the results showed that elderly people who use the Internet on average for more time during the day tend to have lower chances of meeting face to face with the people who belong to their social capital.

A recent Korean study (Nam, 2019) examined the mediating effect of social support on the relationship between older adults' use of social media and their QoL. The results confirmed the mediating effect of social support and showed that social media use not only had a direct effect on QoL but also had an indirect effect through social support. However, another study (Kim, 2018) with a similar sample (Korean adults aged 65 and over) examined the influence of smartphone use on life satisfaction, depression, social activity, and social support and found different results. Specifically, smartphone use produced no statistically significant impact on older adults' social support, even though the general results of the study suggest that use of ICT such as smartphones in advanced age can play generally positive roles in enhancing psychological, mental, and social aspects of the QoL.

The inverse proportionality between Internet use and QoL (particularly as it pertains to social contacts) has also been highlighted by Khalaila and Vitman-Schorr (2018). In their analysis of the extant literature, they show that Internet use is significantly associated with decreased time spent with friends and decreased local social networking, with a risk of increasing loneliness and decreasing various aspects of QoL (Kraut et al., 1998; Coget et al., 2002). Indeed, Internet use would seem to not only replace face-to-face contacts with weaker online ties but also diminish participation in in-person social activities (Nie and Hillygus, 2002), thus outing personal contacts at risk (Veena et al., 2012) and generating new forms of isolation and marginalization (Gardner et al., 2012). However, on the other hand, many other studies suggest that older adults can benefit from Internet use in many aspects of their social life, such as constructing new personal friendships, enhancing the quantity and quality of contacts with family and friends, and maintaining social involvement (Veena et al., 2012; Chen and Schulz, 2016; Yu et al., 2016). In this light, Khalaila and Vitman-Schorr (2018) explored the direct and/or indirect effects of Internet use on QoL, by conducting structured interviews with a sample of 502 respondents aged 50 and older living in northern Israel. Their results show that Internet use is positively associated with QoL, with loneliness being a mediation effect: Internet use is associated with a lower level of loneliness, which in turn is related to greater QoL. Furthermore, results show a moderated effect of time spent daily with family members: Internet use seems to be helpful in increasing QoL only for those who spend average or above-average time with their family. Since without face-to-face contacts Internet use does not represent an added value on predicting QoL, the authors' interpretation is that online contacts (Internet use) and face-to-face contacts (time spent with family) have a synergistic effect on QoL.

In a study with a sample of adults living in Portugal, of which 118 were older adults, Neves et al. (2018) found that social capital is positively related to Internet use but negatively related to age. On the one hand, greater Internet use increases the likelihood of having a high level of social capital. On the other hand, the Internet seems to counterbalance the negative relationship between age and social capital: indeed, older heavy Internet Users were more likely to have high levels of social capital than older light-users or non-users. However, only more highly educated older adults seem to profit from that buffering moderating effect of Internet use. In addition to these results, this study is very interesting since it proposes a difference between elderly users, elderly light-users, and elderly non-users. Furthermore, it considers both online and offline social capital, as they each could have a different and interactive effect on elderly QoL. Interestingly, to measure social capital, the authors proposed a combination of indicators to capture quality and quantity of social ties. In particular, they also used items taken from the Internet Social Capital Scales (Williams, 2006), which consider offline and online bonding and bridging dimensions and feature items very similar to those adopted in the more recent Offline/Online Social Support Scale (Leung and Lee, 2005; Wang and Wang, 2013). Finally, as the authors claimed, the Internet seems to play a contrasting role in the life of the elderly. While it helps them to accrue, maintain, and mobilize social capital, its cumulative advantage effect could reinforce forms of social inequality, particularly those determined by age and education.

THE STUDY

Starting from the extant literature, this observational study considers social capital (both offline and online) as a significant resource for promoting well-being and QoL among elderly people (Nyqvist et al., 2013). Thus, considering social capital as the social ties that could support older people in their daily life in both offline and online contexts (Wang and Wang, 2013; Mazzoni et al., 2016), this study seeks to understand and clarify the effects of Internet use on relationships that characterize self-esteem, life satisfaction, and Online and Offline Social Support in a sample of elderly Italian people (over 60 years). Indeed, as described earlier and as reported by several studies on Active Aging (Boudiny, 2013; Foster and Walker, 2015), self-esteem and life satisfaction are seen as fundamental dimensions in determining the levels of well-being of the person: more precisely, results show a general decrease in the levels of self-esteem and satisfaction with one's life with advancing age (McAuley et al., 2000; Robins et al., 2002;

Pavot and Diener, 2008). At the same time, in the light of the literature reported herein, given that all these factors are related to the QoL and well-being, the study also intends to understand which of the considered Internet use factors prove particularly significant in determining QoL and well-being of the elderly.

MATERIALS AND METHODS

Recruitment Strategy and Data Collection

Recruiting the participant sample for the study was a particularly delicate process. First of all, an online search led to identification of organizations, associations, and centers for lifelong learning that hold digital literacy courses for the elderly; these were then contacted to propose subject participation in the study. One particularly interesting recruitment source was a non-profit organization offering a third-age digital literacy program to train elderly people to use the web and promote active aging. Other members of the subject cohort included participants in computer literacy courses for over-65s that were held by a local council in central Italy. Finally, participants in evening digital literacy courses for over-60s held by a cultural association in a small town in central Italy also agreed to participate. In each context, during the first training session of the respective courses, all participants were required to fill in an online questionnaire with the support of tutor-trainers where needed.

The first part of the questionnaire concerned informed consent about participation in the study and data treatment. Even though the adopted sampling procedure can be seen as a limitation of the study, it allowed us to reach a large number of elderly people with a common interest in learning how to use digital technologies, albeit from different competence/experience baselines.

The online questionnaire was structured in three parts:

- Sociodemographic information (gender, age, region, and province of residence, educational level, current employment, and housing status).
- Information related to access and use of digital technologies, specifically type of device (PC, tablet, and smartphone); average daily hours of use of each device; how access to the device came about and how the subject learned to use it; frequency of activities carried out online; frequency of online interactions with various connection types (weak and strong ties); willingness and interest in improving skills in using technologies to carry out different online activities.
- Information regarding those parameters that the extant literature identifies as influencing QoL: social support, self-esteem, and life satisfaction. This last one was measured using validated scales.

Measures

Offline and Online Social Support

An Italian translation of the Offline and Online Social Support Scales (Leung and Lee, 2005; Wang and Wang, 2013) for the measurement of social support perceived in both offline and online relationships was adopted. Both scales consist of 11 items related to the initial question "How often is each of the following kinds of support available to you if you need it?" To answer, participants select a response from one of the five levels in which the proposed Likert scale response range is divided (from never to always). The scale items can be divided into three subscales (Emotional and Informational, Positive Social Interaction, and Affective). Items 1, 2, 3, and 4 refer to Emotional and Informational (EI) social support, which involves caring, warmth and affection, and sympathy, as well as offering guidance, advice, information, or feedback for problem solving. Items 5, 6, and 7 refer to Positive Social Interactions (PSI), also called social companionship, as it is related to spending time with others in leisure and recreational activities. Finally, items 8, 9, 10, and 11 refer to Affective (AF) social support characterized by (non-problem related) expressions of love and affection.

Self-Esteem

To collect data about self-esteem, the Italian adaptation (Prezza et al., 1997) of the Rosenberg Self-Esteem Scale (Rosenberg, 1965) was used.

Life Satisfaction

To measure participants' general life satisfaction and perceived subjective well-being, we used the Italian adaptation (Di Fabio and Gori, 2016) of the Diener Satisfaction with Life Scale (Diener et al., 1985). To answer the five items in the scale, participants selected from seven levels on a Likert scale (from Strongly disagree to Strongly agree).

Variables Considered for the Analyses

Based on what has been previously described, analyses have been focused particularly on the following variables:

- Gender.
- Age.
- Type of devices (computer, tablet, smartphone, more than one device).
- Time spent online.
- Offline Social Support (OffLine SS): Emotional and Informational (OffLine EI); Positive Social Interactions (OffLine PSI); Affective (OffLine AF).
- Online Social Support (OnLine SS): Emotional and Informational (OnLine EI); Positive Social Interactions (OnLine PSI); Affective (OnLine AF).
- Rosenberg Self-Esteem.
- Life Satisfaction.

Description and Organization of Sample

The sample was composed of 271 subjects (133 males and 138 females) aged between 60 and 94 (mean = 72.48; SD = 6.07) who were attending one of the digital literacy courses previously described. In terms of household status, most of the participants stated that they live with a spouse/partner (71.2%), 8.1% with another family member (8.1%), while 20.7% lived alone. The vast majority of the sample (88.9%) were pensioners, and their overall educational level was high by Italian standards

for this demographic (52.8% had at least gained their high school diploma).

The total sample was divided into two subgroups: Internet Users (IU) and Internet Non-Users (INU). The IU group comprised 236 participants (118 males and 118 females, mean age = 72.33, SD = 6.14), while the INU group totaled 35 subjects (20 males and 15 females, mean age = 73.49, SD = 5.57).

Subjects belonging to the IU group were subsequently divided into three subgroups on the basis of their habitual device use. These were the PC group (61 participants who only access the Internet using a computer or tablet), the SP group (smartphone Internet Users), and the MD group (141 subjects who access the Internet using multiple device types).

A complete statistical breakdown of the whole sample and of the subgroups is presented in **Table 1**, showing participant's age, gender, household status, occupational status, and education level.

Statistical Analysis Strategy

First, a one-way multivariate analysis of covariance (MANCOVA) was performed on Offline Social Support and its subscales (EI, PSI, and AF), Online Social Support and its subscales (EI, PSI and AF), the Rosenberg Self-Esteem Scale, and the Satisfaction With Life Scale, namely, the dependent variables of interest in the study. GROUP (PC, SP, MD) was used as a between-subject factor, while TIME (total hours spent online) and AGE were treated as covariates.

A second one-way MANCOVA was performed on the Offline Social Support scale and its subscales, on the Rosenberg Self-Esteem Scale, and on the Satisfaction With Life Scale (dependent variables), while GROUP (IU vs INU) was treated as a between-subject factor and AGE was treated as a covariate.

The MANCOVA assumptions (multivariate normality, homogeneity of variances, equal covariance matrices across groups, and uncorrelated model errors) were carefully checked and were met.

TABLE 1 | Descriptive statistics of the total sample and the subgroups (IU and INU) according to the participant's age, participant's sex, housing status, occupation, and education level.

	IU (*n* = 236)	INU (*n* = 35)	Overall (*n* = 271)
Age (mean ± SD)	72.33 ± 6.14	73.49 ± 5.57	72.48 ± 6.07
Gender (*n*)			
Males	118	20	133
Females	118	15	138
Housing status (*n*)			
Alone	47	9	56
Spouse/partner	173	20	193
Other family members	16	6	22
Occupation (*n*)			
Employed	13	2	15
Retired	212	29	241
Unemployed	11	4	15
Education level (*n*)			
Low-level education	109	19	128
High-level education	127	16	143

IU, Internet Users group; INU, Internet Non-Users group.

RESULTS

The one-way MANCOVA showed no significant differences between groups [GROUP effect: $F_{(9,218)} = 1.61$; $p = 0.053$; partial $\eta^2 = 0.06$]. More specifically, the groups did not differ for Offline and Online Social Support scales and subscales, for Rosenberg Self-Esteem level, or for life satisfaction (see **Additional Table S1** in the **Supplementary Material** for detailed results).

A significant TIME effect was found [$F_{(9,218)} = 3.19$; $p = 0.001$; partial $\eta^2 = 0.12$]; time spent online significantly predicted the majority of the dependent variables included in the analysis (see **Table 2**). Time spent online negatively affected perceived Offline Social Support (SS), perception of Offline Affective support (AF), and perception of Emotional and Informational support (EI; see **Table 2**). A significant positive TIME effect was found on the Online Social Support (SS) perception and on perceived Online Positive Social Interaction (PSI; see **Table 2**).

These results indicate that the more the subject uses the Internet, the lower their perception of Offline Social Support. On the contrary, greater Internet use raises the perception of Online Social Support.

A significant TIME effect was found regarding self-esteem, in that time spent online negatively predicts the subject's self-esteem. A similar result was found for the Life Satisfaction Scale: time spent online negatively predicts the subject's life satisfaction (see **Table 2**).

AGE was not found to have a significant transversal effect [$F_{(9,218)} = 1.74$; $p = 0.08$; partial $\eta^2 = 0.07$]. However, univariate analysis did show a significant AGE effect on the perception of positive online social interaction (PSI), showing how age negatively predict online PSI (Parameter estimates: b = -0.03, SE = 0.01; $p = 0.04$; partial $\eta^2 = 0.02$).

One-way MANCOVA applied to compare Internet Users (IU) and Internet Non-Users (INU) showed a significant GROUP

TABLE 2 | One-way MANCOVA results: parameter estimates table of TIME effect on OffLine scale and subscales, OnLine scale and subscales, Rosenberg Self-Esteem Scale, and Life Satisfaction Scale.

Parameter: TIME

Dependent variables	*b*	*SE*	*t*	Partial η^2
OffLine SS	−0.02	0.01	−2.33**	0.02
OffLine EI	−0.02	0.01	−2.17**	0.02
OffLine PSI	−0.00	0.01	−0.280	0.00
OffLine AF	−0.03	0.01	−2.93**	0.04
OnLine SS	0.02	0.01	2.15**	0.02
OnLine EI	0.01	0.01	1.28	0.01
OnLine PSI	0.03	0.01	3.11**	0.04
OnLine AF	0.02	0.01	1.86	0.02
Rosenberg Self-Esteem	−0.07	0.03	−2.63**	0.03
Life Satisfaction	−0.04	0.01	−2.59**	0.03

*EI, Emotional and Informational support; PSI, Positive Social Interaction; AF, Affective Support; SS, Social Support. *$p < 0.05$; **$p < 0.01$.*

effect [$F_{(6,256)}$ = 2.23; p = 0.04; partial η^2 = 0.05]. As **Table 3** shows, the INU group perceived a general lower Offline Social Support compared to the IU group [$F_{(1,261)}$ = 4.43; p = 0.04; partial η^2 = 0.02]. A lower Positive Social Interaction [$F_{(1,261)}$ = 4.54; p = 0.03; partial η^2 = 0.02] and a lower Affective Social Support [$F_{(1,261)}$ = 6.21; p = 0.01; partial η^2 = 0.02] compared to IU groups was also found (see **Table 3**).

No significant difference on self-esteem level [$F_{(1,261)}$ = 0.15; p = 0.70; partial η^2 = 0.0] or on life satisfaction [$F_{(1,261)}$ = 0.61; p = 0.44; partial η^2 = 0.0] was found.

Results showed a significant general AGE effect [$F_{(6,256)}$ = 2.82; p = 0.01; partial η^2 = 0.06]. Looking at the estimated parameters, it emerged that age is a significant predictor only of the perception of Positive Social Interaction; in particular, with increasing age, the perception of Positive Social Interaction decreases (b = -0.02, SE = 0.01; t = 0.22.28, p = 0.02; partial η^2 = 0.02).

DISCUSSION

In general, three main results emerge from the data analysis. First, the amount of time elderly people spend online affects their self-esteem and life satisfaction. Second, the same independent variable affects their perception of Social Support, both of the Offline and Online varieties. Finally, elderly people's Internet use is correlated to their perception of Offline Social Support.

The first result could be interpreted in two different ways depending on the adopted perspective. Following Neves et al. (2018), and also the literature analysis of Khalaila and Vitman-Schorr (2018), we could say that elderly people's Internet use seems to have a cumulative disadvantage effect: the more they use the Internet, the more this could decrease their autonomous movement and opportunities to engage in face-to-face contacts. These factors would present the risk of isolation, thereby negatively affecting their self-esteem and life satisfaction. However, following the social compensation hypothesis of Zywica and Danowski (2008), the lower elderly people's self-esteem and life satisfaction (perhaps related to low levels of health, autonomy, social contacts, etc.), the more they try to compensate offline life deficiencies via online experience. Thus, they tend to pass more time on the Internet to try to satisfy their needs.

TABLE 3 | Estimated marginal means on OffLine scale and subscales, Rosenberg Self-Esteem Scale, and Life Satisfaction Scale in Internet Users group (IU) and Internet Non-Users group (INU).

	IU; n = 231 (mean ± SE)	INU; n = 33 (mean ± SE)
OffLine SS	3.37 ± 0.07	3.20 ± 0.18
OffLine EI	3.52 ± 0.0	3.15 ± 0.16
OffLine PSI	3.88 ± 0.07	3.42 ± 0.17
OffLine AF	3.58 ± 0.05	3.25 ± 0.14
Rosenberg Self-Esteem	22.55 ± 0.19	22.34 ± 0.51
Life Satisfaction	5.03 ± 0.10	5.25 ± 0.26

Covariates appearing in the model are evaluated at the following values: AGE = 72.43. EI, Emotional and Informational support; PSI, Positive Social Interaction; AF, Affective Support; SS, Social Support.

Although the other two results regarding social support are both very interesting, the first is not so surprising as the second. The first shows a double effect of time of Internet connection on the perception of Social Support: negative for the Offline variety and positive for Online. This result can be interpreted in the light of the study by Lelkes (2013) in which older people reported preferring to meet their family and friends face to face than communicating with them over the Internet. A hypothesis that Turkle formulated (Turkle, 2017) is that when people pass a lot of time online, they end up preferring online relations to offline ones, due to the illusion of control over interactions that Internet applications (particularly chats) can generate. Thus, despite the functional effect for Online Social Support, elderly people passing more time on the Internet seems to have an inverse instrumental effect (Ekbia and Nardi, 2012) on Offline Social Support. This is probably because the time spent online leaves them less time for face-to-face interactions, thereby negatively affecting their self-esteem and life satisfaction. The inverse instrumental effect, following the compensation hypothesis of Zywica and Danowski (2008), could be generated by the fact that the more elderly people pass time online, the more they perceive a loss in Offline Social Support, and so the more they tend to compensate this by constructing Online Social Support (or re-construction Offline support in Online contexts).

Interestingly, online time negatively affects Emotional and Informational Offline Social Support and Affective Social Support, while it positively affects Online Positive Social Interactions. Thus, in the perception of elderly people, the Internet seems to be particularly useful for leisure activities with others, but it negatively affects those everyday life relations characterized by caring, warmth and affection, sympathy, and their expression. As the elderly, like most people, prefer to meet their family and friends face to face, and considering the differentiation between bridging and bonding social capital (Putnam, 2001; Poortinga, 2012), a hypothesis could be that the more the elderly are circumstantially compelled to use the Internet to stay in touch, the more they perceive a loss in bonding social capital, notwithstanding a perceived gain in online social companionship (which can be associated to bridging social capital).

The second general result (amount of Internet time affects perception of both Offline and Online Social Support) seems surprising since one could hypothesize, in line with the first result, which elderly people who do not use the Internet have a perception of higher Offline Social Support than those who do. In fact, the study results show exactly the opposite outcome. Before hazarding an interpretation, we should consider that many factors that were outside the scope of this observational study play a role in the use of ICTs and QoL in senior adults, e.g., interest levels and socioeconomic and health requirements. In particular, some health problems can affect Internet use among older adults. As reported in a study by Choi and DiNitto (2013), dementia was categorized as being negatively associated with Internet use, while Internet-related affordances like getting information about chronic health conditions or contacting a medical provider was positively associated. Unfortunately, in the present study, it was not possible to control for all these factors while also respecting

the protocols of the participating associations; that said, all the participants reached their various course locations autonomously so we can assume that they enjoy relatively good health levels. An alternative interpretation of this result can be gleaned by rereading it in the light of those studies suggesting that SNSs are frequently used to stay in touch with people that are already part of offline or real, social capital (Lampe et al., 2006; Lenhart and Madden, 2007). A hypothesis is that as many elderly people already have a structured social capital, they do not have such an urgent need to *expand* their existing social networks, but rather to *stay in touch* with them. From this point of view, the Internet becomes part of a functional organ (Kaptelinin, 1996) that allows elderly people to enrich their opportunities to stay in touch with their family and friends or to overcome any difficulties in staying in touch with them. Thus, for elderly people, the Internet can really be interpreted as a supporting technology, helping them to maintain and entertain existing offline social relations more frequently and in diverse communication modalities. Interestingly, the hypothesized effect seems to be particularly useful not only for the perception of social companionship (Positive Social Interaction) but also for the expression of love and affection (Affective Social Support). This is probably due to the fact that the Internet provides the means to stay in touch with those persons (bridging social capital) with whom it can be difficult to stay in frequent contact. Thanks to SNS feedback functions such as *likes* and *follows*, Internet use also simulates responses typical of Offline Affective Social Support.

LIMITATIONS OF THE STUDY

The most important limitation of the study is the adopted sampling procedure, which only allowed data collection from about 33 elderly Internet Non-Users. Despite this critical aspect, the recruitment procedure allowed us to reach a large number of elderly people with different degrees of digital experience but with a proactive interest in learning how to use some digital technologies. In future research, a more carefully designed and broadly based sampling procedure could guarantee greater sample balance and the possibility of implementing a quasi-experimental procedure.

A further limitation is that the study considers principally the time-based quantity of Internet use but not the quality, i.e., the actual activities carried out online by elderly people. Even though many previous studies described in the literature show that (excessive) time spent online is one of the most significant factors determining dysfunctional Internet use, future research could nonetheless consider the range of different activities the elderly perform online (e.g., seeking out health information, interacting with friends or with general contacts, playing videogames, etc.). and also the time spent on each one.

CONCLUSION

The results from the above reported analysis allow us to affirm that the Internet is a functional and significant technological artifact that is beneficial for the QoL and well-being of elderly people. Indeed, even though passing substantial amounts of time online can have a detrimental effect on perception of Offline Social Support, elderly people who lack an online life miss multiple opportunities to stay in touch with family and friends and have fewer opportunities for companionship. From this point of view, paraphrasing Paracelsus, we could say that "All things are poison and nothing is without poison; only the dose makes a thing not a poison." For the elderly, the Internet can be a very useful resource to stay in touch and maintain social relationships, whether weak or strong, provided that this is not at the cost of face-to-face meeting spaces, sometimes limited by their own contingencies (for example, limited mobility due to age), but often also by those of family and friends (for various reasons). For these reasons, future research should deepen the relationship between the elderly and the Internet, focusing on motivations for using the Internet. This could reveal whether their Internet use is proactive and employed to exploit its inherent potential or is more simply determined by personal contingencies or those arising from the circle of family, friends, and acquaintances.

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 University of Bologna Bioethics Committee. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

All authors wrote the manuscript, analyzed the data, interpreted the findings, and reviewed the manuscript. MB and EM designed the current study and recruited the participants.

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SUPPLEMENTARY MATERIAL

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"Finding an Emotional Face" Revisited: Differences in Own-Age Bias and the Happiness Superiority Effect in Children and Young Adults

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People seem to differ in their visual search performance involving emotionally expressive faces when these expressions are seen on faces of others close to their age (peers) compared to faces of non-peers, known as the own-age bias (OAB). This study sought to compare search advantages in angry and happy faces detected on faces of adults and children on a pool of children (N = 77, mean age = 5.57) and adults (N = 68, mean age = 21.48). The goals of this study were to (1) examine the developmental trajectory of expression recognition and (2) examine the development of an OAB. Participants were asked to find a target face displaying an emotional expression among eight neutral faces. Results showed that children and adults found happy faces significantly faster than angry and fearful faces regardless of it being present on the faces of peers or non-peers. Adults responded faster to the faces of peers regardless of the expression. Furthermore, while children detected angry faces significantly faster compared to fearful ones, we found no such difference in adults. In contrast, adults detected all expressions significantly faster when they appeared on the faces of other adults compared to the faces of children. In sum, we found evidence for development in detecting facial expressions and also an age-dependent increase in OAB. We suggest that the happy face could have an advantage in visual processing due to its importance in social situations and its overall higher frequency compared to other emotional expressions. Although we only found some evidence on the OAB, using peer or non-peer faces should be a theoretical consideration of future research because the same emotion displayed on non-peers' compared to peers' faces may have different implications and meanings to the perceiver.

Keywords: visual search advantage, anger superiority, happiness superiority, own-age bias, children and adults, emotional expressions

INTRODUCTION

A growing number of studies (Anastasi and Rhodes, 2006; Kuefner et al., 2008; Hills and Lewis, 2011; Rhodes and Anastasi, 2012; Macchi Cassia et al., 2015) point out that both children and adults exhibit poorer performance recognizing non-peer compared to peer faces. If there is such a bias, it seems plausible that it also affects the recognition of emotional cues on the faces. Previous studies (Calvo and Nummenmaa, 2008; Purcell and Stewart, 2010; Becker et al., 2011; Tamm et al., 2017; Becker and Rheem, 2020) listed several possible confounding variables that might be responsible for mixed results in visual search tasks for emotional facial expressions both in children and adults. Most studies point out several possible sources of confound in the facial stimuli, leading to incorrect inferences; such confounding factors were found in both photographs and schematic faces. For instance, Purcell et al. (1996) first noted that photographs' illumination, brightness, and contrast artifacts were to be carefully controlled. The use of schematic faces cannot be the answer (Coelho et al., 2011; Beaudry et al., 2014; Watier, 2018, see also Kennett and Wallis, 2019 for more recent findings) as—beyond violating ecological validity—they also comprise low-level visual features related to the interaction between the lines representing eyebrows and mouth and the surroundings representing the head, forming "T" junctions with the surround. These junctions and differences in line orientation are likely responsible for the search advantage seen in schematic stimuli rather than the "emotions" displayed on the faces. Nonetheless, previous research aiming to discover which emotional facial expression (i.e., anger or happiness) has an advantage in visual processing in preschool children mostly used adult faces (Silvia et al., 2006; Waters and Lipp, 2008; Waters et al., 2008; Lobue, 2009; Farran et al., 2011; Rosset et al., 2011). Thus, the goal of this study is to address another potential confounding variable, the own-age bias (OAB), which was rarely, if at all, acknowledged in previous experiments. The OAB refers to a phenomenon in which individuals exhibit reduced performance in recognizing and detecting expressions of emotions on faces that are either much younger or much older than themselves (Anastasi and Rhodes, 2005, 2006; Kuefner et al., 2008; Hills and Lewis, 2011; Riediger et al., 2011; Rhodes and Anastasi, 2012; Marusak et al., 2013; Craig et al., 2014b; Macchi Cassia et al., 2015).

From an evolutionary point of view, prioritized detection for emotional cues on the faces of others was likely adaptive throughout human evolution as it helped survival by, for instance, foreshadowing danger (angry expression), or promoting trustworthiness (happy expression). Several research fronts are focused on the root causes of visual search advantage related to schematic faces (Kennett and Wallis, 2019), emotional interpretation of Emojis (Franco and Fugate, 2020), or comparing different methods related to happy faces search advantage research (Rohr et al., 2012; Calvo and Beltrán, 2013; Wirth and Wentura, 2020). However, whether happy or angry emotional facial expressions portray particular features that foster accurate and prompt recognition and detection is still debated (e.g., Calvo and Nummenmaa, 2008; Becker and Rheem, 2020). One of the first theories, the anger superiority effect (ASE), demonstrated a fast detection of angry faces when presented in a visual search task—the face in the crowd paradigm (Hansen and Hansen, 1988; Lundqvist et al., 1999; Öhman et al., 2001). It has been argued that this search advantage was a key factor in survival as the advantaged recognition of anger on faces provided a warning that aversive consequences were likely to follow, and thus, gave the perceiver's CNS more time to prepare a fight or flight response (Öhman et al., 2001). These studies (e.g., Hansen and Hansen, 1988; Öhman et al., 2001) often used a 3×3 matrix array with nine (adult) faces each trial, one of them displaying a different emotion than the other eight. Participants' (adults) task was to detect if discrepant faces were present and respond (yes/no) as quickly as possible on a keyboard or by pointing the target's position through the use of a touchscreen. Many of these studies concluded that angry faces pop out of the crowd; i.e., they were found much faster than happy, sad, or fearful facial expressions. More recently, the ASE has been shown with a large sample of preschool children using color photographs and schematic adult faces (Lobue, 2009; LoBue et al., 2014). Results in various clinical populations lend further support for the ASE, e.g., children suffering from different developmental issues, such as autism spectrum disorder and Williams Syndrome (Rosset et al., 2011) as well as adults suffering from Asperger Syndrome (Ashwin et al., 2006). However, the results are not consistent.

In parallel to the ASE, numerous other studies (Kirita and Endo, 1995; Juth et al., 2005; Miyazawa and Iwasaki, 2010; Svärd et al., 2012; Craig et al., 2014a; Nummenmaa and Calvo, 2015; Lee and Kim, 2017, see also Pool et al., 2016 for review) found a search advantage to happy faces compared to negative emotional expressions in adults using faces of adults. This was named the happiness superiority effect (HSE). The HSE asserts that the quick detection of happy faces conveys an adaptive function to maximize social reward and foster alliances and collaborations (Calvo and Nummenmaa, 2008). Furthermore, it has been shown that processing happy faces requires less attentional resources compared to anger and other expressions (Becker et al., 2011; Pool et al., 2016). Studies demonstrating the HSE use a similar visual search task to the ASE. Furthermore, HSE has also been shown in children with different developmental or personality disorders, such as autism spectrum disorder (Farran et al., 2011) and social anxiety (Silvia et al., 2006).

Most of the aforementioned research in preschool children examining the advantage of emotional facial expressions in visual search tasks used mainly adult faces as targets (Silvia et al., 2006; Waters and Lipp, 2008; Waters et al., 2008; Lobue, 2009; Farran et al., 2011; Rosset et al., 2011). The perceived intentions of a peer relative to either another peer (e.g., another child) or non-peer (e.g., an adult) showing a similar expression can very well differ (Rhodes and Anastasi, 2012; Marusak et al., 2016). Therefore, the interpretation of the expression might be different when displayed on the faces of people of different ages (Craig et al., 2014b). Indeed, due to the emergence of social competence needs in preschool children, emotional cues from peers become more critical than that of non-peers (Trentacosta and Fine, 2010). To the best of our knowledge, this is the first study systematically examining the recognition of emotional facial expressions in a

sample of children using faces of age-matched peers and non-peers.

Therefore, our overarching goal of the present study was to test ASE vs. HSE on two independent samples of preschool children and adults, using photos of children as well as adult faces displaying emotions. Considering this age gap variable, the matrix of interactions comprises (a) a child observing another child's facial expression, (b) a child observing an adult, (c) an adult observing another adult, and (d) an adult observing a child. When (a) a child observes another child's angry face, anger might imply social rejection and even some danger as children might hurt each other. In contrast, when (b) an adult angry face is shown to a child, it may signal authority or a reprimand, for example, related to something necessary. However, it can also signal violence (White et al., 2019). In fact, children have been shown to have stronger amygdala activation in response to angry adult faces compared to angry child faces (Hoehl et al., 2010). Albeit the survival value of quickly detecting angry facial expressions, regarding children, we expected a HSE, as peer connections have growing importance at this age (e.g., Craig et al., 2014a). Furthermore, recognition expertise and speed depend on the extent of exposure to certain groups; e.g., children may see other children particularly often in kindergartens. In contrast, they less frequently see a lot of older people (Anastasi and Rhodes, 2005). Moreover, happy faces are seen more often in general, which might lead to an added expertise effect (Calvo et al., 2014). In (c), an adult–adult situation, the angry face can convey a more grave reason, with the potential for severe consequences (Öhman and Dimberg, 1978; Hansen and Hansen, 1988). Among adults, happy expressions can signal a variety of intentions that are relevant to the observer, such as acceptance, affiliation, collaboration, safety, trustworthiness, and even sexual attraction. In contrast, when (d) an adult sees an angry expression on a child's face, they might not find anger on a child's face threatening (Hoehl et al., 2010). However, fearful signals on a child's face could mean a need for attention and calls for comfort and care. Regarding happy expressions, a child's happiness is a strong positive feedback and would signal contentment toward the adult (Ahn and Stifter, 2006).

Due to the versatility of the happy facial expression and its possible interpretations, happy faces are expected to present the highest search advantage in both adults and children, regardless of the age of the faces. Moreover, happy faces are also more frequently observed, leading to familiarity (Calvo et al., 2014). In addition, a recent meta-analysis (Pool et al., 2016) have shown that positive stimuli are particularly able to recruit more attentional resources when the individual is motivated to obtain the positive stimulus, and despite the presence of concurrent competing stimuli (see also Gable and Harmon-Jones, 2008; Harmon-Jones and Gable, 2009). If attention is automatically oriented toward stimuli that are motivationally relevant for the temporary goal of the individual (Vogt et al., 2013; Mazzietti et al., 2014), it might be more likely that people attend faster to happy faces as these not only are usually non-threatening but also often bring some reward and represent a friendly and accepting environment.

MATERIALS AND METHODS

The paradigm used in this paper is similar to previous studies developed to test the attentional bias toward emotional facial expression (e.g., Hansen and Hansen, 1988; Eastwood et al., 2001; Calvo and Nummenmaa, 2008). Participants were asked to observe nine pictures at a time in a 3 × 3 block arrangement. The facial expression in one of the pictures, *the target*, was different from the others, i.e., *the crowd*. All pictures presented in one trial were of different people. In line with previous studies (Juth et al., 2005), we used angry, happy, and fearful faces as targets and neutral faces as a crowd.

However, our paradigm includes a critical novelty. Both children and adults completed the experiments. We used color photographs of children and adults of similar age to our participant groups, instead of faces of adults only or schematic pictures. A 3 × 2 × 2 design was used with emotion (i.e., angry, happy, and fearful) as a within-subject factor and Group (adult or child) and Model (adult or child) as between-subject factors. The gender of models was balanced to present a female target in a female crowd in half of the trials, and a male target in a male crowd, in the other half.

The control of low-level features is particularly necessary when studying a single group of participants responding to several types of emotion. If not well-controlled, one might erroneously find a misleading result, suggesting, for example, that particular emotion is more rapidly processed, when in fact, the angry pictures were a bit brighter by chance due to the eyes being more open or the teeth more showing. This study used a large number of pictures (70 adults and 80 children) controlled for color brightness, contrast, spatial frequency, and luminance values; exposed teeth ratio; and used two participant groups to minimize error.

Our research was approved by the local Ethical Review Committee for Research in Psychology (Nr. 2018-62) and carried out following the Code of Ethics of the World Medical Association (Declaration of Helsinki). Informed written consent was obtained from adult participants and parents of children participants, and oral consent was obtained from the children.

Participants

The exclusion criteria for the current study were a history of depression, anxiety, or a neurodevelopmental disorder[1]. The inclusion criterion was the successful completion of an emotion labeling task. First, participants were shown the faces used in the experiment and asked to name the emotions displayed on them. If they reached a success rate of 70%, *a priori* set by the authors, separately for each emotion, could progress to the visual search task[2]. If not, they were told that the experiment is over; children

[1]Adults filled out the trait subscale of the short, five-item version of the Spielberger State-Trait Anxiety Inventory (Zsido et al., 2020) and were asked to report if they had a history of depression, while in the case of children, we asked their parents to do so. Participants did not know we are asking these questions as an inclusion criterion.

[2]We also used Pearson correlation to test the correlation between reaction time and emotion knowledge indicated by the success rate on the emotion naming task in children. When children saw faces of other children, we found a significant

could choose a small gift for their participation. Including only those who could correctly identify the facial expressions was essential to reduce confounding biases and variance due to false recognition.

A total of 146 volunteers participated in our study (78 children and 68 adults); about half of them completed the visual search task with faces of children, while the other half completed the visual search task with faces of adults. This design resulted in a total of four groups: (1) children who completed the visual search task seeing faces of children (n = 43) or (2) adults (n = 34), and (3) adults who completed the task with faces of children (n = 37) or (4) adults (n = 31). See details about the groups in the next two sections *"Visual search with faces of children"* and "*Visual search with faces of adults*"). The sample size for our study was determined by computing the estimated statistical power based on the effect sizes of prior experiments on HSE and ASE using a similar task (Hansen and Hansen, 1988; Eastwood et al., 2001; Juth et al., 2005; Lobue, 2009; LoBue et al., 2014). For this estimation, we used the G*power 3 software (Faul et al., 2007). The initial analysis was based on previous results (β = 0.8, f = 0.40, and a correlation between measures = 0.5), indicating that a total sample size of 12 would provide sufficient statistical power. A more conservative estimation (β = 0.95, f = 0.25, and r = 0.35) indicated that a total sample size of 76 is required. Therefore, we collected nearly double the required sample size. The *post hoc* analysis showed that the achieved power in this study was 0.99.

Visual Search With Faces of Children

Initially, 56 children were recruited. However, 12 children failed to reach *a priori* criteria (70% success rate) and, therefore, were excluded. Forty-three (19 boys, 24 girls) preschool children completed the visual search task. Their mean age was 5.65 years (SD = 0.78). Their ability to name the facial expressions displayed on the photographs used was tested (see section *"Procedure"*). The mean success rate for this sample was 91.71% (SD = 21.50%). The mean success rate for the whole sample was 72.88% (SD = 33.63%).

The adult sample comprised 37 (13 males and 24 females) adults with a mean age of 21.8 years (SD = 0.78). All of the adults passed the *a priori* criteria of naming the facial expressions (M = 96.33%, SD = 12.27%). All of the participants were Caucasian, right-handed, with normal to corrected-to-normal vision.

Visual Search With Faces of Adults

Initially, we recruited 44 children. However, 10 children failed to reach *a priori* criteria (70% success rate) and were, therefore, excluded. The children tested sample comprised 34 (14 boys and 20 girls) preschool children who completed the visual search task. Their mean age was 5.47 years (SD = 0.75). The mean success rate of naming the facial expressions for this sample was 90.57% (SD = 20.90%). The mean success rate for the whole sample was 71.23% (SD = 34.68%).

The adult sample comprised 31 (12 males and 19 females) adults with a mean age of 21.1 years (SD = 1.31). All of the adults passed the *a priori* criteria of naming the facial expressions (M = 98.67%, SD = 5.46%). All of the participants were Caucasian right-handed with normal or corrected-to-normal vision.

Stimuli

Child's Faces

All of the pictures (target and crowd) were taken from the Dartmouth Database of Children's Faces (Dalrymple et al., 2013). The Dartmouth Database contains a set of photographs of 80 Caucasian children between 6 and 16 years of age, each of whom displaying eight different facial emotions. Photographs were taken from the same angle, frontal view, and under the same lighting condition. The models in the database are wearing black hats and black gowns to minimize extra-facial variables. We selected 18 child models (9 girls), ranging in ages between 6 and 10 years (estimated age: 5.7–8.6), and three emotions as target expressions (angry, happy, and fearful). Photographs with neutral expressions served as a crowd. Past studies (Calvo and Nummenmaa, 2008) have warned that exposed teeth could produce high local luminance, increasing physical saliency, and, thus, attract attention and facilitate detection based on physical and not emotional saliency. In our study, there was no difference between the ratio of expressions with exposed and concealed teeth among the three emotion categories ($\chi^2 < 1, p > 0.1$).

Adult Faces

All of the pictures (target and crowd) were taken from the Karolinska Directed Emotional Faces database (Lundqvist et al., 1998). The database contains a set of photographs of 70 Caucasian individuals, each displaying seven different emotional expressions, each expression being photographed twice from five different angles and under the same lighting condition. We only used frontal views similarly to Exp1. We selected photographs with three emotions as target expressions (angry, happy, and fearful). The pictures exposed teeth ratio was matched as used in Exp1 until no difference was observed between the ratio of expressions with exposed and concealed teeth among the three emotion categories ($\chi^2 < 1, p > 0.1$). Again, photographs with neutral expressions served as the crowd.

Visual Display and Apparatus

The 3 × 3 sets were created in a block arrangement (measuring 22.45° × 22.45° in total), with eight crowd members (measuring 7.57° × 7.57° each), and one target (same size as background pictures). Images were separated with a 2pt wide black border. All three target emotions were presented in each of the nine possible locations, separately for boy and girl models. Thus, the stimuli set consisted of 54 matrices, i.e., nine trials of each of the six conditions. The male and female trials were presented separately, in 27-trial blocks, counterbalanced over participants, i.e., half of the respondents started with male trials, the other half started with female trials.

correlation between reaction time and emotional knowledge ($r = -0.33$, $p = 0.032$), indicating that children who performed better on the emotion naming task were generally faster to find the emotional faces. The correlation between reaction time and emotional knowledge (r = -0.29, p = 0.096) was non-significant, indicating a similar trend when children searched among faces of adults.

Although visual search paradigms can be sensitive to potential low-level confounds, face color and original appearance were retained for ecological validity. We calculated color brightness, contrast, spatial frequency, and luminance values for each matrix using Matlab after data collection to monitor whether these values could be a source of bias. We found no significant difference between the calculated low-level visual feature values within the pictures. Furthermore, these values had no covariate effects on the results (all Fs < 1, $p > 0.1$).

The stimuli appeared on a 17-inch LCD touchscreen color monitor with a visible area of 15 inches and a resolution of 1,366 × 768, refresh rate, and a sampling rate of 60 Hz, 24-bit color format. The stimuli set were presented using PsychoPy Software version 1.83 for Windows (Peirce, 2007).

Procedure

All participants (children and adults) completed the same procedure. Those who passed the emotion labeling task were taught how to use the touchscreen monitor if it was necessary. In the case of children, the experimenter helped them to create a drawing of their right hand on a sheet of paper. For adults, we used a previously printed and laminated paper that had the outline of a hand on it. Participants were asked to place their right hand on this paper between trials. Children were seated approximately 30 cm and adults approximately 60 cm in front of the monitor. First, all participants completed nine practice trial matrices, one with each target. Responses to practice trials were excluded from further analyses. If the experimenter saw that they understood the task, and the participants also gave their oral consent to continue, the experiment started. Respondents completed the task in two sessions with a short break between them. The instruction was to find the picture that shows a different emotional expression from the others as quickly as possible. For children, the experimenter started each stimulus by hitting a button on the keyboard; for adults, the images automatically appeared (with 1 s interstimulus interval). Each image was preceded by a cartoon figure (for children) or a fixation cross (for adults) presented for 500 ms. Then, the participant indicated the target's location by touching it on the touchscreen monitor. Upon completing the experiment, children could choose a small gift as a reward for their efforts. The task lasted for approximately 15–20 min, including the break between the two blocks[3].

Data Analyses

Trials with very low pointing accuracy (i.e., above the two-standard-deviation criterion on the raw data of coordinates) or very high reaction time values (two standard deviations from the mean) were excluded from further analyses, comprising less than 1% of the data. The statistical analyses were performed using the JAMOVI Statistics Program Version 0.9. for Windows (Jamovi Project, 2018). Reaction times were averaged over trials yielding three variables—Emotion (i.e., angry, happy, and fearful)—for all groups: Group (children vs. adults) × Model (children vs. adults). These variables were then entered into a 3 × 2 × 2 mixed ANOVA with emotion as a fixed factor; Group and Model as independent factors.

RESULTS

The Effect of Emotion on Search Performance

The main effect of emotion was found significant [$F(2,284) = 64.89$, $p < 0.001$, and $\eta_p^2 = 0.31$]. The Tukey corrected pairwise comparisons revealed that participants found happy faces ($M = 3.14$ s, 95% CI = 3.00–3.27) faster than angry [$M = 3.62$ s, 95% CI = 3.49–3.75; $t(284) = 8.66$, and $p < 0.001$] and fearful faces [$M = 3.74$ s, 95% CI = 3.60–3.87; $t(284) = 10.74$, and $p < 0.001$], but the latter two did not differ [$t(284) = 2.08$, $p = 0.095$].

We also found a two-way interaction between Emotion and Group [$F(2,284) = 9.08$, $p < 0.001$, and $\eta_p^2 = 0.06$]. To tease apart this interaction, we used two separate ANOVAs for children and adults. These follow-up analyses revealed that, for adults, the main effect of emotion was significant [$F(2,140) = 61.23$, $p < 0.001$, and $\eta_p^2 = 0.47$] with the same pattern as reported above; i.e., participants found happy faces faster than angry [$t(140) = 10.47$, $p < 0.001$] and fearful faces [$t(140) = 8.34$, $p < 0.001$], while the latter two did not differ [$t(140) = 2.13$, $p = 0.087$]. For children, the main effect was also significant [$F(2,144) = 29.09$, $p < 0.001$, and $\eta_p^2 = 0.29$]. However, the pattern was different: Children found happy faces faster than angry [$t(144) = 3.90$, $p < 0.0001$] and fearful faces [$t(144) = 7.63$, $p < 0.001$] and also angry faces were found faster than fearful ones [$t(144) = 3.73$, $p < 0.001$]. See **Figure 1** for the interaction and **Table 1** for detailed descriptive statistics.

The other interactions involving Emotion were non-significant, i.e., between Emotion and Model [$F(2,284) = 1.64$, $p = 0.196$] and between Emotion and Model and Group [$F(2,284) = 0.62$, $p = 0.539$].

The Effects of Model and Group

The main effect of the Group was significant [$F(1,142) = 174.55$, $p < 0.001$, and $\eta_p^2 = 0.55$], meaning that adults ($M = 2.71$ s, 95% CI = 2.55–2.88) were generally faster than children ($M = 4.28$ s, 95% CI = 4.12–4.45) in both tasks. Furthermore, the main effect of the Model was also significant [$F(1,142) = 5.61$, $p = 0.019$, and $\eta_p^2 = 0.04$] showing that participants were faster to identify the emotions on faces of adults ($M = 3.36$ s, 95% CI = 3.19–3.52) compared to faces of children ($M = 3.64$ s, 95% CI = 3.47–3.80).

The two-way interaction between Group and Model was significant [$F(1,142) = 6.56$, $p = 0.011$, and $\eta_p^2 = 0.04$], revealing that the main effect of the Model was only significant for adults but not for children. Interestingly, children detected emotions on the faces of adults ($M = 4.29$ s, 95% CI = 4.06–4.53) and faces

[3]Children's performance can be sensitive to load; i.e., it may change during the experiment. Although we did not intend to measure the effects of cognitive load and we used two blocks with a short break in-between to avoid any effect of overwhelming the children, one of the reviewers pointed out that it might still be feasible to check the time course data. Therefore, we used Spearman correlations to test whether reaction time changed over time. We found no indication of effect of load (rho values $< |0.1|$). Further, the visual check confirmed that there was no non-linear connection either.

FIGURE 1 | The three-way interaction between Emotion, Group, and Model. The significant effects were the main effect of Emotion, Group, and Model as well as the two-way interactions between Emotion and Group and between Group and Model. The results are in seconds; 95% confidence intervals are shown.

of children (M = 4.27 s, 95% CI = 4.04–4.50) at similar speeds. In contrast, adults were faster to detect emotions on the faces of adults (M = 2.42 s, 95% CI = 2.18–2.66) compared to faces of children (M = 3.00 s, 95% CI = 2.78–3.23).

DISCUSSION

The present study sought to test visual search advantages for angry and happy faces, i.e., to compare ASE with HSE theories, respectively. Past research has shown mixed results, and an important possible confounding variable—namely the OAB—has been overlooked in previous research designs, as children usually completed the visual search for emotional expressions on the faces of adults. However, the emotions could portray very different meanings based on who sees it (a child or an adult) on whose face (a peer or a nonpeer). For example, previous research (Thomas et al., 2001; Adolphs, 2010; Marusak et al., 2013) has shown different activation patterns in the amygdala in children and adults while viewing adult faces. Therefore, we recruited a pool of children and adults who performed a classical visual search task with children and adult models showing various facial expressions. We found that children and adults found happy faces significantly faster than angry and fearful faces regardless of it being present on the faces of peers or non-peers. This is compatible with the notion of previous results showing an attentional bias for positive emotional stimuli (Brosch et al., 2011; Pool et al., 2016; Wirth and Wentura, 2020). Furthermore, we did not find clear evidence for an OAB regarding the visual search of emotional expressions; there were only some differences between adults and children searching among faces of peers and non-peers. The reason behind this might be that it has been shown that very similar neural networks were implicated in the processing of angry and happy faces, in both adults and children (Hoehl et al., 2010). Including children and adults in the study, performing as both model and participant, allowed us to explore OAB in a face in the crowd "scenario." This was a particular strength of our study, and data showed significant differences between the peer and non-peer faces.

Overall, our findings support the HSE across both samples. That is, faces displaying a happy expression were found quicker in a visual search task and had an advantage in visual processing

TABLE 1 | Descriptive statistics of the search times in seconds for child and adult participants' search task (angry, fearful, and happy) on faces of children and adults.

				95% Confidence interval	
Group	**Model**	**Emotion**	**Mean**	**Lower**	**Upper**
Adults**	Child's faces*	Angry	3.28	3.02	3.54
		Fearful	3.14	2.88	3.39
		Happy**	2.60	2.34	2.85
	Adult faces*	Angry	2.62	2.34	2.90
		Fearful	2.52	2.25	2.80
		Happy**	2.11	1.83	2.39
Children**	Child's faces	Angry**	4.26	4.00	4.51
		Fearful**	4.71	4.45	4.97
		Happy**	3.85	3.59	4.10
	Adult faces	Angry**	4.32	4.05	4.59
		Fearful**	4.57	4.30	4.84
		Happy**	3.99	3.72	4.26

Mean scores and confidence intervals are in seconds.
**p < 0.05, **p < 0.001; and the value differs from the other categories.*

corroborating previous studies (Hoehl et al., 2010) using adult faces in testing adult participants (Kirita and Endo, 1995; Nummenmaa and Calvo, 2015; Savage et al., 2016) and children (Silvia et al., 2006; Farran et al., 2011; Lagattuta and Kramer, 2017). In peer relations (for both children and adults), the happy expression could be seen as a powerful social tool to communicate friendly intent and show assurance and acceptance (Juth et al., 2005). Moreover, a child's happiness would signal contentment toward the adult and strong positive feedback (Ahn and Stifter, 2006). Also, an adult showing happiness toward children could mean, for instance, reward, reinforcement, friendly intent, and safety (McClure, 2000). Furthermore, trustworthiness is also highly associated with happy expression (Calvo et al., 2017). Hence, the processing advantage of happy faces is adaptive due to its importance in social situations, such as reconciliation, sharing, and collaborations (Calvo and Nummenmaa, 2008; Becker et al., 2011). Indeed, it has been shown (LaBarbera et al., 1976; Walden and Field, 1982; Striano et al., 2002; Grossmann et al., 2007) that children identify happy expressions earlier in development and more reliably. Regarding the cognitive mechanisms underlying these results, it has been argued that (1) the procession of angry faces requires less attentional resources compared to angry and other expressions (Becker et al., 2011; Pool et al., 2016) and, furthermore, that (2) happy faces facilitate global processing while angry expressions facilitate local processing (Kerusauskaite et al., 2020). However, the HSE may also reflect a positivity bias due to our expectations of positive over negative signals (Leppänen and Hietanen, 2004), i.e., facilitating the recognition of happy faces. Another possible explanation may be driven by the relative occurring frequency of each emotional expression in social encounters (Calvo et al., 2014). Calvo and colleagues have shown that happy faces are seen more often, leading to more exposure that adds expertise to the detection of these expressions. They found that happy faces are seen more often and detected faster than angry faces and that angry faces are seen more often and detected faster than fearful faces, which also corroborates our findings. Similarly, OAB might be explained by natural visual statistics alone, because adults and children may differ in exposure frequency to faces of adults or children and also to the different emotions (for a more detailed review, see Calvo and Nummenmaa, 2008).

Adults also found happy faces first; nonetheless, we only found a marginally significant effect showing they reacted to angry faces slower than fearful faces regardless of the age of the model. It is likely that adults did not find anger on a child's face as threatening (Hoehl et al., 2010). Presumably, adults are more attuned to recognize and attend to children's fearful expressions. Fearful signals on a child's face could mean a need for attention, protection, and calls for comfort as the child might be in pain or need of care. Fear can also alert the perceiver to danger in the environment (Thomas et al., 2001) and can also be perceived as affiliative and appeasing and preventing aggressive encounters and reduce the likelihood of injuries (Marsh et al., 2005). As for adults detecting fear on other adult's faces, our results are somewhat contradictory to previous findings. Yet, a fearful face can signal an indirect threat that the viewer is not aware of, which in turn could facilitate visual search performance and preattentive capture of attention (Bannerman et al., 2009; Pritsch et al., 2017).

In children, anger was detected faster than the fearful expression in line with our expectations. When anger is present on an adult's face, it could signal reprimand or even aggression, triggering a quick defensive reaction (LeDoux and Daw, 2018; White et al., 2019). When it is present on another peer's face, anger can signal rejection. Peer connections become more important around this age (Trentacosta and Fine, 2010), and emotional cues of acceptance and rejection from peers turn out more critical compared to other expressions. Hence, the detection of fearful faces was the slowest, which is similar to previous research in adults using eye-tracking measures (Wells et al., 2016).

We also found that adults detected emotions in other adults' compared to children's faces faster, an effect we did not observe in children. On the one hand, this could lend further support to the notion that the OAB is likely not the product of familiarity as older adults have necessarily previously been members of other age groups (Anastasi and Rhodes, 2005). Adult faces are associated with enhanced neural processing (Marusak et al., 2013) and children appear to be more accurate at recognizing faces of adults (Macchi Cassia, 2011). However, people such as school teachers interact with children more frequently and show improved capacity to recognize child faces (Harrison and Hole, 2009). Our adult sample consisted of participants who were rather young and did not have children and they supposedly did not have daily contact with preschool children, while children did have daily contact with adults. We think that the frequency effect (Calvo et al., 2014) could explain this finding as well.

Some limitations of this study shall be noted. First, we used only three emotional expressions based on previous studies investigating CFE and HSE. Nonetheless, including all basic emotions would be necessary for future studies, particularly neutral faces as controls. The visual search paradigm adopted in our study made it impossible to include a neutral condition. Prioritization of a specific emotion may be task-dependent (see also Cisler et al., 2009; Zsido et al., 2019). Also, there is some evidence showing that, under some circumstances, neutral facial expressions may be evaluated as negative (Lee et al., 2008). The fact that, in this study, all participants successfully categorized neutral faces as neutral in the pre-test might point to the notion that this issue was not present. Changing the expression of the faces in the crowd in future experiments might also carry interesting theoretical implications. Although steps were taken to control for visual confounds by the creators of Dartmouth and the Karolinska Directed Emotional Faces databases, the photographs used were not originally averaged on low-level visual features. Although our study is a promising first step in controlling for an often-neglected factor, future studies are needed to explore the effects of OAB on the detection of emotional expressions. Finally, our results could be explained by simple natural visual statistics; i.e., adults and children may differ in exposure frequency to faces of adults or children and also to the different emotions. Nevertheless, OAB still stands as a bias to be controlled in future studies.

Despite these limitations, to our knowledge, this is the first study to demonstrate the happiness advantage effect in both children and adults using peer's and non-peer's faces. That is, young children found happy faces quicker compared to angry and fearful ones. This novel developmental evidence might add further support to the robustness and reliability of the HSE. Overall, this finding contributes to the understanding of the differences in detecting emotional faces. Using peer or non-peer faces should be a theoretical consideration of future studies because results will change based on the choice as emotions seen on either peer or non-peer faces have different implications and meanings to the perceiver.

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 Hungarian Ethical Review Committee for Research in Psychology. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

AZ, VI, JB, and AS: conceptualization. AZ, NA, OI, BL, and CC: methodology. AZ, NA, OI, VI, and JB: formal analysis and investigation. AZ, NA, VI, JB, TM-B, OI, AS, BL, and CC: writing—original draft preparation. AZ, NA, VI, JB, TM-B, OI, AS, BL, and CC: writing—review and editing. AZ, NA, TM-B, OI, BL, and CC: funding acquisition. NA, VI, JB, TM-B, and OI: resources. AZ, AS, BL, and CC: supervision. All authors contributed to the article and approved the submitted version.

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The Potential Role of Awe for Depression: Reassembling the Puzzle

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Recently, interest in the unique pathways linking discrete positive emotions to specific health outcomes has gained increasing attention, but the role of awe is yet to be elucidated. Awe is a complex and transformative emotion that can restructure individuals' mental frames so deeply that it could be considered a therapeutic asset for major mental health major issues, including depression. Despite sparse evidence showing a potential connection between depression and awe, this link has not been combined into a proposal resulting in specific intervention guidelines. The aim of this perspective was three-fold: (i) to provide a new unifying model of awe's functioning—the Matryoshka model; (ii) to show systematic and explicit connections between this emotion and depression; and (iii) to suggest specific guidelines of intervention utilizing the potential therapeutic role of awe for mental health, specifically for depression. This theoretical endeavor in its entirety has been framed within the health domain.

Keywords: awe, mental health, depression, Matryoshka model, complex emotions

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INTRODUCTION

Recently, within the framework of positive psychology (Ryff and Singer, 2000; Seligman and Csikszentmihalyi, 2000), interest in the unique pathways linking discrete positive emotions to wellbeing promotion has emerged increasingly (e.g., Barrett-Cheetham et al., 2016). Although awe—a complex emotion characterized by an appraisal of vastness and a need for accommodation—has attracted the interest of many researchers in the last 20 years (Sundararajan, 2002; Keltner and Haidt, 2003; Shiota et al., 2007; Chirico et al., 2016; Nelson-Coffey et al., 2019; Chirico, 2020), this phenomenon is still "*in need of research attention in the realm of well-being*" (Barrett-Cheetham et al., 2016, p. 603). This is especially true in the mental health domain.

Pathways between several negative emotions and poor health have been widely investigated (Coifman et al., 2016; Kunzmann et al., 2019), yet the role of specific discrete positive emotions in fostering mental health has only recently become an object of interest (Tugade et al., 2004; Cohen and Pressman, 2006; Anderson et al., 2018; Chirico et al., 2021), especially within the positive psychology framework (Shiota et al., 2017). However, the contribution of discrete complex emotions, such as awe, is practically unexplored. Awe could be considered as an exemplar of this category due to its multi-componential nature stemming from the interaction of simpler emotional aspects, both positive and negative (Grossmann and Ellsworth, 2017). Just its unusual nature would deserve special attention when mental health is involved.

Here, we focused on a specific mental issue whose potential connection to awe has progressively emerged but is still only implicitly discussed and whose relevance has increased and will likely

increase in the near future (Frankham et al., 2020; Gunnell et al., 2020): Major Depression Disorder (MDD). We aimed to outline the potential therapeutic role of awe for depression by considering the potential connections between these two phenomena across multiple levels—namely, the psychological, hormonal, neurophysiological, and existential levels. To this end, we provided a preliminary unifying proposal on awe's functioning based on empirical studies addressing the neuro-psycho-physiologic, metabolic, psychological, and existential dimensions of awe. We then drew connections between awe and depression, relying on the same levels. Finally, we combined this evidence into a proposal resulting in specific intervention guidelines for solutions exploiting the therapeutic potential of awe for the depression domain, where scientifically valid accessible and feasible solutions are always needed (e.g., Biddle and Asare, 2011; Bourne et al., 2018).

A UNIFYING PROPOSAL ON AWE'S FUNCTIONING: THE "MATRYOSHKA" MODEL

The role of several functionally distinct positive emotions for mental health has been increasingly investigated in the last 20 years (e.g., Tugade et al., 2004; Ong et al., 2018; Chirico et al., 2021), including the depression domain (e.g., Gruber et al., 2009). Awe has acted as a special case. After the seminal theoretical work of Keltner and Haidt (2003), which reported the dimension of *vastness* and *need for accommodation* as the core components of this emotion, several empirical efforts have been devoted to unveiling the potential of awe for human flourishing [for a review, see Chirico (2020)], but the mental health domain has remained nearly unexplored. At the same time, the empirical effort around awe has not been accompanied by an up-to-date unifying proposal on its functioning that is also able to elucidate its unique pathway to health outcomes. Here, using empirical data on awe collected so far, we provided an up-to-date unifying proposal on its fuctioning in the short, medium, and long term in order to elucidate the link between this emotion and Major Depression Disorder as one of the most severe mental issues nowadays.

The potential of this emotion has been deemed to be so vast that it has been considered in relation to a wider process of *transformation* (Pearsall, 2007; Chirico et al., 2018a; Chirico, 2020), or a sudden change after which the person is no longer him-/herself (Skalski, 2009; Paul, 2014; Gaggioli, 2016; Riva et al., 2016); it requires a catalyst, which might be awe (Schneider, 2009; Valdesolo and Graham, 2014; Gaggioli, 2016). This emotion emerged as having a differential impact on individuals as featured by two dimensions: *complexity* of awe-related changes and *time* (i.e., duration or frequency of occurrence). Specifically, empirical studies on this emotion evidenced that awe can affect people by unfolding from a physiological or neurophysiological level, through a psychological one, to an existential one (Schneider, 2009, 2017; Stellar et al., 2015, 2018; Gordon et al., 2016; Hoeldtke, 2016; Bai et al., 2017; Hu et al., 2017). Awe can then act as both a contingent moderately intense phenomenon (Silvia et al., 2015) and a really intense punctual emotion (Chirico et al., 2018a,b) or as a frequent emotional state occurring several times (Shiota et al., 2006; Bonner, 2015; Zhao et al., 2019; Chirico et al., 2021). *The more awe involves increasingly sophisticated changes, the more it evolves toward more complex forms*. To unify all these dimensions of awe, we proposed a synthetic model organizing all of these changes, which we called the "Matryoshka" model, where the most basic levels of awe unfold toward a more sophisticated experience over time (**Figure 1**).

Awe's *electrical* changes (i.e., DMN activity, parasympathetic, sympathetic activity) would act as mediators between a single awe exposure and its *psychological* (i.e., small self, connectedness, expansion of mental frames, seeking for order, relief from contingencies, meaning in life, broader attention), perceptual (i.e., body perception), and behavioral consequences (i.e., generosity behaviors, helping behaviors, ecological purchase, creative ideas), all tapping into superordinate *existential* processes related to well-being and general health (e.g., satisfaction with life, spiritual well-being, nature connectedness, connection with Others, self-transcendence). Repeated exposure to awe entails the reduction of proinflammatory cytokines—*the neuroendocrinal level*—and this aspect encompasses the whole process of awe, but it becomes evident later.

To show the potential therapeutic role of awe for depression, we showed potential *connections* between this emotion and Major Depression Disorder (MDD), relying on the four previously presented levels of awe's functioning: (i) the electrical level; (ii) the immediate basic psychological level, (iii) the more sophisticated psychological level, which also includes hormonal chemical changes; and (iv) the existential level. We then further clustered the four levels according to their *time occurrence*. First, the neurological and physiological changes associated with awe were reported in the very short term. We then deepened the medium-term changes involving a basic and more sophisticated psychological level as well as hormonal effects. Finally, we introduced and discussed the most complex changes expected in the long run at the existential level.

AWE AND DEPRESSION: A *FIL ROUGE*?

Depression is a major health problem, with a prevalence of between 8 and 12% worldwide, and it is considered as the second biggest disease burden (Ferrari et al., 2013). Its incidence is assumed to increase in the coming months given the past and actual conditions due to the Covid-19 pandemic (Gunnell et al., 2020), and this needs to be managed in advance (Gunnell et al., 2020).

According to the DSM-5, to be diagnosed as MDD, a person must be experiencing five or more core symptoms (e.g., mood decay most of the day; diminished pleasure; significant weight loss; loss of energy; concentration difficulties; suicidal ideation or thinking of death frequently; feelings of worthlessness; reduced physical movement and slowing down) over a 2-week period, and at least one of the symptoms should be either depressed mood or the loss of interest or pleasure.

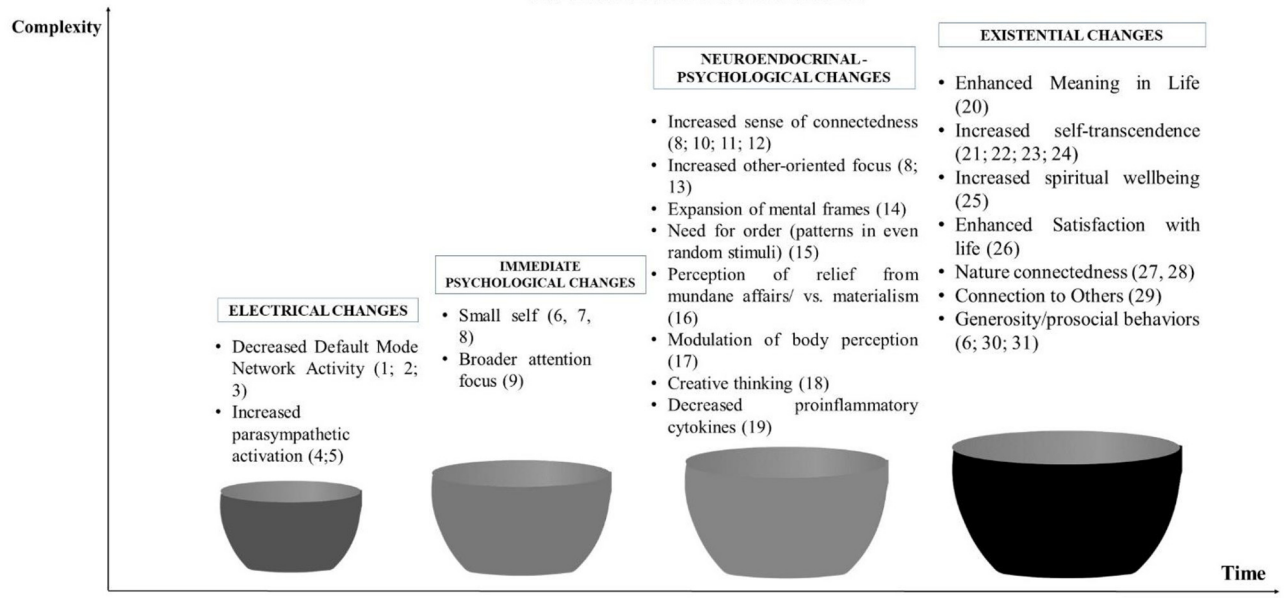

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FIGURE 1 | The Matryoshka model.

The link between awe and depression was elaborated from some core symptoms of MDD. We considered that not all individuals fully meet MDD criteria, thus falling under the threshold of MDD, but they still present difficulties associated with this disease, such as a persistent and relevant decay of moods or a sense of hopelessness (Uher et al., 2014), which, according to our hypothesis, could be ameliorated by awe anyway [see Anderson et al. (2018), Leavell et al. (2019)]. The rationale of this work concerns the potential therapeutic role of awe in contrasting both the symptoms of MDD and some neurophysiological and psychological mechanisms characterizing this pathology.

An Electrical Connection: The Short-Term Level

Neurological Changes

A few studies have begun to shed light on the neurophysiological correlates of awe. Hu et al. (2017) investigated the EEG correlates of ten positive emotions (including awe), which were clustered

in three superordinate factors. Awe clustered along with pride, inspiration, hope, and gratitude and was classified as belonging to an "encouragement" factor. Gamma and alpha activity suggested including awe in this cluster as it was positively related to both the central alpha and the beta band and showed negative correlations with the gamma band. The authors explained these findings in terms of an association between these emotions and enhanced cognitive processing. Actually, awe is known to come along with a need to restructure mental schemas—a "*need for accommodation*," in the words of Keltner and Haidt (2003)—also associated with a deep uncertainty (Valdesolo and Graham, 2014). Other authors have furthered this research by analyzing the activity of a specific brain network, such as the Default Mode Network (DFM) (van Elk et al., 2019), whose increased activity is usually related to increased self-processing and mind-wandering (Qin and Northoff, 2011; Whitfield-Gabrieli and Ford, 2012) and is attenuated during goal-oriented activities (Bressler and Menon, 2010; Menon, 2011). DMN activity decreased during awe-inspiring videos, especially when participants were required to get absorbed passively (van Elk et al., 2019).

The decreased activity of the DMN is a key neural counterpart of MDD, as shown in several works (e.g., Whitfield-Gabrieli and Ford, 2012). Abnormal activity of DFM is associated with more persistent MDD (Li et al., 2013) while increased DFM connectivity (Greicius et al., 2007) is linked to a higher familiar risk for depression (Posner et al., 2016) and generally increases in depressive individuals (Zeng et al., 2012), especially in the anterior portions (Coutinho et al., 2016). Indeed, functional MRI studies have often showed hyperactivity in the amygdala and the ventral components of the anterior cingulate cortex in MDD, which would also play a key role in treatment response (Arnone, 2019).

Moreover, recently, awe has also been proposed as a potential psychological mechanism mediating the effect of psychedelic-occasioned mystical experiences—especially due to psilocybin—on depression (Hendricks, 2018). This link with the psychedelics domain is not new, as Keltner and Haidt described awe as a "psychotic break or a psychedelic experience" (p. 298) when discussing awe in religion. Specifically, at the neural level, psychedelics generate an augmented global functional connectivity and a reduced activity of the DMN, much like the experimentally induced awe. In other terms, psychedelics originate an experience of ego dissolution having a clear overlap with the "small self" experience induced by awe (Hendricks, 2018). Awe may act as a vicarious mechanism modulating the activity of DMN, akin to psychedelics.

Psychophysiological Changes

Regarding the peripheral physiological system, preliminary evidence has shown that a single experience of awe was associated with both the withdrawal of a sympathetic system (Oveis et al., 2009) and a parasympathetic activation (Chirico et al., 2017b), as well as with goose bumps (Quesnel and Riecke, 2018). In other words, awe's physiological response resembled a sort of freezing, which resulted in being consistent with evolutionary explanations of this emotion (Keltner and Haidt, 2003; Shiota et al., 2017; Chirico and Yaden, 2018) and its behavioral consequences concerning the perception of the "small self" (e.g., Piff et al., 2015; Stellar et al., 2018; Perlin and Li, 2020).

The ability of awe to modulate cardiac activity can be a key asset for consideration in relation to depression. Indeed, MDD is associated with reduced activity of the vagus nerve (Chang et al., 2012), which affects the overall self-regulation of the organism (Laborde et al., 2018).

A Psychological and Chemical Connection: The Medium-Term Levels

Psychological Changes

At the immediate basic psychological level, awe generates a deep sense of self-diminishment, different from annihilation, where the self is set apart and the attentional focus is oriented "outside" (Sung and Yih, 2015) and above (Yaden et al., 2017). In addition, grief associated with a significant loss by art and nature can be softened if a person experiences awe (Koh et al., 2019). Conversely, patients with MDD reported an increased focus on the self and a decreased one on others, which dons the guise of an uninterrupted negative self-referential thinking associated with dysfunctional regulatory strategies, such as rumination and hopelessness (Nejad et al., 2013).

In this regard, preliminary evidence concerning the potential role of awe in reducing ruminative self-referential tendencies and sense of hopelessness was provided by Tarani (2017), who exposed healthy participants to awe-inspiring vs. amusement-inducing 4-min-long videos. They found that this emotion could decrease two key MDD symptoms: brooding ruminative tendencies (i.e., constant negative self-reflection associated with self-blame) and sense of hopelessness (i.e., expectancy of negative outcomes and helplessness).

Moreover, experimentally induced awe can orient people to interpreting even random events as the result of intentional and purpose-driven agents (Valdesolo and Graham, 2014). For instance, awe prompts us to deal with uncertainty and overcome it by also finding a completely novel explanation (i.e., accommodation). Moreover, awe enables us to broaden our attention focus (Sung and Yih, 2015), thereby facilitating the creation of unprecedent connections among ideas (Chirico et al., 2018b). Awe can even shape people's tendency to support either a scientific or a supernatural explanation of events, depending on their existing levels of theism (i.e., to what extent they believe in God). This cognitive pattern is opposite to the one showed by patients with MDD, who tend to perceive a lack of meaning, order, and purpose in the world (i.e., sense of hopelessness; Abramson et al., 1989). It should be noted that awe and hope fell within the same cluster in Hu et al. (2017).

Neuroendocrinal Changes

At the hormonal level, psychoneuroimmunology has drawn upon a different perspective on emotions, which are now considered more than ephemeral phenomena and closer to drivers of our well-being and health. Preliminary evidence suggests that awe is associated with a reduction of proinflammatory cytokines, specifically levels of interleukin-6 (IL-6) (Stellar et al., 2015).

From this perspective, living in awe on a daily basis would—alone—be able to shape individuals' physical health at the endocrine level.

On the other hand, peripheral inflammatory states have been found to be associated with central nervous system changes in depression (Peruga et al., 2011; Haji et al., 2012; Lee and Giuliani, 2019). Specifically, an acute increase in pro-inflammatory cytokines produced a sickness syndrome with symptoms overlapping with depression (Capuron et al., 2002). If inflammation contributes to depression (Raison and Miller, 2011), then, interventions targeted at reducing inflammation may act as a preventative measure toward this mental disorder.

An Existential Connection: The Long-Term Level

At the existential level, both empirical and theoretical evidence supports the self-transcendent nature of this emotion (Van Cappellen et al., 2013; Yaden et al., 2016, 2017, 2019; Li et al., 2019; Kitson et al., 2020). As also reported by the recent work of Chen and Mongrain (2020), awe is a "self-expansive emotion" making us transcend our self. Awe expands our sense of connection with the world (Yang et al., 2018) and other human beings, (Quesnel and Riecke, 2018) thereby making us overcome the sense of loneliness and meaninglessness at the core of MDD (Fried et al., 2015).

Preliminary evidence has already shown a link between self-transcendence and depression (Haugan and Innstrand, 2012). Awe, alternatively conceived as an emotional component of the transcendent experience of the sublime (Bethelmy and Corraliza, 2019; Clewis et al., 2021), as a disposition able to foster self-transcendence meaning in life (i.e., spiritual self-transcendence (Lin et al., 2020), or as a mediator between nature and reduced rumination (Lopes et al., 2020), can always elevate us beyond the limit of our mundane affairs toward something bigger than our self and our concerns (Saroglou et al., 2008; Van Cappellen et al., 2013; Krause and Hayward, 2015). This also provides relief from the constant decay of mood characterizing MDD, and it emerged especially in the field of study related to awe-inspiring natural scenarios (e.g., Anderson et al., 2018).

Finally, the ability of awe to deconstruct existing expectations of the world and others—the "transformative potential" of awe (Chirico et al., 2016)—can act as a counterpart to the major issue of cognitive fixedness in MDD (Kube et al., 2017), as also supported within a recent framework on depression provided by the free-energy theory (Fabry, 2019). Therefore, we speculate that awe's transformative potential may be key in unlocking fixed-expectation processes typical of MDD at different ages (Benzi et al., 2018, 2020, 2021).

Awe and Depression: Reassembling the Puzzle

All the components of awe outlined in **Figure 1** can act as counterparts to specific dimensions of depression (see **Figure 2** for a graphical synthesis). First, awe can decrease the activity of DMN, which is hyperactivated in MDD. In addition, this modulation may also have beneficial effects on the amygdala's activity, which would be involved in the self-dysregulation of the organisms along with reduced vagal control. With regard to this aspect, awe can stimulate the activation of the parasympathetic system and promote the withdrawal of the sympathetic one, thereby modulating the activity of the vagal nerve on the heart. Moreover, awe's self-transcendence nature would act as a counterpart to the incessant self-referential process at the base of rumination and sense of hopelessness. Awe acts as a trigger of accommodation, thereby fostering a process of positive change ranging from basic beliefs to more specific expectations of events. This potential of awe could be beneficial for overcoming cognitive fixedness and updating existing *prior* hypotheses used by people to predict and react to world circumstances.

CONCLUSIONS: POTENTIAL FOR AWE-BASED INTERVENTIONS IN MDD

Positive psychology's recent endeavors to understand the potential of specific discrete positive emotions for health promotion (e.g., Barrett-Cheetham et al., 2016) have partially involved awe. However, this complex emotion has shown great potential at several levels in the last 20 years. First, from this perspective, we proposed an up-to-date unifying proposal of awe's functioning, which allowed for a revision of all the empirical evidence supporting the potential therapeutic role of awe for contrasting specifically MDD. The core message of this work concerns the elicitation of awe as a potential therapeutic integrative intervention for contrasting depression.

Although awe induction has not been explicitly considered as a clinical intervention for depression, we reported evidence showing that even an experimental induction of awe had several beneficial effects for mental health, with some also overlapping specific depression components. **Figure 2** shows all connections between awe and depression.

Recent research has demonstrated that the combination of format and content of a given awe-inspiring technique influenced the intensity of awe experience by participants (Chirico et al., 2017b), in order to enhance the ecological validity of the resulting experience. Therefore, it would be useful to focus not just on the most suitable "instrument" to elicit awe, but also on the content used to induce this emotion.

At the level of emotion-induction techniques, recent evidence has outlined different effective awe-eliciting techniques ranging from videos to virtual reality (VR) (Chirico et al., 2016). However, the long-term potential of videos, music, images, and VR for inducing awe has not been tested yet. Although their momentary benefits can be promising for administering doses of awe to people suffering from MDD and subthreshold conditions, a research protocol based on awe for MDD should assess the long-term effects associated to an awe experience as well as the durability of its benefits. Moreover, studies on dispositional awe have shown that a repeated exposure to this emotion brought forth benefits, especially at the hormonal level, which are just assumed to be durable (Stellar et al., 2015).

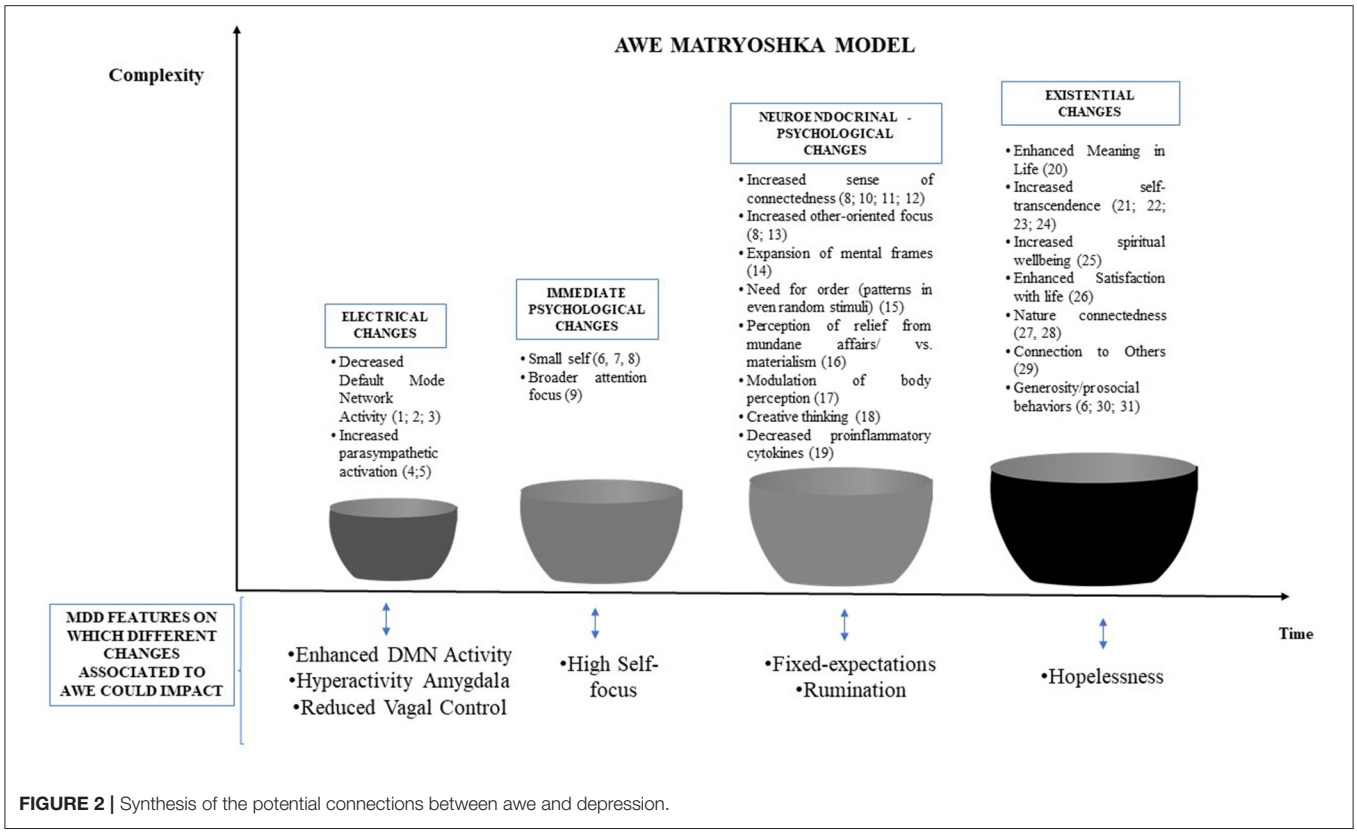

FIGURE 2 | Synthesis of the potential connections between awe and depression.

Moreover, given the social distancing measures adopted worldwide during the Covid-19 pandemic, another caveat would concern the possibility of delivering this intervention remotely as well. For instance, videos can be an effective, though less immersive and involving, solution to implement at distance. On the other hand, a VR setup, which provides an affordable and engaging tool, could be applied in a lab context following specific hygiene standards.

Another key aspect concerns the nature of the awe-inspiring *content* featured in images, videos, VR, and music. Given the multifaceted nature of this emotion, effective awe-inducing stimuli should provide an appropriate balance in terms of valence, thereby resulting into an emotionally mixed experience, which should be validated in advance to allow for the control over other potentially intervenient emotions (Chirico et al., 2017a) and could rely on individuals' preferences for specific elicitors. Combining more awe-eliciting techniques could be a potential solution able to enhance the effectiveness of awe-based interventions. For instance, customized self-selected awe-inspiring music (i.e., reflecting participants' preferences and personality) (Silvia et al., 2015) could be used in combination with visual techniques, such as images and VR, to enhance the personal relevance associated with an awe-inspiring intervention while always using standardized materials. A growing body of evidence concerns the potential of naturalistic scenarios able to release the self-transcendent nature of awe (Bethelmy and Corraliza, 2019) and nature itself, as one of awe's key elicitors (Ballew and Omoto, 2018; Graziosi and Yaden, 2019; Yaden et al., 2019), resulting in a powerful way to contrast depressive symptoms (e.g., Reklaitiene et al., 2014; Lopes et al., 2020) in both real and digital formats (Browning et al., 2020).

At this stage, we have outlined the key points to define the links between awe and MDD as well as guidelines for designing effective awe-based interventions for MDD. Extant evidence has depicted awe as an encounter with something greater and infinite that could don the guise of an explosion in terms of perceived possibilities, thereby acting as a new "big bang" (or new start) in our lives. This new overarching level would encompass all those that we have introduced so far (i.e., hormonal, neurophysiological, and psychological), acting as a spiral of change. Maybe this is also why awe has often been considered a core moment of transformation (Schneider, 2009). In this regard, the potential of awe for depression might also reside in this renewed sense of perceived *possibilities* (Chirico, 2020), which is at the basis of life and the need to trust the future. This sense would stem from neural processes and hormonal ones, reinforced by other persons and nature itself, while bridging our life, our world view, and sufferance, considering the complexity of life and the universe. All this complexity can be encapsulated in even a constrained space, such as a lab or room, if the specifics of this emotion are considered carefully and interventions are built upon them.

AUTHOR CONTRIBUTIONS

AC wrote the first draft and the final version. AC conceived the rational while AG revised and supervised the entire work.

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CONCEPTUAL ANALYSIS
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Defining Transformative Experiences: A Conceptual Analysis

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The concept of transformative experience (TE) has been widely explored by several disciplines from philosophy to neurobiology, and in different domains, from the spiritual to the educational one. This attitude has engendered heterogeneous models to explain this phenomenon. However, a consistent and clear understanding of this construct remains elusive. The aim of this work is to provide an initial comprehensive interdisciplinary, cross-domain, up-to-date, and integrated overview on the concept of TEs. Firstly, all the models and theories on TEs were reviewed to extract and analyze TEs' main components emerging from different disciplines. Then, this preliminary analysis was integrated with an in-depth examination of redundancies and particularities across domains and disciplines, to provide an integrated theoretical framework of TEs and a preliminary interdisciplinary operational definition of TEs. This examination, in turn, can help organize current research and theories, thus providing suggestions for operationalizing TEs as well as encouraging new interdisciplinary research endeavors.

Keywords: transformative experiences, psychological change, conceptual analysis, complex emotions, transcendence

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ALL THE FACETS OF TRANSFORMATIVE EXPERIENCES: TOWARD AN INTEGRATED PICTURE

As early as 1622, an example of a memorable transformation can be identified, in the work of renowned sculptor Bernini, in his representation of the precise moment in which Daphne, while fleeing from Apollo, physically transformed herself into a laurel tree. In Ovid's Metamorphoses (Fantham, 2004), which inspired Bernini, transformation was conceived as a sudden and unexpected phenomenon, which irreversibly changes the state of things. More recently, in 1999, the Wachowskis staged one of the most famous transformative moments in the history of cinema, within their masterpiece "The Matrix." Red or blue pill? The main character, Neo, faced the choice of whether to continue living in his habitual illusory world, or to discover the true reality, thus, embarking upon a change with no way back.

Although these fascinating examples of transformation may suggest that this phenomenon could pertain more to the domain of art and fiction than to that of reality, evidence has shown that transformation – at least, several instances of it – may occur in any moment of an individual's life (e.g., Pearsall, 2007). The current COVID-19 pandemic could be taken as an example, in terms of events and consequences deriving from it that may be considered *transformative*. For instance, suddenly and unexpectedly, the pandemic has prompted people to change their daily routine as well as their personal view of the world, themselves, and of others (Marmarosh et al., 2020; Vos, 2021). It is not unusual to read about people changing their lives, their jobs, divorcing, or moving away from home.

Anecdotally, many readers could identify with the above descriptions of transformative experiences (TEs), and several definitions and types of TEs already exist; nevertheless, an interdisciplinary cross-domain operational definition of this complex phenomenon is yet lacking. However, given the consequences of personal transformation, understanding its underpinnings, its elicitors, as well as the boundaries of this process has become an urgent scientific issue.

The complexity within the scientific investigation of TEs unfolds through three levels. First, the exceptional and fascinating nature of this topic has garnered the interest of different disciplines across the years (e.g., James, 1902; Maslow, 1962; Mezirow, 1978; Turner et al., 1986; Bruner, 1991; Calhoun and Tedeschi, 1995; Miller and C'de Baca, 2001; Brown, 2009; Stone, 2014; Gaggioli, 2015; Yaden et al., 2017; Kason, 2019), but this endeavor has yet to establish an integrated operational interdisciplinary definition of the term TEs. Specifically, most researchers agree that TEs can be conceived as phenomena able to engender long-lasting, irreversible, pervasive consequences on individuals' beliefs, perceptions, identity, and values (for an overview, see White, 1993; Brown, 2000; Paul, 2014; Gaggioli, 2016). However, this definition captures just one side of the process. Conversely, phenomenological features, elicitors or facilitating conditions enabling a transformative change are still open issues, which have been investigated separately.

Secondly, each discipline (e.g., anthropology, philosophy, psychology, neurobiology, education) has defined and investigated this construct at different levels of analysis. For instance, anthropology has defined this phenomenon at a meso-level of analysis, as strictly related to the specific experience of passage rites in which the central component would concern the break between past and future identities (Van Gennep, 1908). Philosophy has adopted a broader and a higher-level view of TEs' analysis by focusing on their definitory characteristics (Paul, 2014; Carel and Kidd, 2020). Psychology has addressed mainly the micro-level of analysis, by elucidating elicitors, correlates, and effects, which have been also used to categorize and distinguish various types of TEs. Finally, a recent neurobiological model by Brouwer and Carhart-Harris (2020) suggested specific neurological correlates and mechanisms. Education has adopted a separate view on TEs, mainly relying on transformative learning theory (Mezirow, 1997, 2000), which outlines the steps to make core frames of references malleable to change. Finally, a recent neurobiological model by Brouwer and Carhart-Harris (2020) introduced the construct of "pivotal mental states" (PiMSs), defined as "transient, intense hyper-plastic mind and brain states" (p. 320), to indicate unique states mediating psychological transformation. While the perspectives of various disciplines can contribute to the richness of the understanding of TEs, a synthesis of diverse insights can facilitate research efforts and results.

Different disciplines have focused more on some instances of TEs, instead of others. For instance, in clinical psychology, an increasing attention has been devoted toward traumatic experiences and, recently, to post-traumatic and post-ecstatic experiences (Calhoun and Tedeschi, 2006; Roepke, 2013). In experimental psychology the focus has been placed on the concept of complex emotions (Gaggioli, 2015; Chirico et al., 2016). In anthropology, there is a long tradition in the study of rites of passage (Van Gennep, 1908). In the field of education, the focus has been on the process of transformative learning as achieved by means of disorienting dilemmas (Mezirow, 1997, 2000).

This has brought forth "varieties of transformative experience," which still need to be captured within a comprehensive picture including efforts to elucidate their underpinnings. Moreover, some efforts have focused only on specific types of TEs. For instance, White (1993) and Brown (2000) introduced a model on "exceptional human experiences" including near-death experiences (NDEs), encounter-type experiences, and out-of-body experiences (OBEs) analyzed at the psychological and phenomenological level.

In this conceptual analysis, we built upon these theoretical contributions, which were integrated with a more grounded approach, focusing on specific interdisciplinary and cross-domain types of TEs. By elucidating wide varieties of TE, we moved toward an integrated picture of these phenomena, involving a preliminary interdisciplinary operational definition of TEs, using the following methodology. First, all models, theories, and empirical evidence on TEs across specific disciplines (anthropology, philosophy, psychology, neurobiology, and education) and domains (spiritual, religious, technological, educational) were analyzed and integrated with specific instances of TEs that cannot be framed within a specific discipline or domain. Then, the analysis focused on distinctiveness and commonalities among these types of TEs. This turned into indications for achieving a preliminary integrated operational definition of the varieties of TE. Finally, new research directions to improve our understanding of transformative change were presented and discussed.

A Theoretical Overview

The need for the scientific study of transformation can be traced back to basic evidence. Some types of change can appear as different from others because they occur suddenly, unexpectedly, and without clear clues (Hayes et al., 2007; Paul, 2014). Crucially, these types of changes can deeply impact an individual's life in an unpredictable manner (Hayes et al., 2007); they also can occur in different cultures (Carel and Kidd, 2020), stages of life (Mezirow, 1997), and in response to different (potential) elicitors (Gaggioli, 2016) or apparently spontaneously (Hood, 2014).

Given the multifaceted, universal, and impactful nature of these phenomena, it is not surprising that several disciplines have sought to understand their essence, describing their functioning, their elicitors, and how to reproduce them. Here, first, we focus on specific disciplines that provide well-established accounts of TEs. Then, examples of acknowledged interdisciplinary instances of TEs are presented and examined.

Anthropology

An anthropological account of transformative change provided in Van Gennep's theory "rites of passage," can evidence the intrinsically paradoxical or ambiguous nature of TEs elicitors. Specifically, these unusual circumstances would be able to trigger

a *liminality* space (Van Gennep, 1908) – "a transformative middle-space in which individuals find themselves in between past and future identities" (Gaggioli, 2015, p. 115) – enabling transformation. Turner expanded the concept of liminality by introducing the concept of *liminoid spaces* (Turner, 1974) – out-of-the-ordinary experiences – that can be found in leisure, arts, and sports, aside from productive labor. Crucially, these are moments of freedom in which a "ludic recombination" (Turner, 1974, p. 61) of cultural factors occurs. Contemporary instances of liminoid spaces could be exceptional experiences far from the ordinary routine, which are highly memorable, very special, emotionally charged, and potentially life altering (Jefferies and Lepp, 2012, p. 38). For example, these could be unusual journeys (e.g., pilgrimages) (Kirillova et al., 2017) or extreme sports (e.g., white water rafting, spelunking, or base jumping) (Arnould and Price, 1993; Gaggioli, 2015). According to this perspective, then, there should be an out-of-ordinary elicitor/facilitating condition, acting as a liminoid space, to enable transformation. These moments would create a unique space as a potential for recombining existing cultural norms and factors into new patterns.

Philosophy

According to Paul (2014), out-of-ordinary elicitors should involve the choice to profoundly live a new experience, able to change our life in important ways. However, a TE entails opacity regarding the effects of being involved in such experiences. We do not know what it will be like since we dwell in a mid-suspended moment and we "only learn what we need to know after we've done it, and we change ourselves in the process of doing it" (Paul, 2014, p. 4). Specifically, the seminal model proposed by Paul (2014) suggested that each TE would encompass both an *epistemic* and a *personal* dimension. At the epistemic level, a TE would allow individuals grasping forms of knowledge unreachable before ("only learn what we need to know after we've done it"; Paul, 2014, p. 4). At the personal level, a TE can deeply change people' values, priorities, and self-conception deeply, thus transforming an individuals' identity ("we change ourselves in the process of doing it"; Paul, 2014, p. 4). This personal dimension consists of an irreversible cognitive shift leading to new frameworks of reference for differently viewing ourselves and others, thus, marking a clear "before" and "after."

Recently, Carel and Kidd 's (2020) work broadened Paul's conception on the role of human agency in TEs' emergence, by elaborating more on personal and contextual constraints and affordances that can limit human control over choices. The two scholars framed Paul's TEs within the category of (1) *voluntary* TEs, adding two more types of TEs imposed by life: (2) *non-voluntary* (e.g., being arrested and sent to Nazi concentration camps, as in the case of Primo Levi), and (3) *involuntary TEs* (e.g., saving a child who was being hit by a car remaining severely injured).

This dimension – namely, *intentionality* – allowed for a more detailed nature of TEs' elicitors. These inductors entail a dimension of *contingency* (i.e., the occurrence of casual and unpredicted situational conditions); *vulnerability* (i.e., the helpless and unavoidable exposure to many kinds of affliction); and *subjection* (i.e., the condition of undergoing a certain event with a lack of control over it). Moreover, this broader view on TEs included also negative and ambivalent forms of transformation. Finally, and importantly, according to this model, TEs cannot be seen just as sudden life-changing moments, instead, also as the apical result of a sequence of cumulative small ordinary changes.

Psychology

Contrary to Carel and Kidd's (2020) work – which also endorsed a gradual path to TEs – in the clinical psychological domain, Miller and C'de Baca (2001), drawing from the lexicon and models of quantum physics, preferred the label "quantum change," focusing more on the impacting nature of TEs. Specifically, a quantum change would consist of a breaking point in which a radical change must occur irreversibly. According to the two scholars, there would be two types of quantum changes, as two instances of TEs: (1) *insightful* quantum changes, that are mainly *cognitive* in nature and can be associated with insight; (2) *mystical* quantum changes, having a more *emotional* character and similar to mystical experiences (MEs) (Miller, 2004). These categorizations suggested the need for emphasizing the cognitive side over the emotional one or vice versa, according to the type of TE.

Building upon previous psychological contributions on TEs, White (2004) outlined some key psychological features of transformational change. TEs were defined as unexpected, brief experiences, usually remembered vividly, entailing enduring, and comprehensive effects (i.e., they represent a "revolution in character"; White, 2004, p. 465), in which the person acts more as a "recipient," rather than an "initiator" (p. 464), and which are positive in nature. However, this last feature has emerged as the most questionable.

For instance, the impacting - whether cognitive or emotional - nature of TEs was further elaborated by Calhoun and Tedeschi (2006) who focused on stressful and traumatic events as key elicitors of both negative (traumatic) and positive ("posttraumatic growth," PTG) changes that have "quality of transformation" (p. 2). (Calhoun and Tedeschi, 1995, 2006). Specifically, traumatic events can result in deep, sometimes irreversible, and negative change, in which suffering disrupts individuals' functioning. Moreover, traumas can impact individuals' schemas and beliefs, leading also to structured syndromes such as the posttraumatic stress disorder (PTSD). Crucially, the appraisal of these events, in terms of controllability, expectancy, and probability plays a key role in the process of coping with it (Kira, 2001). After the occurrence of those traumatic events, sense of time distortion and bodily distortion are considered precursors of posttraumatic disorder in specific circumstances (McNally, 2003).

Instead, PTG occurs when the individual, after facing a traumatic struggle, changes permanently and positively, going above and beyond resilience and finding durable benefits (Carver, 1998). PTG is defined as a "positive change experienced as a result of the struggle with trauma" (Calhoun and Tedeschi, 1995; Kilmer, 2006). This definition emphasizes the transformative quality of responding to highly stressful and/or traumatic events (Calhoun and Tedeschi, 2006). The intense and dramatic experience of trauma, indeed, fosters a powerful potential for psychological transformation, as it alters the normal stable structure of the mind (Grof, 2000). A person's pretrauma beliefs

concerning the world as a just, benevolent, and controllable place can be replaced by new views, in which the negative and the positive effects of a traumatic event are combined, thus turning into a more elaborated, and complex conception of themselves and of the world (Park, 2004). In this sense, adverse events, or potentially traumatic events (e.g., developmental adversity, disability, and mental health problems) have been indicated as diversifying experiences – highly unusual and not predictable but being able to push individuals "outside the realm of normality" (Ritter et al., 2012) – able to promote forms of creative adaptation in terms of reframing an experience using new cognitive and emotional lenses (Orkibi and Ram-Vlasov, 2019). In the end, it should be noted that not all traumas and PTGs are transformative: when they lead individuals to a relevant and permanent psychological transformation, they could be considered as TEs. Research on traumatic and stressful events has generally focused on individuals' transformation related to suffering and turmoil events (Kesimci et al., 2005; Kashdan and Kane, 2011), thus excluding perceived positive events as potential triggers of transformative growth.

Conversely, the framework of post-ecstatic growth (PEG) (Roepke, 2013) considers life events that enhance positive emotions, such as elevation and awe, as new possible triggers able to boost personal growth (Keltner and Haidt, 2003; Fredrickson, 2004; Taubman-Ben-Ari et al., 2012). Indeed, PEG concerns the idea of thriving also after highly impacting and positive experiences, giving as a result moral growth as well as deeper and closer relationships (Mangelsdorf and Eid, 2015).

Thus, in terms of factual post-event growth, there is a significant overlap in the perceived benefits of PTG and PEG, even though they are opposite in terms of valence and triggers (Roepke, 2013). However, for the purposes of this analysis, the valence of eliciting factors and outcomes is crucial to distinguish among these experiences, which consist mainly of the same processes. More specifically, triggers can have different valence and outcomes: (1) negative valence and outcomes for traumatic events that individuals were not able to accommodate and to cope with; (2) positive valence and outcomes for PEGs; (3) a negative valence but a positive outcome for PTGs, as in this case, individuals who lived a trauma were able to accommodate and to cope with it, gaining a positive as well as transformative outcome.

Human–Computer Interaction

Recently, the interest toward transformative and self-transcendent experiences (STEs) has grown also in the field of human computer interaction (Gaggioli, 2016; Kitson et al., 2019), and experience design (Blythe and Buie, 2021). Specifically, Gaggioli (2016) collected all these endeavors and developed a novel framework concerning how interactive technologies [e.g., virtual reality (VR)] can be used to elicit TEs. This is the transformative experience design (TED) model (Gaggioli, 2016). Transformative features associated to effective elicitors of TEs were identified on the basis of three technological assets: (1) medium, (2) content, and (3) purpose.

Regarding the medium, immersive VR was suggested as the best candidate to invite these *technologically mediated* TEs by enhancing the ecological validity of even complex experiences in the lab, thanks to the sense of presence (Barfield and Weghorst, 1993; Riva et al., 2004, 2011). Specifically, VR can be (and it has already resulted as) a valid source for experiencing new worlds, for challenging and restructuring individuals' cognitive schemas, and as key mechanisms and correlates of TEs (Gaggioli, 2016; Riva et al., 2016; Chirico., in press). VR, indeed, allows individuals to alter their own bodily self-consciousness, providing the illusion of being placed in a different body. This is a useful asset for generating a sense of detachment from the actual body, as in the case of OBEs, later discussed. Further, VR can also cause modulation and recalibration of time perception (Bansal et al., 2019), which is a common feature of TEs.

Crucially, drawing from Paul (2014) philosophical model on TEs, the TED model suggested that technology-based TE content should involve both epistemic and emotional affordances (Gaggioli, 2016). The former is included within circumstances designed to stimulate reflection and trigger insight (Gaggioli, 2015), as the artificial representation of disorienting dilemmas, recalling Mezirow (2000) pedagogical theory. The latter are defined as perceptual stimuli aimed to boost a deep emotional engagement by evoking feelings of interest, curiosity, inspiration, or awe.

Finally, the general purpose of a technologically mediated TE is the creation of new transformative possibilities. In this regard, such TEs should let individuals enter a space of liminality, as suggested by anthropology perspective, described, according to the definition of Turner (1974) as an unfamiliar and disorienting place that creates room for reviewing and deconstructing life meaning (Turner, 1985). In other words, allowing people to experience impossible internal and external realities through VR (i.e., by modifying their own body perception, or by letting them experience the body and the perspective of another person, or again by allowing them to explore impossible and unknown environments where physics' laws are violated) can lead them to destabilize their own mental schemes, deconstructing and reconstructing them in a new way. To date, this approach has been effective in eliciting specific transformative emotional states (Chirico et al., 2018a), as well as key micro-mechanisms related to the emergence of a TE, such as schema violations (Ritter et al., 2012).

However, further technological media can also be deemed as possible means to elicit TEs (Gaylinn, 2005). A more traditional medium, like movies, can be considered as a catalyst for personal and social growth and development (Morin, 2005; Kaplan, 2013). Transformative potential of movies has been widely explored in the education domain, by focusing on impactful masterpieces, such as Dead Poets Society[1] (Spirou, 2016) or Billy Elliot[2] (Schwarz-Franco, 2016). Finally, recently, also artificial intelligence (AI) has been proposed as a powerful technology able to trigger a societal change from a narrower sectorial level to a higher radical one, and always in an irreversible way (Gruetzemacher and Whittlestone, 2022). For instance, at the narrower level, the artistic domain has been increasingly influenced by different AI applications, including

[1]Dead Poet Society, Peter Weir, 1989.

[2]Billy Eliot Steven Daldry, England, 2000.

more collaborative forms of artistic production in music (McCormack et al., 2020), in figurative art (Schröter, 2019), and in fashion (Kautish and Khare, 2022).

Neurobiology

Brouwer and Carhart-Harris (2020) provided a neurobiological explanation for the emergence of PTG or traumatic potential consequences of transformation, by relying on the theory of dynamical systems (Kielhöfer, 2011). Specifically, they suggested that when an individual is involved in a long-lasting period of crisis (chronic stress), acute stress can trigger PiMSs – i.e., "transient, intense hyper-plastic mind and brain states" (Brouwer and Carhart-Harris, 2020, p. 320) – able to mediate psychological transformation. Crucially, also the surroundings and the relational context were indicated as key factors interacting with the neurobiological system to define the quality and outcomes of a PiMS.

Pivotal mental states involve the serotonin system and its 2A receptor subtype (5-HT2AR). Various acute stressors consistently induce serotonin release, upregulating 5-HT2AR expression specifically in the cerebral cortex (Anju et al., 2010; Benekareddy et al., 2011; Godar et al., 2019). Further, direct stimulation of the 5-HT2AR can induce enhanced associative learning and psychological transformation, and it can be stimulated by both spontaneous extreme stress and relevant doses of psychedelic drugs (Joëls et al., 2006; Hefferon et al., 2009; Briere et al., 2015). The mechanisms underlying PiMSs would aid rapid and deep learning in situations of existential crisis, catalyzing psychological change when circumstances demand this. Thus, according to this perspective, *learning* – rapid and associative – was considered as an essential consequence of transformation, both stemming from spontaneous acute stress (as in traumatic and PTG experiences) or induced, for instance, by psychedelics.

Education

A full, comprehensive model of how transformation works and can be facilitated in the learning process can be found in the domain of education. Mezirow (1978) elaborated on the theory of transformative learning as a specific transformative process taking place in education and resulting in both a deep change in a frame of reference (Mezirow, 1997, 2000; Sawatsky et al., 2018) and a shift in thinking, which irreversibly alters the way individuals are and act (Coghlan and Gooch, 2011; Stone, 2014). The main elicitor of a transformative learning process can be a "disorienting dilemma" (Mezirow, 1997) (e.g., a field trip) (Herbers and Mullins Nelson, 2009) that challenges usual mental schemas. The disorienting dilemma would lead to a cognitive self-examination, along with feelings of guilt or shame. This leads to recognizing discontentment, thanks to which individuals can express and negotiate their change through discourse, moving to explore new options for roles, relationships, and actions. According to this view, emotions and feelings would provide not only the trigger to reflect critically, but also the substance on which to reflect deeply, so that the cognitive and emotional components become strictly related. Expected outcomes entail learners become "more inclusive, discriminating, open, emotionally capable of change, and reflective so that they may generate beliefs and opinions that will prove truer or justified to guide action" (Mezirow, 2000, p. 7). Main interdisciplinarity reported outcomes concern the following typologies: worldview; self; epistemology; ontology; behavior; capacity (Hoggan, 2016).

Grounding Transformative Experiences: Specific Instances of Transformation

Since not all studies on TEs can be framed within a specific discipline, we also chose a more grounded approach to capture all the studies conducted on this phenomenon, that is, we focused on instances of TEs occurring in specific domains and acknowledged as TEs. For instance, interdisciplinary works, combining psychological, neurobiological, sociological, and philosophical approaches, focusing only on a peculiar type of TE are discussed.

Religious Conversion

Within the religious domain, the transformation par excellence coincides with the phenomenon of religious conversion. Several sociological and psychological endeavors have successfully accounted for their emergence, features, underlying mechanisms, timeframes, role of the individual, and effects, but several open questions still remain (Snook et al., 2019). At a micro-level of analysis conversion is conceived as a core identity change (beliefs and personality). For instance, recently, it has been shown that religious conversion phenomena entail personality changes as a key effect (Stronge et al., 2021). In psychology, religious conversion has been investigated using the first-hand experiences of Tolstoy, Bunyan, Edwards (etc.). James (1902), in the *The Varieties of Religious Experience* identified two types of conversions. The *volitional type* concerned situations in which "the regenerative change is usually gradual, and consists in the building up, piece by piece, of a new set of moral and spiritual habits" (James, 1902, p. 189). The *self-surrender type*, emerged as an unconscious and involuntary surrender of the individual, after an intense internal struggle between one's aspirations and an internal hindrance. A paradigmatic example concerns the transformation of Saul (the persecutor) into Paul, the saint, as a *Road to Damascus Moment*, which stemmed from a supernatural experience of *calling* (Yaden and Newberg, 2015). Crucially, as in Carel and Kidd's philosophical model, also in William James' vision, it would be possible to identify a more gradual view of TE emergence. Anthropological accounts of religious conversion have acted as a key trait d'union among different disciplines, including psychology (Rotman, 2021).

Finally, mainly the sociological perspective, at a macro-level, focused on how cultural and social factors (e.g., economy, socioeconomic status, ethnicity, etc.) can influence the identities and beliefs of a potential convert (Snook et al., 2019). Generally, current accounts of conversion suggest an active role for the convert and a low impact of external, supernatural, and irresistible forces (Snook et al., 2019).

Self-Transcendent, Emotionally Complex, Peak, and Mystical Experiences

Spirituality is a wide domain of study, which goes beyond the realm of religion, even though the two overlap to some extent. Within this intersection, it would be possible to include STEs,

which have a strong spiritual character and can be detached from any religious tradition. These experiences can be defined as transient mental states marked by decreased self-salience and increased feelings of connectedness (Yaden et al., 2017), although as for TEs, the definition of self-transcendence varies across disciplines (Kitson et al., 2020). When a STE is highly intense, it also shows a high transformative potential (Yaden et al., 2016a, 2017). Potential conditions facilitating the emergence of these states can be paradoxical VR environments (Kitson and Riecke, 2018), psychedelic substances (Garcia-Romeu et al., 2015), spiritual instructions, dance, prayer (Garcia-Romeu et al., 2015), meditation (Hanley et al., 2020). Also peculiar social events, such as festival and parades, designed *ad hoc*, could bring forth self-transcendent shared experiences (Neuhofer et al., 2020). Therefore, STEs do not always occur as private moments, instead, the social sharing of this experience, here, emerges as a key trigger (and not just effect or correlate) for these phenomena. At the physiological level, lower respiration rate has been found to be positively correlated to a higher level of mindfulness (Ahani et al., 2014), while on the contrary, STEs have been found to induce an increase in alpha and theta EEG power (Cahn and Polich, 2006).

Self-transcendent experiences could be placed on a continuum, as they encompass a collection of phenomena ranging from mindfulness, flow, and ST emotions to TEs of awe, peak experiences, and MEs (Yaden et al., 2017).

First, as core transformative elements of a STE, it would be possible to identify special emotional states deemed as complex and transformative (Chirico and Gaggioli, 2021b; Chirico et al., 2021c), such as the emotion of awe (Chirico and Yaden, 2018c; Clewis et al., 2022). These specific emotions encompass the two main dimensions of STE, that is, connectedness and the small self. Moreover, they can be elicited by a variety of inductors, including specific VR simulations (Chirico et al., 2021a). At the physiological level, for example, awe results as a mixed valenced emotional state, as captured by electromyographic measures (EMGs) and testified by a concurrent activation of the parasympathetic nervous system and withdrawal of the sympathetic one (Chirico et al., 2017). Positive awe has been positively related to the central alpha and the beta band. It also showed negative correlations with the gamma band (Hu et al., 2017). After an experience of awe, indeed, individuals have shown more prosocial attitudes and behaviors toward other people and nature, as well as decreased aggressivity, increased generosity (Piff et al., 2015; Stellar et al., 2018), enhanced creative thinking abilities (Chirico et al., 2018b), and decreases in the cognitive emotion regulation strategy of rumination (Lopes et al., 2020). At the same time, when the awe experience is negatively connotated, it has been associated with the feeling of fear and powerlessness, loss of self-control, uncertainty, and lowered sense of situational control (Piff et al., 2015; Stellar et al., 2017).

Secondly, peak experiences can be seen as prototypical transformative examples of STEs (Maslow, 1964) consisting in a moment of elevated inspiration and enhanced well-being that can permanently influence individuals' attitudes toward life and that can occur in all cultures (Maslow, 1962). Several characteristics are associated with peak experiences, including the perception that the world is good, beautiful, and desirable. Additional features are mainly emotional, such as feelings of being lucky, fortunate, or graced. Other features are more related to space and time dimensions, describing usual disorientation and strain for both. Peak experiences are also known for their short duration, although time perception could be expanded. They can be observed during a learning process (Lanier et al., 1996), during peak performance, sports activities (Privette, 1983), and within the musical domain (Gabrielsson et al., 2016). They can be triggered in various contexts, also in response to psychological turmoil (Taylor, 2012), and nature exposure (Naor and Mayseless, 2020). Among frequent aftereffects, there are heightened feelings of happiness, joy, and ecstasy, as well as fulfillment, peak performance; and, generally, psychological effects are seen as dependent on the context of emergence of peak experiences (Lanier et al., 1996; Solberg and Dibben, 2019).

Finally, MEs can also occur during structured spiritual or religious practices or even unintentionally (Barrett and Griffiths, 2017). These phenomena have been deemed as a particularly intense variety of self-transcendent TEs (Yaden et al., 2017) that hinge on a sense of reality far from ordinary experiences and that are characterized by feelings of unity with the whole reality (Cardeña et al., 2017). Initial characterizations of MEs suggested – within the variety of MEs – either a mysticism of introspection or of unifying vision (Otto, 1932). Indeed, MEs alter some key aspects of consciousness, such as the sense of time and space (Hood, 1975; James, 1902; Newberg and d'Aquili, 2008; MacLean et al., 2012). In addition, if they are induced by psilocybin, they also encompass the dimensions of sacredness and positive moods (MacLean et al., 2012). For instance, Stace (1960) stated that an ultimate unity "is the very essence of all mystical experiences" (p. 132), which can be further detailed as introvertive (characterized by a pure consciousness overcoming the boundaries of space and time) vs. extrovertive (featuring an "inner subjectivity of life in all things"; Stace, 1960, p. 131). These two types of MEs also share a sense of objectivity, peace, sense of sacredness, paradoxicality, and supposed ineffability (Wulff, 2014). At the emotional level, MEs entail mixed feelings ranging from fear to intense positive feelings (van der Tempel and Moodley, 2020). At the phenomenological level, these experiences have been described as brief, ineffable, and overwhelming (Yaden et al., 2017). James (1902) particularly highlighted that MEs possess *ineffability* and *noetic* quality (i.e., they reveal an otherwise hidden or inaccessible knowledge), and, sometimes, a sense of passivity and transiency. Other authors stated that MEs entail the perception that the self is perfectly integrating with one's surroundings (James, 1902; Stace, 1960; Newberg and d'Aquili, 2000; Hood, 2002). Overall, MEs are associated to positive psychological outcomes, such as an enhanced sense of connectedness, meaning in life, positive affect (e.g., more compassion toward self and the others), or a deeper sense of identity (Brett, 2010; Nixon, 2012; Garcia-Romeu et al., 2015; Chirico et al., 2022).

When MEs are spontaneous they can maximally challenge an individual's worldview, sometimes triggering emotional distress, confusion, and increased severity of previous psychological problems (for an overview,

see van der Tempel and Moodley, 2020). When MEs are induced, they tend to reinforce previous religious schemas (Pargament et al., 2005).

Crucially, MEs can emerge in different ways, such as during sacred ritual, aesthetic experiences, physical illness, and meditation. Recently, Evans and Lynn (2021), showed that even a brief 5-min hypnosis induction could foster MEs in the lab. Longer hypnotic inductions can result in high levels of MEs in the lab (from a moderate to a great degree) in one-third of participants, as a function of their hypnotic suggestibility. MEs can be occasioned also by the psychedelic substance psilocybin in laboratory settings (for an overview, see Johnson et al., 2019), resulting in experiences comparable to those occurring in other settings both deliberately facilitated and occurring apparently spontaneously (Hood, 2014; Yaden et al., 2017b). At the neural level, the disintegration of different brain networks has been associated to a sense of dissolved self and altered salience processing (Carhart-Harris et al., 2016; Wahbeh et al., 2018).

Exceptional Bodily Experiences

The role of the body represents a crucial aspect that has not emerged before from the analysis of TEs provided within each discipline. Specifically, there is a class of TEs in which the body acquires a central role. It is the case of exceptional bodily experiences, in which the transformation is canalized and expressed through the body. This class of TEs can include: (1) kundalini awakenings; (2) NDEs; (3) OBEs.

In Hinduism, *Kundalini awakenings* reflect the release of inner energies through various forms, accompanied by several specific physical phenomena, such as feelings of energy in the hands, deep ecstatic sensations, and awareness of energy currents flowing through the body (Taylor, 2015; Woollacott et al., 2020) from the base of the spine (Greyson, 1993). These physical sensations are associated with a sense of joy and deep interconnectedness with others (Grey, 1985; Ring and Agar, 1986; Ossoff, 1993; Kason and Degler, 1996; De Lubac, 1999; Kason, 2019). The energetic awakening involves feelings of expansion and a dissociative and conscious awareness of leaving the body, and a sense of being enveloped in light or love (Woollacott et al., 2020). It can range from mild to intense feelings of joy to dramatic states (Taylor, 2017). As a result, kundalini awakenings entail long-term transformations in *beliefs* and *values*, including an increase in love for family, the desire to serve others, a belief in spiritual immortality, as well as deeper spiritual insights (Woollacott et al., 2020). According to western researchers, kundalini awakenings can occur in several circumstances, either spontaneously or induced (e.g., meditation, psychological turmoil, psychedelics), and they show a certain degree of overlap with NDEs (Ring, 1984; Greyson, 1993, 2000; Sanches and Daniels, 2008; Taylor, 2012).

In NDEs, – an acronym coined by Dr. Raymond Moody (1975) – the body is a key element (Holden et al., 2009). This non-ordinary state of consciousness emerges in response to a real or perceived proximity to death and entails – among other phenomenological correlates (Greyson, 1983) – the perception of leaving the body boundaries, traveling through a tunnel, and of being in front of an irreversible threshold (Martial et al., 2020). Individuals who survive them share a transformative sense of cosmic unity, transcendence of time and space, deep positive mood, sense of sacredness, noetic quality of intuitive illumination, paradoxicality, ineffability, transiency, and persistent positive aftereffects (Noyes and Slymen, 1979; Greyson, 2006). NDEs' transformations are deep and long-lasting, with permanent and usually positive results (Morse, 1994; Simpson, 2001). For a comprehensive overview of NDEs, see Greyson (2015).

Although NDEs share many similarities with OBEs – and actually, may include OBEs (Blanke and Arzy, 2005; Blanke et al., 2016), they are quite different. Their major point of difference is that OBEs, conversely to NDEs, are not necessarily perceived as a threat to one's life, conversely to NDEs (Nelson et al., 2006). OBEs are states during which the self appears to occupy a position spatially apart from the experiencer's body (elevated extracorporeal location) (Blanke et al., 2016), involving both visual and somesthetic perception in which one's own physical body is illusory (Smith and Messier, 2014). OBEs' transformative impact on an individual's psychological well-being has been recognized (Riva et al., 2016), followed by an increasing interest in their healing potential (Sellers, 2019). OBEs and NDEs are similar both for their transformative outcomes and their nature, as they involve a dissociation from the body and hyper-real sensorial, perceptual, cognitive as well as affective processes (Blanke et al., 2016). NDEs are even less common than OBEs, with OBEs generally occurring rarely in lifetime (no more than once or twice) (Blanke et al., 2016).

Kundalini awakenings, NDEs, and OBEs can be considered three different manifestations of a sudden transformation unfolding through the body. However, the elicitors (or triggers) most frequently associated to these kinds of TEs are different. For example, elicitors could be traumatic events for NDEs (Greyson, 2000), e.g., cardiac arrest (Van Lommel et al., 2001), and meditation for kundalini awakenings (Woollacott et al., 2020). Crucially, OBEs can be caused, besides specific pathological conditions (e.g., depression, personality disorders), pharmacological substance consumption (e.g., LSD, marijuana, etc.), stimulation of specific brain areas (i.e., the temporoparietal junction, TPJ; Bos et al., 2016) or general anesthesia, also by the simulation of multisensory conflicts between a visual stimulus and a tactile, vestibular, or cardiac stimulus induced in a VR setting, by means of videos or robotic devices (Blanke, 2012; Fernandez-Alvarez et al., 2021).

Psychedelically Induced Experiences or Psychedelic-Like Experiences

Increased attention has been given to psychedelics-induced experiences (Fadiman and Kornfeld, 2013), specifically, with regard to peculiar chemical triggers of TEs: psilocybin administration provided one of the first models for experimentally controlled investigation of quantum changes (Barrett and Griffiths, 2017). Under supportive conditions, psilocybin can foster deeply meaningful and significant experiences (e.g., mystical-type experiences, which are discussed later in detail) (Pahnke, 1963; Griffiths et al., 2006, 2011). Follow-up studies at 2 and 14 months confirmed that psilocybin experiences enabled participants to change durably and

positively their attitudes and behaviors, and consistently with what community observers stated (Griffiths et al., 2006, 2008). Attributions to the psilocybin experience included changes in attitudes, mood, altruism, and other behaviors, as well as interpersonal closeness, gratitude, life meaning/purpose, forgiveness, death transcendence, daily spiritual experiences, religious faith, and coping (Griffiths et al., 2018).

Ibogaine was also found to have similar transformative effects too (Brown et al., 2019). Observational studies have described participants' increased reflection, forgiveness, and self-forgiveness (Brown et al., 2019), which allowed them to enhance empathy and to attain relief from guilt (Heink et al., 2017), thus enabling personal transformation. Also quantitative results (Brown et al., 2019) sustained ibogaine's psychotropic effects as being psychologically profound, leading to far reaching transformations (pp. 3–4), which is consistent with numerous other studies exploring ibogaine (Naranjo, 1969, 1974; Lotsof and Alexander, 2001; Schenberg et al., 2014; Heink et al., 2017; Camlin et al., 2018; Rodger, 2018) and other hallucinogens' effects, such as DMT, LSD, as well as mescaline (Hood, 1975; Griffiths et al., 2008; MacLean et al., 2011). For an up-to-date review of long-term effects associated to psychedelic drugs consumption, see Aday et al. (2020).

Crucially, it has been showed that it was possible to experience drug-like effects without consuming a drug but just by being close to someone who did so (Tart, 1971). Indeed, the effects of psychedelics originated also from contextual factors, including previous expectations. In a recent single-blind between-subjects study (Olson et al., 2020), some participants, belonging to the placebo group, reported intense alterations in consciousness, which had been usually found associated with moderate or high doses of psychedelics.

These controlled drug experiences, similar to mystical ones, incorporated the dimensions of *unity*, sacredness, positive mood, transcendence of time/space, ineffability (MacLean et al., 2012), and of being overwhelming both cognitively and emotionally. Like MEs, these states could be emotionally ambivalent, as they could involve not only positive emotions but also regret, fear, anxiety, and upset (Brown et al., 2019).

Specifically, at the phenomenological level, several authors have also tried to outline the unique experiential profile of psychedelic experiences (e.g., Preller and Vollenweider, 2016), and this phenomenon has been conceived as a dynamic process lying on a perception–hallucination continuum, which is characterized by an increasing arousal and by the loosing of ego boundaries (Preller and Vollenweider, 2016).

AN INTERDISCIPLINARY INTEGRATED PICTURE OF TRANSFORMATIVE EXPERIENCES: WHAT IS SHARED AND WHAT IS DIFFERENT

The initial comprehensive analysis conducted so far by giving voice to all the acknowledged interdisciplinary varieties of TE provides a foundation for a new integrated picture of these phenomena. Hereinafter, first, we focus on the redundant characteristics that frequently have emerged within different domains and disciplines' discourse by applying the reasoning by analogy approach (Ketokivi et al., 2017). We provide an overview of the outcomes of this analysis in **Table 1**. Then, shared elements (at any levels, from the biological to the existential one) and distinctive features of each TE are discussed.

Applying the Reasoning by Analogy Approach

As a first step, we focus on the shared aspects across different instances of TEs, at a higher level. To this end, we drew from a reasoning by analogy approach (Ketokivi et al., 2017). This methodological approach, which was proposed by Ketokivi et al. (2017), relies on the concept of analogy, whose value has been recognized across all the sciences. (Hesse, 1966), since it provides links between two or more different domains of knowledge (Gentner and Markman, 1997), exploiting their similarities regarding one specific phenomenon, in order to make inferences that connect them (Gentner and Namy, 1999; Ketokivi et al., 2017). Analogies have proven to be effective in enabling progress for both research and theory, especially in boundedly rational and resource-constrained contexts, since they allow researchers to focus and deepen only the relevant part of the phenomenon, abstracting out other parts, and overcoming discrepancies (March, 1994; Ketokivi et al., 2017). Here, this approach permits to combine knowledge from different domains on TEs, in order to elucidate their transversal functioning. Then, we move to consider how each TE fulfills the shared elements differently, thus bringing forth varieties of TE.

From the implementation of the reasoning by adopting analogy approach, four specific high-level shared elements emerged that can be used to frame the multifaceted nature of TEs. Firstly, these concern, first, TEs' phenomenological dimensions (i.e., characteristics subjectively perceived by individuals during TEs). These features can be further divided into: (1) epistemic expansion (new forms of knowledge of the self and of the world) and (2) emotional complexity, involving intense, mixed emotions, and emodiversity (Berrios, 2019). In addition to the phenomenological elements, two psychological elements can be identified: (3) facilitating conditions/elicitors, and (4) specific effects on the recipient (aftereffects).

The **epistemic expansion** component concerns new forms of knowledge about the self and the world. For instance, in STEs, a sense of self-diminishment and of being connected with all beings is a predominant result. Peak experiences entail the appraisal of the world as a good, beautiful, desirable, place, and the awareness that all polarities and dichotomies have been resolved. In NDEs, there is a dissolution of body boundaries, perception of being able to suddenly understand everything, and being on the edge of an irreversible threshold. Moreover, subjective time perception is recurrently expanded or dilated, while the experience itself could last even a few moments. Space perception is also often strained, distorted, and transcended, as in the case of OBEs and NDEs. This dimension of altered time perception, instead, was less relevant (if not absent) in Mezirow's transformative

TABLE 1 | Overview TEs instances' main features: main reference discipline(s), domain(s), phenomenological correlates, elicitors, and aftereffects.

TE instance	Main involved discipline(s)	Domain	Main reference(s)	Description	Epistemic expansion	Emotional complexity	Elicitors/ Facilitating conditions	Aftereffects
Religious conversion	Psychology, philosophy, anthropology, sociology	Religion, spirituality	James, 1902; Ullman, 2013; Snook et al., 2019	A moment of enlightenment, self-surrendering, and union with a new religious awareness of superiority consisting in a process through which persons move from their previously held religious beliefs to the beliefs of a new religious tradition.	Perception of new truths that were inaccessible before; time perceived as stopped, slowed down, or dilated; brief duration.	Sudden loss of all concerns, relief, sense of peace, harmony, deep happiness, faith. High emotional intensity.	Current theories: key active role of the convert, lower impact of external supernatural causes, more emphasis on converts' need for meaning and purpose, despite also cultural factors play a role.	Key personality changes (e.g., increase in honesty-humility, conscientiousness, and neuroticism after the conversion); key identity changes; new language; new beliefs.
Self-transcendent and emotionally complex experiences	Psychology, neurobiology, nursing, psychiatry, design, human computer interaction	Miscellaneous	Garcia-Romeu, 2010; Yaden et al., 2016a, 2017; Kitson et al., 2020	The *transient* mental state marked by the transcendence from the material and physical limitations, and by a deep connection with something greater than oneself.	Perception of self-diminishment and decreased self-salience; time is perceived as unbounded.	Self-transcendent positive emotions: elevation, compassion, gratitude, love, and awe. High emotional intensity.	Meditation, peculiar social events hinging on connection with others, virtual reality paradoxical scenarios, nature; catalyzed with spiritual instruction, dance, prayer, and psychedelic substances.	Decreased anxiety, increased energy, insight, social ability, and sustained positive affect, value re-orientation, increased concern for others, increased positive affect, and disidentification from old patterns of thinking or behavior; increased prosociality (toward other people and nature); increased generosity, enhanced creative thinking; decreased ruminative strategies. The negative counterpart of ST emotions emerged as associated to highly intense fear and powerlessness, loss of self-control, uncertainty, and lowed sense of situational control.
Peak experience	Psychology, neurobiology	Miscellaneous	Maslow, 1962, 1964	A *sudden* and *unexpected* acceleration of personal development or self-actualization.	The appraisal of the world as good, beautiful, desirable, sudden certainty that polarities and dichotomies have been resolved, strain in both time and space, rapid duration while perceived time is expanded.	High inspiration, awe, wonder, gratitude, deep well-being, high emotional intensity.	Exposure to nature, sport, music, spiritual and religious context, learning.	Effects depends on the context in which the peak experience takes place; individuals recognized immediately this experience as a turning point, achieving peak performance; highest positive feelings (joy, happiness, and ecstasy).

(Continued)

TABLE 1 | (Continued)

TE instance	Main involved discipline(s)	Domain	Main reference(s)	Description	Epistemic expansion	Emotional complexity	Elicitors/ Facilitating conditions	Aftereffects
Mystical experience	Philosophy, psychology, neurobiology	Religious, spiritual	James, 1902; Stace, 1960; Newberg and d'Aquili, 2000, 2008; Hood, 2002	Particularly intense variety of self-transcendent experiences (Yaden et al., 2017). An experience that tends to occur suddenly, it is often transient, it appears as ineffable, joyful, it involves the perception of an ultimate unity, of oneness; transcendence of the ego; a full conviction of immortality; and it tends to be attributed supreme value. Some people interpret MEs as experiences of unity with God (Thalbourne, 2003).	Perception of vanishment of the whole self, cognitively overwhelming, ineffable, noetic quality, sacredness; strain in space and mostly in time while it has a short duration.	Mixed feelings raging from fear to intense positive affect.	Psychedelics; hypnosis; meditation; sacred ritual, aesthetic experiences physical illness.	Enhanced sense of connectedness, meaning in life, positive affect (e.g., more compassion toward self and the others) or a deeper sense of identity.
Kundalini awakening	Psychology, anthropology, sociology	Spirituality, self-transcendence	Taylor, 2015; Kason, 2019; Woollacott et al., 2020	Exceptional physical experience consisting of a huge release of energy, accompanied by temporary corporeal symptoms.	Conscious awareness of leaving the body, increased sensory sensitivity, deep interconnection with others; time is perceived as loosened, as the sense of linear time was lost (i.e., "out of time" experience).	Deep ecstatic sensations, joy, enhanced sense of connectedness and unity, reduced fear of death, feelings of expansion, envelopment in love or light; possible dramatic negative emotions.	Meditation, psychological turmoil, psychedelics.	Change in beliefs and values, reduced tendency to aggression; possible negative cognitive outcomes that leave an indelible mark, as disruptions of psychological functioning and mental illness; new sense of identity.
Near-death experience	Psychology, philosophy, neurobiology	Miscellaneous	Greyson, 2000, 2006, 2015; Simpson, 2001; Holden et al., 2009	Altered state of consciousness on the (real or perceived) threshold of death. Major focus on the peculiar feeling of leaving the physical body and encountering non-physical entities/ environments.	Accelerated thoughts; life review; perception of understanding everything, flash from the past, perception of leaving the body boundaries, and of traveling through a tunnel and of being in front of an irreversible threshold; absence of time and space.	Sense of cosmic unity and sacredness, peace, positive mood, feelings of harmony, unity, joy, revelation, and connectedness.	Meditation, psychological turmoil, psychedelics; alternations in oxygen levels; neurological alterations.	New responses to life-threatening dangers, life review, sense of being controlled by an outside force, transformation of attitudes, shift to a new belief system, decreased death anxiety, heightened spiritual awareness.

(Continued)

TABLE 1 | (Continued)

TE instance	Main involved discipline(s)	Domain	Main reference(s)	Description	Epistemic expansion	Emotional complexity	Elicitors/ Facilitating conditions	Aftereffects
Out-of-body experience	Psychology, philosophy, neurobiology	Miscellaneous	De Foe et al., 2012; Smith and Messier, 2014; Sellers, 2019	States during which the self appears to occupy a position spatially apart from the experiencer's body (elevated extracorporeal location) (Blanke et al., 2016).	Disembodiment; the self appears occupy an elevated extracorporeal location; enhanced reality, hyper-real cognitive perception, extremely vivid stimuli, and settings, intensified sensory inputs that lead to transformative outcomes.	Highly intensified emotions, hyper-real affectivity.	Pathological conditions (e.g., depression, personality disorders), pharmacological substances assumption (e.g., LSD, marijuana, etc.); stimulation of specific brain areas (temporoparietal junction area, TPJ); general anesthesia, also by the simulation of multisensory conflicts between a visual stimulus and a tactile, vestibular, or cardiac stimulus induced in virtual reality (VR), by means of videos or robotic devices.	Changes in bodily self-consciousness (self-identification and self-location); decreased fear of death; dissociation.
Trauma	Psychology, philosophy, clinical medicine, neurobiology	Clinical	Calhoun and Tedeschi, 1995, 2006; Tedeschi, 1999; Grof, 2000	Radical changes given by the experiencing of a negative high-impacting event. If changes are negative, the TE leads to trauma. If changes are positive, the TE turns into posttraumatic growth.	Expectancy, probability, and controllability evaluations associated to the events; sense of time distorted and bodily distortion as predictors of PTSD.	Terror, perception of threat.	Negatively overwhelming psychological stressors individuals could not cope with.	Altered self-capacities, mood disturbance, enhanced avoidance responses, posttraumatic stress.

(Continued)

TABLE 1 | (Continued)

TE instance	Main involved discipline(s)	Domain	Main reference(s)	Description	Epistemic expansion	Emotional complexity	Elicitors/ Facilitating conditions	Aftereffects
Posttraumatic growth	Psychology, philosophy, clinical medicine, neurobiology	Clinical	Calhoun and Tedeschi, 1995, 2006; Tedeschi, 1999; Grof, 2000	Positive change experienced as a result of the struggle with traumatic events.	Expectancy, probability, and controllability evaluations associated to the events; sense of time can be distorted.	Terror, perception of threat; relief.	Negatively overwhelming psychological stressors individuals could cope with; the perception of the triggering event depends also on individual differences, e.g., the degree of previous religiosity.	Personal development, enhanced authenticity responsibility toward oneself and others, accepting attitude to death, increased self-confidence, new identity, values, and perspectives.
Post-ecstatic growth	Psychology	Miscellaneous	Fredrickson, 2004; Roepke, 2013; Mangelsdorf and Eid, 2015	Radical positive changes given by the experience of highly impacting positive events.	The relevance of time and space varies according to the ecstatic or peak experience, which generally involves a transcendence of these dimensions.	High positive emotional valence, which can be associable to the peak experience's one.	Positive affective experiences, awe moments.	Durable and positive changes regarding appreciation of life, relationships, enhanced spirituality, renewed life meaning, and personal strengths.
Psychedelic experience	Psychology, psychopharmacology, neurobiology, anthropology	Miscellaneous	Barrett and Griffiths, 2017; Camlin et al., 2018; Griffiths et al., 2018; Brown et al., 2019; Brouwer and Carhart-Harris, 2020	Dynamic process lying on a perception–hallucination continuum, which is characterized by an increasing arousal and by the loosing of ego boundaries.	Space and time transcendence; ineffability; overwhelming in nature; unity, ego-dissolution; perceptual illusions (alterations of the environment and of the body image; peculiar visual phenomena); deep insights into the nature and structure of the universe.	Gratitude, forgiveness, unity, death transcendence sacredness, positive mood, but also regret, fear, anxiety, and upset.	Typically elicited by psychedelic substances (e.g., psilocybin; Ibogaine; DMT; LSD).	Positive changes in attitudes and behaviors, increased positive coping, prosociality, and empathy. Negative long-term changes at the neurological, personality, molecular, and psychological level (see Aday et al., 2020).

(Continued)

TABLE 1 | (Continued)

TE instance	Main involved discipline(s)	Domain	Main reference(s)	Description	Epistemic expansion	Emotional complexity	Elicitors/ Facilitating conditions	Aftereffects
Transformative learning experience	Education, psychology, philosophy	Learning	Mezirow, 1978, 1997; Kleiber et al., 2002; Stone, 2014	Process of changing accustomed assumptions, thus producing an effective shift of reference frameworks.	Deep and structural shift in mental schemas, beliefs, and perspective, loss of old meaning perspectives to find new selves, heightened self-reflection.	Emotional and social learning, hope, newness, intense emotions as drivers for self-reflection, but also guilt, shame, disorientation, dissonance.	Disorienting dilemma.	Both positive and negative outcomes, e.g., changes in worldview, schema and paradigm, changes concerning how learners conceptualize themselves, and how they related to others or to the world in general; increased empowerment/responsibility; new ways of knowing, which is more open, discriminating, extrarational. Development of new skills. Implementation of new social actions, which are consistent with epistemological changes; heightened spirituality.

Quantum change has not been included since it has been often considered as an overall experience encompassing mystical experiences and the phenomenon of insight. Liminality as well has been indicated as a broader anthropological framework for capturing transformative experiences, while PiMSs address mainly the neurobiological level of a transformative experience, thus, acting as an explanatory neurobiological model of a special phase of the transformative process.

learning process. However, during transformative learning, the disorienting dilemma acted as a central moment of belief shift through the violation of previous expectancies. Finally, Brouwer and Carhart-Harris (2020) model on PiMSs could provide a particularly suitable framework to address the neurobiological underpinnings of this epistemic expansion component, which reflects the phenomenological transversal dimensions shared by all the types of TEs considered so far.

The **emotional complexity** component deals with the extremely intense and mixed nature of feelings, affects, and discrete emotions involved during ongoing TEs. Extremely intense feelings can be found during traumatic events, OBEs, NDEs, or STEs. Emotional complexity mainly refers to the experiencing of positive and negative states together (i.e., emotional dialecticism) (Larsen et al., 2001; Spencer-Rodgers et al., 2010) and to the experiencing of emotions with high granularity, with a wider variety of discrete emotions reported (i.e., emotional differentiation) (Kashdan et al., 2015). Although the literature has often evidenced generally positive emotional characteristics of TEs, a deeper overview of these experiences showed that they are characterized by mixed emotions – involving the co-activation of opposite emotions at the same time – or by emotional variability (Larsen et al., 2001; Berrios, 2019). There could be two main mechanisms in which mixed emotions underlying TEs could work to give rise to these experiences. According to the bipolar view (Russell, 2017), mixed emotions may be felt when individuals have already undergone a transformation, but they still emotionally fluctuate between rejection and acceptance of a chosen behavior. Conversely, the bivariate view by Larsen (2017) suggests that an event could be characterized by two simultaneous opposite feelings (e.g., fear and happiness at the same time) (Roseman, 2017). People living a TE are likely to experience a diverse and abundant array of emotions, ranging from ecstasy, bliss, and relief (e.g., as in religious conversions) to guilt, fear, and regret (see psychedelic-induced MEs in Brown et al., 2019). The breadth of TEs' emotional repertoire can suggest that these experiences are characterized by *emodiversity*, which refers to the richness of emotional complexity (Quoidbach et al., 2014; Berrios, 2019).

Finally, TEs can usually be conceived as either spontaneous events or as induced by specific facilitating conditions, also by recognizable elicitors. **Facilitating conditions/elicitors** for each TE analyzed in this work are reported in **Table 1**.

Some specific state-conditions act as recurrent triggers of different TEs (psychedelics, meditation, spiritual practices), others as peculiar elicitors of specific instances of TEs (e.g., cardiac arrest for NDEs) (for a finer and up-to-date list of triggers, see White and Brown, 2000). In addition, recently, more stable variables (trait-like) have emerged as potential preparatory conditions for engendering specific TEs, as in the case of PTG, which is facilitated by previous religiosity (i.e., religious affiliation and strength of religious beliefs) (Taku and Cann, 2014). Crucially, novel technological devices, such as VR, have been proposed as valid tools for inviting even more complex TEs in the lab (see OBEs in Bourdin et al., 2017; van Heugten-van der Kloet et al., 2018). VR, indeed, allows manipulating (also separately) several components of cognition and emotion

(Slater et al., 2010; Slater, 2018; Bolt et al., 2021) as well as overall potentially TEs (Chirico et al., 2020).

However, if basic underpinnings of TEs are not previously captured and understood, VR can turn useless. Indeed, there is always a risk of mistaking the role of this tool in promoting this class of experiences by nurturing fallacious reasoning. It should be noted that VR can easily resemble phenomenological features typical of a given TE. However, this would not guarantee that the same underlying mechanisms/underpinnings of a TE are activated during an equivalent VR experience. Therefore, a deeper comprehension of the basic mechanisms underlying each TE (starting from their facilitating conditions) is essential to reproduce it in the lab by means of VR or any other simulation tool.

Finally, although it may look redundant, it would be useful to demonstrate that all the experiences included in this conceptual analysis show **specific effects on the recipient (aftereffects)** that would be able to impact individuals' cognition, emotions, and personality in the long run. This has always been a basic criterion used to define TEs, as mentioned at the beginning of the present work. However, even though all instances of TEs considered so far entail long-lasting, pervasive aftereffects, they also feature a high degree of variability in terms of their consequences. This, again, could support the idea that – echoing William James's seminal work on religious experience – it would be useful and appropriate to indicate TEs as "varieties of transformative experience" with two shared core components, elicitors/facilitating conditions particular to specific types of TEs, along with a certain degree of internal differentiation.

These components were summarized in **Table 1**.

Toward a Tentative Integrated Interdisciplinary Conceptualization of Transformative Experience

In line with all the evidence reviewed and analyzed so far, a new preliminary integrated definition of TEs is here advanced.

Transformative experiences can be defined as brief experiences, perceived as extraordinary and unique, entailing durable and/or irreversible outcomes, which contribute to changing individuals' self-conception, worldviews, and view of others, as well as their own personality and identity by involving an epistemic expansion (as new forms of knowledge of the self, others, and the world) and a heightened emotional complexity (emotional variability, high intensity, mixed emotions), as the two core phenomenological features. They are usually remembered vividly.

These experiences emerge suddenly, either apparently spontaneously or they can be invited by specific elicitors/facilitating conditions encompassing both state (related to contingencies) and trait elements (related to more stable conditions of the experiencer). Elicitors, usually, are perceived as novel stimuli, able to challenge an individual's mental schema, thus also resulting in disruption.

Some TEs can also encompass transcendental elements. Some TEs (and some phases of a TE) can be marked by peculiar neuropsychophysiological underpinnings.

Finally, it is appropriate to conclude this section by suggesting that a more active dialog among several disciplines and domains would be not only be desirable but also especially advantageous, despite the effort that this would require.

CONCLUSION

Although literature on specific types of TEs is growing and bringing forth promising results, an integrated view of this phenomenon has yet to be developed. In this conceptual analysis, we aimed to provide this interdisciplinary view by marking shared phenomenological features of TEs, as well as their intrinsic particularities, to outline a preliminary interdisciplinary operational definition of TEs.

This effort could turn, as a first outcome, into a more fluid dialog among scholars from different disciplines interested in examining this phenomenon at different levels of analysis, thus resulting in a finer and more comprehensive view of the phenomenon and its underpinnings. Otherwise, the risk can be a fragmentation of TEs' conceptualization and research.

As a second outcome, this endeavor could lead to a paradigmatic shift, as the direction of research is moving from retrospective to predictive study of TEs. For instance, nowadays, it is only possible to sense pandemic as a *potentially* TE. An open issue is to scientifically predict the extent to which this will occur, that is, to measure its transformative potential. This would be possible only after having elucidated the underpinnings of transformation at different levels, from the biological to the existential level. In this regard, the results of this analysis could inform the design of novel, integrated, and comprehensive instruments to measure the potential of an event to engender a specific type of TE in a particular person. Moreover, future studies could also consider the possibility of developing a new comprehensive and interdisciplinary instrument capturing the "minimal transformation" embedded into an experience, also building upon the conditions for the appearance of a minimal phenomenal self (e.g., Windt, 2015b; Josipovic and Miskovic, 2020; Metzinger, 2020). This could be useful, for instance, in the assessment of health promotion interventions. Other possible research lines could elucidate and systematically analyze the antecedents/facilitating conditions giving forth different types of TEs, thus enriching the examination of these class of experiences. The aim of this work is to stimulate a fluid dialog among researchers to acquire a comprehensive view of this phenomenon, despite it should be noted that this work is preliminary in nature and needs to be constantly updated by new evidence, insights, and suggestions.

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AC and EG wrote the first draft. AC conceived the rational along with AG and MP. AK and BR revised the manuscript, provide relevant suggestions, and improvements. All authors contributed to the article and approved the submitted version.

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