Enjoy it! Cosmetic try-on apps and augmented reality, the impact of enjoyment, informativeness and ease of use

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Virtual Try-On cosmetics apps based on Augmented Reality (AR) technology can improve both consumer product evaluation and purchase decisions, while also supporting companies' marketing strategies. This study explores the factors influencing the use of AR-based cosmetics apps by administering the Technology Acceptance Model (TAM) and additional scales on a sample of 634 Italian consumers. Perceived Informativeness (PI) and Perceived Ease of Use (PEOU) were hypothesized as predictors of TRUST, DOUBT, Makeup Involvement (MI), Perceived Diagnosticity (PD), and Behavioral Intention (BI), with Perceived Enjoyment (PE) acting as a mediating variable. The structural equation model (SEM) confirmed PI as a strong predictor, with PE serving as a key mediator. The findings suggest that a moderate level of PE and PEOU is ideal - excessive simplicity or playfulness increases DOUBT and decreases TRUST. Both PD and BI are positively affected by the AR experience, with their coexistence being crucial for effective app usage. Additionally, PI, mediated by PE, significantly influences BI, emphasizing the role of information in consumer decision-making. These results provide valuable insights for the cosmetics industry, offering guidance to refine user experiences and enhance consumer engagement and satisfaction.

KEYWORDS

augmented reality, cosmetics, beauty, trust, perceived enjoyment, virtual try-on apps, technology acceptance model, percieved informativeness

1 Introduction

Augmented Reality (AR) technology combines real images/environments, captured by the camera of PC, mobile phones or other smart devices, with virtual 3D digital graphics/objects, making them coexist in the same space at the same time (Azuma, 1997; Fox, 2012; Kounavis et al., 2012; Rese et al., 2017; Russo et al., 2022). It can be implemented on cutting-edge devices such as Apple Vision Pro or Spacetop AR laptop, as well as on mobile apps for general purpose off-the-shelf smartphones (Arena et al., 2022). Reduced costs and technological advances are expanding AR globally: worldwide revenues are expected to surpass US$198 billion in 2025, and the number of users to exceed US$1.33 billion (Rejeb et al., 2023). According to research data from the IDC Worldwide Augmented and Virtual Reality Spending Guide, the consumer sector accounted for 53% of the market share of AR-related spending in 2020 (Hsu et al., 2021).

This technology digitally reshapes the real world by providing enhanced experience in terms of perceived hedonistic, informative and utilitarian values (Voicu et al., 2023) and it is becoming an attractive means of commercialization and revenue generation (Khan et al., 2015). In fact, it has been estimated that it will be adopted by 59.1% of companies worldwide by 2027 (Dhianita and Rufaidah, 2024).

AR applications span various fields, including healthcare (Douglas et al., 2017; Fida et al., 2018), manufacturing (Eswaran and Bahubalendruni, 2022) and maintenance (Lamberti et al., 2014), ergonomics and work safety (Karlsen et al., 2022), education (Hidayat and Wardat, 2024), vocational training (Chiang et al., 2022) and support to learning disabilities (Shaaban and Mohamed, 2024). They also impact marketing and communication (Rauschnabel et al., 2024) within E-commerce (Shah, 2024) and retail settings (Attri et al., 2024). Notable examples include mobile apps for furniture positioning and layout planning (Alves and Luís Reis, 2020), nutritional information and food tractability (Penco et al., 2021), immersive digital storytelling (Farshid et al., 2018) and pre-purchase evaluation of products (Barta et al., 2023a), especially in the cosmetic sector, with a reported effectiveness in boosting the purchase intentions (Ebrahimabad et al., 2024) and the users' self-perception and satisfaction (Lee and Oh, 2018; Kosmala et al., 2019).

1.1 Make-up use and the "augmented beauty"

The use of dyes and paints for body and face adornment has long been a means of human self-expression (Jones and Kramer, 2016). Historically, cosmetics was primarily geared to women (Jones and Kramer, 2016; Russell, 2011), but in recent years, there has been a notable increase in men's interest in it (Infante et al., 2016). Although makeup is commonly used to accentuate youth-related features, its use begins during adolescence, with the average consumer falling within the 20 to 30-year-old age range (Ramshida and Manikandan, 2014; Park et al., 2018).

Cosmetics serve to enhance facial contrasts and conceal imperfections (Korichi et al., 2008), thus improving individuals' attractiveness and aligning their appearance with societal ideals of beauty (Kosmala et al., 2019; Arai and Nittono, 2022). Research also suggests that makeup can make people appear healthier (Nash et al., 2006), more competent and trustworthy (Etcoff et al., 2011), and even more prestigious (Mileva et al., 2016). On a psychological level, it supports self-expression (Smith et al., 2021), alleviates anxiety related to social appearance and conformity (Korichi et al., 2008), and boosts self-esteem (Lee and Oh, 2018; Kosmala et al., 2019). Furthermore, it enhances psychological wellbeing (Kosmala et al., 2019) and has been found to play a therapeutic role for cancer patients, reducing distress and promoting self-improvement (Park et al., 2015). There is also an increasing focus on sustainable and eco-friendly cosmetics (Dini and Laneri, 2021), which contributes to raising awareness about personal care (CFA Center for Food Safety and Applied Nutrition, 2022).

Beauty and cosmetics had a global market of USD 374.18 billion in 2023, with sales expected to double by 2032 and beauty tech revenues to increase from USD 214 billion in 2021 to USD 292 billion in 2026 (Statista, 2024). In particular, the Asian population, especially Chinese and South Koreans, shows a strong interest in the cosmetics industry, contributing to its growing popularity globally (Butt et al., 2021).

AR technology is impacting the beauty and cosmetics sector, both in retail and online contexts. In physical retail environments, the "Magic Mirrors" provide augmented reflections that enhance the process of self-recognition (Javornik and Pizzetti, 2017) and help consumers establish a threshold for self-perception, influencing their sense of self and how they view their appearance (Javornik et al., 2021; Scholz and Duffy, 2018). E-commerce settings, that are often marked by lower buying rates due to challenges such as the inability to physically evaluate products before purchase (Theopilus et al., 2021), incomplete product information (Lian and Yen, 2013), and issues with color selection (Jain and Bhatti, 2010; Kadyrova et al., 2020), have gained benefit from AR. Through a digital visualization, it offers enhanced product information (Kristi and Kusumawati, 2021). Additionally, through the "Virtual Try-On" (VTO) (Barta et al., 2023a) functionality, it allows an advanced and more reliable pre-product evaluation, significantly reducing the gap between the pre-purchase and post-purchase experience, a common issue in online shopping that often leads to dissatisfaction and abandoned carts (Yim et al., 2017; Hsu et al., 2021).

Cosmetic consumers using AR services report higher confidence and satisfaction in their purchases, which ultimately increases their likelihood to buy (Butt et al., 2021; Qin et al., 2021). This effect is similar to trends observed in the tourism sector (Wu and Li, 2017; Genç, 2018). Additionally, AR reduces cognitive load (Barta et al., 2023a), simplifying decision-making and enhancing the overall shopping experience. Several cosmetics companies, including L'Oreal (Ulaş, 2020), Sephora (Wanick et al., 2023) and Estée Lauder (Erbaş, 2019) have already adopted AR applications for marketing strategies.

Despite its promising applications, scientific literature on AR technology in the beauty and cosmetics sector remains limited (Chakraborty et al., 2024). Furthermore, only a few studies have explored the impact of behavioral and psychological factors on the adoption of AR-based apps and the associated consumption behaviors.

Bialkova and Barr (2022) identified usability and immersion as key elements for effective usage of AR-based apps. Gabriel et al. (2023) confirmed this also for the usage intention. Voicu et al. (2023) found a dependency of usage intention from fit confidence, innovativeness, immersion and social value, as well as perceived hedonistic and utilitarian values. Adawiyah et al. (2024) underlying, as predictors of usage intention, both the innovativeness and attitude, while Oyman et al. (2022) emphasized on informativeness and enjoyment. Holdack et al. (2022) underlying the role of enjoyment both as predictor of attitude and mediator between informativeness and usage intention. Sekri et al. (2024) observed a direct relationship between purchase intention and perceived value - further affected by both perceived usefulness and perceived costs - but not with perceived enjoyment. Finally, Laberger et al. (2024) associated escapism and perceived usefulness to the purchase intention, eventually mediated by personal satisfaction.

The available studies concentrated on a limited set of dependent variables mainly focusing on attitude towards AR (Fan et al., 2020; Holdack et al., 2022), satisfaction with the AR experience (McLean

and Wilson, 2019; tom Dieck et al., 2023), and behavioural intention to use AR (Oyman et al., 2022; Rese et al., 2017) and not considering the complex interconnection of other psychological variables that may arise.

To address these limitations, we proposed a model based on different predictors and mediators, as well as multiple outcomes, considering also the potential psychological and behavioral barriers that might lead consumers to distrust e-commerce platforms employing AR, abandoning the app and/or opting to visit physical stores to finalize their purchases after identifying the desired product (Kim and Han, 2022). Our aim was not limited to fostering the application of AR in the cosmetics industry, but also to advance knowledge of human-machine interactions across different sectors.

1.2 Research model and hypotheses

To identify the factors influencing consumers' use of AR apps for purchasing cosmetics online, a theoretical framework is essential (Perea y Monsuwe et al., 2004; Riar et al., 2023). We adopted the Technology Acceptance Model (TAM), initially proposed by Davis in 1986, which aims to explain the determinants of new technology acceptance (Davis, 1986; Davis et al., 1989; Davis et al., 1992; Rese et al., 2017). TAM is considered one of the most widely used frameworks in examining marketing practices, also in AR applications (Du et al., 2022) as it helps explain its acceptance and potential future use (Rese et al., 2017). Several studies supported the idea that AR applications can influence consumer behavior by offering additional informational and interactive features, which may affect behavioral intentions (Childers et al., 2001; Pantano and Di Pietro, 2012; Dehghani et al., 2020; Romano et al., 2021). This study focused on the interaction between 4 TAM's dimensions, which are key factors that influence decisions regarding the adoption of technology: perceived informativeness (PI), perceived ease of use (PEOU), perceived enjoyment (PE), and behavioral intention (BI), In addition, we incorporated four additional constructs: makeup involvement (MI), perceived diagnosticity (PD), TRUST, and DOUBT.

The following subsections provide a description of each of the 8 variables, justifying their inclusion in the model and their roles as antecedents, mediators, and outcomes.

1.2.1 Perceived informativeness (PI)

Perceived Informativeness (PI) is a key factor in decision-making, providing consumers with relevant and useful product information that enhances clarity and helps achieve satisfactory product choices (Rese et al., 2017). PI positively impacts online purchase intention (Toraman, 2022; Kang et al., 2020), particularly in AR environments, where it emphasizes the functional and utilitarian aspects of the technology (Holdack et al., 2022). PI improves PEOU (Machdar, 2016) and perceived usefulness (Wixom and Todd, 2005). Additionally, higher PI positively influences PE, as the playful presentation of information increases hedonic value (Pantano and Di Pietro, 2012). In AR applications, PI and PE work together by providing useful digital information and enhancing the hedonic experience (Olsson et al., 2013). Recent studies show a direct positive effect of PI and PE on BI

in the cosmetic domain (Oyman et al., 2022). Therefore, AR devices have the potential to provide more information, reduce uncertainty, and aid decision-making (Pantano and Di Pietro, 2012; Poushneh, 2018; Rese et al., 2017). As per TAM, PI is an important antecedent of AR usage.

1.2.2 Perceived ease of use (PEOU)

Perceived Ease of Use (PEOU) refers to the perceived ease with which individuals use technology, requiring minimal mental effort (Rouibah et al., 2011; Amin et al., 2014). It reduces learning costs and facilitates information seeking (Wang et al., 2014), promotes greater use of online platforms (Li and Yeh, 2010), and shapes positive attitudes toward technology adoption (Ahn et al., 2004). While PEOU is not always directly linked to BI (Kim and Kang, 2012; Chan and Teo, 2007), it remains a key factor in assessing user acceptance of online platforms (Amin et al., 2014). PEOU indirectly influences BI in online purchases (Wang et al., 2014) and predicts repurchase intentions (Rezaei and Amin, 2013). The mediating role of perceived enjoyment (PE) has been highlighted in the PEOU-BI relationship (Balog and Pribeanu, 2010; Holdack et al., 2022; Toraman, 2022), positioning PEOU as a crucial predictor in the AR framework of TAM (Holdack et al., 2022). However, high PEOU does not always predict system usage or improve attitudes, as shown in online banking (Al-Sharafi et al., 2016; Zheng and Li, 2020; Chang et al., 2015). In some cases, ease of use, especially in security-sensitive contexts, can signal liability or mistrust (Al-Sharafi et al., 2016), leading to doubts about the application (Sugandini et al., 2019). Thus, ease of use remains a critical factor in the engagement with AR tools and is considered an antecedent.

1.2.3 Behavioral intention (BI)

Behavioral Intention (BI) is a key factor for predicting the future use of a technology (Jackson et al., 1997). As noted by Oyman et al. (2022), it can be used to forecast AR application usage and it frequently emerges as an outcome in TAM models in marketing and online AR-based consumer experiences (e.g., Zhuang et al., 2020; Saleem et al., 2021; Park and Yoo, 2020) as it reflects the likelihood of engaging in a particular behavior (Ajzen and Fishbein, 1977; Turner et al., 2010). Oyman et al. (2022) found that both PI and PE positively and directly influence BI in the context of AR usage in the cosmetics domain. The positive relationship between PE and BI has been confirmed in previous studies (e.g., Qiu and Li, 2008), as well as the direct effect of PI on BI (e.g., Richard and Meuli, 2013). However, the role of PEOU in predicting BI is less consistent, with some studies suggesting direct (e.g., Lee et al., 2017), indirect (e.g., Revels et al., 2010; Wang et al., 2014) or negligible effects (e.g., Oyman et al., 2022; Hur et al., 2017; King and He, 2006). PE's role as a mediator between PEOU and BI has been discussed previously. Given its importance, BI is considered an outcome of the model, with PEOU and PI as potential predictors, and PE as a mediator.

1.2.4 Perceived enjoyment (PE)

Perceived Enjoyment (PE) refers to how enjoyable users find interacting with technology (Qiu and Li, 2008). Both PEOU and PI positively influence PE in virtual environments, contributing to positive attitudes toward technology and subsequent BI (Holdack et al., 2022). In AR or VR environments, PE plays a key role in technology acceptance (Pantano and Servidio, 2012; Balog and

Pribeanu, 2010). AR provides hedonic experiences like self-expression, entertainment, and stimulation (Olsson et al., 2013), which positively impact attitudes toward online purchases through virtual try-on technology (Zhang et al., 2019) and AR wearables (Holdack et al., 2022). Additionally, PE influences behavioral intention to use mobile media and shop online (Alalwan et al., 2018; Hasan et al., 2021; Dickinger et al., 2008). In this study, PE is considered a mediator.

1.2.5 Makeup involvement (MI)

Involvement refers to the subjective relevance, interest, and attentional resources directed toward a product category with personal significance and priority (Zaichkowsky, 1985; Zaichkowsky, 2010; Laurent and Kapferer, 1985). In the beauty and cosmetic sector, it is crucial for profiling customers (Stiehler and Jordaan, 2019; Guthrie et al., 2008) and refers to the level of attention and value consumers place on makeup use (Lee and Oh, 2018). Involvement is shaped by social, psychological, and functional values (Lichtenstein et al., 1988), enhanced by the self-expressive role of makeup (Bloch, 1982). As a result, Involvement drives consumers to engage more enthusiastically with products and to have higher expectations of both utilitarian and symbolic outcomes (Bloch and Richins, 1983). Scholars have emphasized different perspectives on involvement, including the role of rewards in interactions (Bloch and Bruce, 1984) and the motivation to fulfill functional and symbolic needs (Rothschild, 1984; Laurent and Kapferer, 1985). Involvement also has an emotional component, as highly involved consumers seek pleasure in product-related experiences (Venkatraman, 1989; Mathwick and Rigdon, 2004). Using TAM, Koufaris (2002) demonstrated the positive relationship between involvement and enjoyment in online shopping. Lee and Oh (2018) incorporated 'pleasure pursuit' into their model of *Makeup Involvement (MI)*, confirming its role as a potential outcome in cosmetics usage. Involvement helps protect products from negative evaluations (Dens and De Pelsmacker, 2010), increases willingness to pay (Steenkamp et al., 2010), enhances consumer brand identification (Stokburger-Sauer et al., 2012), and leads to product purchase (Olsen, 2007). Given its connection to reward and symbolic and utilitarian use, we expect MI to be a potential outcome of the model, directly linked to both PI and PEOU. Additionally, as MI is fostered by enjoyable experiences, we hypothesize that PE mediates the relationship between PEOU and PI.

1.2.6 Perceived diagnosticity (PD)

Perceived Diagnosticity (PD) refers to the effectiveness of a product experience in shaping opinions about a brand and its attributes (Kempf and Smith, 1998; Kempf, 1999). In virtual product experiences, PD reflects how effectively technology communicates useful, relevant, and helpful information for evaluating products (Jiang and Benbasat, 2004). A key factor in PD is the informativeness of the product or technology (Jiang and Benbasat, 2007; Chrimes et al., 2022; Yoo, 2020). In the AR context, Uhm et al. (2022) found higher PD levels compared to traditional web environments, due to greater information personalization. Yoo (2020) demonstrated that PD in AR is positively influenced by the accuracy, objectivity, and relevance of displayed information, aligning with the information quality of an information system
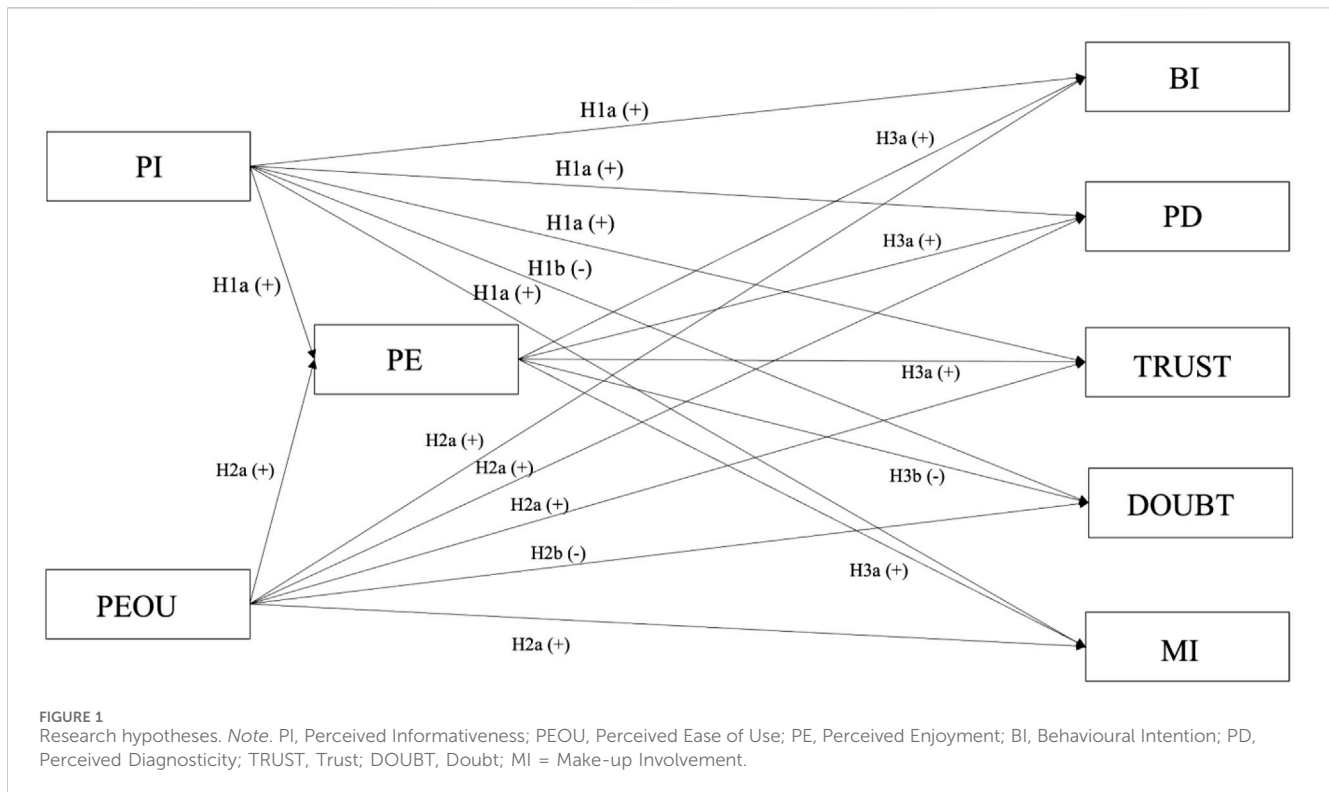
(DeLone and McLean, 2003; Zheng et al., 2013). However, PEOU does not directly affect PD (Yoo, 2020), as usability can be influenced by personal characteristics (e.g., Aldás-Manzano et al., 2009) or task difficulties (e.g., Jiang and Benbasat, 2007), leading consumers to focus less on technical issues when evaluating diagnosticity (Park and Yoo, 2020). Nonetheless, Jiang and Benbasat (2004) found that PD increases when users perceive greater control over the environment, a factor also linked to PEOU (Venkatesh, 2000; Mathieson et al., 2001). Vividness (Chen et al., 2022) and visual quality (Yoo, 2020), along with interactivity with the product and environment (Chen et al., 2022), also enhance PD, contributing to enjoyment (Pantano et al., 2017). PD reduces perceived information asymmetry (Choe et al., 2008), increases perceived usefulness (Peukert et al., 2019), and strengthens the link between virtual brand experiences and purchase intentions (Gabisch and Gwebu, 2011), positively influencing behavioral intentions such as purchase and transaction intentions (Gabisch and Gwebu, 2011; Verhagen et al., 2016; Fang, 2012) and contributing to positive brand attitudes (Lee, 2012). In AR, PD is particularly important as it helps overcome the limited product interaction typical of online experiences (Yoo, 2020), and is driven by higher levels of tangibility (Verhagen et al., 2016). Based on these findings, we hypothesize that PD is an outcome of both PI and PEOU, with PE potentially serving as a mediator.

1.2.7 TRUST

TRUST is a key factor in consumer behavior and a crucial element in TAM models applied to AR (Khoshroo and Irani, 2024). It is defined as "a psychological state comprising the intention to accept vulnerability based on positive expectations of the intentions or behavior of another" (Rousseau et al., 1998, p. 395). TRUST helps reduce uncertainty, social complexity, and perceived risk by increasing the expectation of favorable outcomes (Pavlou, 2003; Bano and Siddiqui, 2022). In e-commerce, TRUST and PE are essential for online shopping quality (Ha and Stoel, 2009; Bilgihan, 2016; Kim and Peterson, 2017; Weisberg et al., 2011). Perceived usefulness and PEOU directly influence TRUST in online applications (Bano and Siddiqui, 2022; Beldad and Hegner, 2018; Ha et al., 2019; Hansen et al., 2018; Handoyo, 2024). TRUST also impacts BI in online banking (Rouibah et al., 2016) and mobile experiences (Hameed et al., 2024). AR technology in e-commerce enhances product interaction and facilitates shopping, with users' intention to use AR being shaped by performance expectations, PEOU, and hedonic motivation (Marto et al., 2023; Smink et al., 2019). TRUST plays a significant role in shaping performance expectations, reinforcing BI to use AR, and influencing the final perception of the tested product. Kim et al. (2010) found a positive relationship between the PI of a digital shopping experience and TRUST, confirming the former as a potential predictor. The authors also noted that entertainment during the experience positively shapes TRUST, reinforcing the role of PE in fostering positive attitudes (Chakraborty et al., 2003). Greater TRUST in AR for realistic product trials increases the likelihood of purchase, thus we hypothesized it as an outcome.

1.2.8 DOUBT

DOUBT is defined as "the subjective uncertainty people experience when evaluating the correctness of their decisions,

FIGURE 1
Research hypotheses. *Note*. PI, Perceived Informativeness; PEOU, Perceived Ease of Use; PE, Perceived Enjoyment; BI, Behavioural Intention; PD, Perceived Diagnosticity; TRUST, Trust; DOUBT, Doubt; MI = Make-up Involvement.

beliefs, or opinions" (Van de Calseyde et al., 2018, p. 98). It is also referred to as skepticism (Romani, 2006) and was included in the model due to its inverse relationship with TRUST, as highlighted by some scholars (e.g., Evans et al., 2021). Both DOUBT and TRUST play roles in decision-making processes (Evans et al., 2021), with the reverse relationship being particularly strong when exploring new products or using novel tools. In such cases, DOUBT significantly raises barriers to product usage (Naaz et al., 2021; Sääksjärvi and Morel, 2010). TRUST helps alleviate DOUBT and uncertainties in AR-mediated e-commerce (Manchanda and Deb, 2021), turning these into an incentive to adopt new technologies (Joerss et al., 2021). However, correlations have been found between DOUBT and PEOU (Rodrigues et al., 2024). In e-commerce, AR helps differentiate product options, reducing confusion, DOUBT, and anxiety (Barta et al., 2023b). As a result, AR can enhance the shopping experience by making it more engaging and increasing its PE (Basari and Dewanti, 2024). Thus, doubt was included as a potential outcome.

1.3 Research hypotheses

As summarised in Figure 1, we hypothesize that:

H1a - PI has a positive association with PE, BI, PD, TRUST, and MI.

H1b - PI has a negative association with DOUBT.

H2a - PEOU has a positive association with PE, BI, PD, TRUST, and MI.

H2b - PEOU has a negative association with DOUBT.

H3a - PE has a positive association with PE, BI, PD, TRUST, and MI.

H3b - PE has a negative association with DOUBT.

H4a - PE has a role as a mediator between PI as an antecedent and TRUST, MI, PD, DOUBT, and BI as outcomes.

H4b - PE has a role as a mediator between PEOU as an antecedent and TRUST, MI, PD, DOUBT, and BI as outcomes.

2 Materials and methods

2.1 Participants and procedure

We conducted a self-report questionnaire using an online platform (Google Forms). The sample consisted of 634 Italian cosmetics consumers, primarily female (82%), with an average age of 30 years (SD = 12.72, range: 18–75). Most of them were unmarried (67%), held a university degree (42%), and were either students (44%) or employees (25%).

Before completing the questionnaire, participants provided informed consent that acknowledged their voluntary participation and ensured their anonymity. The study adhered to the principles outlined in the Declaration of Helsinki (World Medical Association, 2013) and complied with the General Data Protection Regulation. Ethical approval was obtained from the IULM Ethical Committee (Protocol 0073876 of 19/09/24). The questionnaire was administered from February 2024 to April 2024.

2.2 Measures

PI, PEOU, PE, BI, PD, TRUST, DOUB and MI dimensions were averaged from multiple items, with participants indicating their level

TABLE 1 Means (M), Standard Deviations (SD), and Correlations (Pearson's r) for each measure.

	M	SD	1	2	3	4	5	6	7	8
1. PI	3.39	1.75	(0.96)							
2. PEOU	3.99	1.91	0.72**	(0.98)						
3. PE	3.68	1.75	0.84**	0.81 **	(0.93)					
4. BI	2.87	1.70	0.78**	0.64**	0.75**	(0.94)				
5. PD	3.46	1.36	0.66**	0.55**	0.67**	0.61**	(0.93)			
6. TRUST	2.90	1.20	0.60**	0.41**	0.55**	0.64**	0.74**	(0.92)		
7. DOUBT	2.73	1.31	0.08*	0.21*	0.19*	0.09	0.09*	0.63	(0.88)	
8. MI	3.72	1.05	0.39**	0.37**	0.43**	0.41**	0.41**	0.40**	0.09*	(0.71)

Note. **$p < 0.01$ level; *$p < 0.05$ level. Cronbach's alphas are on the diagonal (between brackets). PI, perceived informativeness; PEOU, perceived ease of use; PE, perceived enjoyment; BI, behavioural intention; PD, perceived diagnosticity; TRUST, trust; DOUBT, doubt; MI, Make-up Involvement.

FIGURE 2
Results of the path analysis. Note. PI, perceived informativeness; PEOU, perceived ease of use; PE, perceived enjoyment; BI, behavioural intention; PD, perceived diagnosticity; TRUST, trust; DOUBT, doubt; MI, make-up involvement.
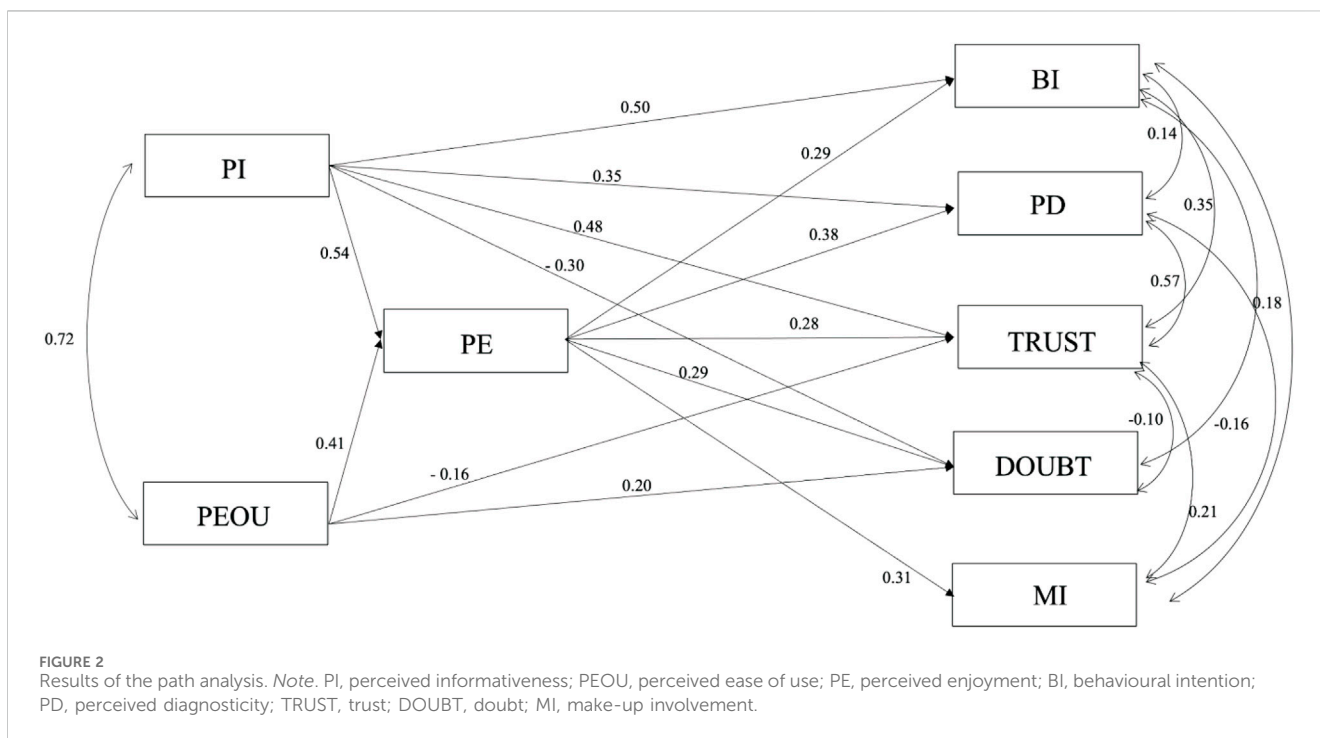
of agreement or disagreement on a Likert scale, which varied in range.

PI, was measured through three items adapted from Rese et al. (2017) and Holdack et al. (2022) on a 7-point Likert scale ranging from 1 (strongly agree) to 7 (strongly disagree); an example is "This AR try-on site provided detailed information about make-up".

PEOU was measured through three items adapted from Huang and Liao (2015) on a 7-point Likert scale ranging from 1 (strongly agree) to 7 (strongly disagree); an example is "I found the virtual trial site easy to use".

PE was measured through three items adapted from Rese et al. (2017) on a 7-point Likert scale ranging from 1 (strongly agree) to 7 (strongly disagree); an example is "Using AR applied to the cosmetics site is a lot of fun".

BI was measured through three items adapted from Ahn et al. (2004) and used in the digital context by Rese et al. (2017) on a 7-

point Likert scale ranging from 1 (strongly agree) to 7 (strongly disagree); an example is "If I were to buy cosmetics in the future, I would download or use this virtual try-on app immediately.".

PD was measured through four items. Three of them were adapted from Yoo (2020) on a 6-point Likert scale ranging from 1 (strongly agree) to 6 (strongly disagree), an example is "I think that cosmetics tested with AR allows for better product comparisons"; a further item was added out of completeness for which the Cronbach alpha fitted very well.

TRUST was measured through three items adapted from Arghashi and Yksel (2022) on a 6-point Likert scale ranging from 1 (strongly agree) to 6 (strongly disagree); an example is "I think AR is reliable".

DOUBT was measured through three items adapted from Sääksjärvi and Morel, (2010) on a 7-point Likert scale ranging from 1 (strongly agree) to 7 (strongly disagree); an example is

TABLE 2 Indirect effects of the estimated SEM.

Indirect effects	Standardized indirect effects		
	Est.	s.e.	p
PI → PE → BI	0.16	0.03	0.00
PEOU → PE → BI	0.12	0.02	0.00
PI → PE → PD	0.20	0.03	0.00
PEOU → PE → PD	0.16	0.03	0.00
PI → PE → MI	0.17	0.04	0.00
PEOU → PE → MI	0.13	0.03	0.00
PI → PE → DOUBT	0.16	0.04	0.01
PEOU → PE → DOUBT	0.12	0.03	0.01
PI → PE → TRUST	0.15	0.04	0.00
PEOU → PE → TRUST	0.12	0.03	0.00

Note. PI, perceived informativeness; PEOU, perceived ease of use; PE, perceived enjoyment; BI, behavioural intention; PD, perceived diagnosticity; TRUST, trust; DOUBT, doubt; MI, Make-up Involvement.

"Thinking back to the experience of using AR to purchase products online, I doubt a product really does what it should".

MI was measured through three items from Steenkamp et al. (2010), adapting them to the Make-Up context on a 6-point Likert scale ranging from 1 (strongly agree) to 6 (strongly disagree); an example is "Make-up interests me a lot".

2.3 Data analysis

Data analyses were performed through two different software. SPSS v. 27 (IBM Corp., Armonk, N.Y., USA), was used to calculate descriptive statistics, correlations (Pearson's r) and reliabilities (Cronbach's α) for each scale. MPLUS v. 8 (Muthén and Muthén, 1998-2013) was used to perform a path analysis based on a Structural Equations Model (SEM). This study specified hypotheses a-priori and performed a partial mediation model (James et al., 2006). The Goodness of fit of the model was controlled though different indices: the chi-square value (χ^2), the Comparative Fit Index (CFI), the Tucker Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR).

To evaluate possible effects of common method bias, Harman's single-factor test has been performed (Podsakoff et al., 2003). The model, calculated through MPLUS 8, showed the following fit indices: $\chi^2(20) = 416.753$, $p < 0.00$, CFI = 0.87, TLI = 0.83, RMSEA = 0.18, SRMR = 0.07. These indices suggest that the model cannot be identified, thus indicating that the one single factor is not accounting for the variance in the data and suggesting that the common method is unlikely.

3 Results

Psychometric analyses showed satisfactory Cronbach's alphas in all the assessed variables, ranging between 0.71 and 0.98, meeting the criterion of exceeding 0.70 (Nunnally and Bernstein, 1994).

On average, PEOU and PE exceeded the central point of the scale, with PEOU showing a higher value, while BI did not. Additionally, PD and MI surpassed the central point, while TRUST and DOUBT did not, although TRUST was very close.

High, positive significant correlations were observed among almost all assessed variables, with the strongest correlations found between PI and: PE ($r = 0.84$); BI ($r = 0.78$); PEOU ($r = 0.72$); PD ($r = 0.66$); TRUST ($r = 0.60$); and MI ($r = 0.39$). Furthermore, strong correlations were found between PE and: PEOU ($r = 0.81$); BI ($r = 0.75$); TRUST ($r = 0.55$); and MI ($r = 0.43$). PE showed a positive but weak correlation with DOUBT ($r = 0.19$). PEOU also showed positive and relatively strong correlations with other variables, particularly with: BI ($r = 0.55$); TRUST ($r = 0.41$); and MI ($r = 0.37$). Additionally, the correlation between PEOU and DOUBT was weak and positive ($r = 0.21$).

The following Table 1 summarises the correlations and descriptive statistics for each measure.

The estimated SEM, summarised in Figure 2, showed satisfactory indices of fit, confirming the goodness of the model: $\chi^2(0) = 0.00$ $p < 0.00$, CFI = 1, TLI = 1, RMSEA = 0.00; SRMR = 0.00. PI showed a direct and positive strong association with PE ($\beta = 0.54$), BI ($\beta = 0.50$) and TRUST ($\beta = 0.48$), and a lower but significant positive association with PD ($\beta = 0.35$). PI showed a negative and significant association with DOUBT ($\beta = -0.30$), and a non-significant association with MI. PEOU showed a direct and positive strong association with PE ($\beta = 0.41$), and a lower but significant positive association with DOUBT ($\beta = 0.35$). PEOU showed a negative and significant association with TRUST ($\beta = -0.16$), and a non-significant association with BI, PD, and MI. PE showed positive significant associations with all the considered variables: PD ($\beta = 0.38$) MI ($\beta = 0.31$); BI ($\beta = 0.29$); DOUBT ($\beta = 0.29$), and TRUST ($\beta = 0.35$).

The model supported the mediating role of PE, with all the hypothesized indirect effects significant, as shown in the following Table 2.

4 Discussion

Augmented Reality (AR) has been shown effective in providing enhanced product information, addressing the primary limitation of e-commerce in the beauty and cosmetic market, namely, the lack of a pre-purchase product evaluation. This technology has been suggested to create a win-win situation for both companies, which can promote their products online and increase sales, and consumers, who can more easily evaluate products and make informed decisions with the aid of Virtual Try-On (VTO) apps. However, AR technology is still emerging, and more work is required to overcome the psychological challenges that hinder its widespread adoption: the impact of the individual characteristics on consumers' perceptions and experiences, as well as the influence of the enjoyment on the overall experience, the decision-making processes and the app usage.

Previous studies focused on a limited set of outcomes, namely, the attitude towards AR, the satisfaction with the overall experience and the behavioural intention to use AR-based apps, and did not take into account the complex interconnection of other psychological variables.

To address these limitations, we performed a path analysis based on a Structural Equation Model (SEM), considering 4 dimensions of the Technology Acceptance Model (TAM): perceived informativeness (PI), perceived ease of use (PEOU), perceived enjoyment (PE), and behavioral intention (BI). We additionally included, as outcomes of the model, makeup involvement (MI), perceived diagnosticity (PD), TRUST, and DOUBT.

The observed value of PEOU, PE, and MI, all above the midpoint scale, suggests that VTO cosmetic apps are perceived as simple, user-friendly, and engaging.

The strong correlations between PI and the PEOU, PE, BI, PD and TRUST dimensions suggest its key role. If consumers feel that the app is able to convey information about the products, their perception of user-friendliness increases, as does their enjoyment of using the app itself. Moreover, as long as they feel that they have received detailed information about the products, they are more inclined to purchase the products, which is consistent with the literature (Pai and Yeh, 2014). Additionally, they consider AR as effective in conveying product details, helping them form their opinions, consistent with the literature (Jiang and Benbasat, 2007; Chrimes et al., 2022; Yoo, 2020). PI increases alongside TRUST in the technology and product, highlighting how useful detailed information is in helping consumers feel confident about the product. PI correlation with MI suggests that the more consumers believe they have received interesting information about the cosmetics, the more they tend to increase their relevance and attention to them. Similar results can be found in past studies (e.g., Kim et al., 2010).

The strong correlation between PEOU and PE, also confirmed in previous studies (Holdack et al., 2022; Huang and Liao, 2015), suggests that as much as consumers appreciate the simplicity of the app, they also enjoy the experience and have fun. PEOU also correlates positively with BI, which is in line with other studies on mobile wallets (To and Trinh, 2021) or on e-business environments (Leyton et al., 2015). Another strong correlation is with PD, confirming that the easier an app is to use, the more you feel that it can provide all the information you need to form a correct

opinion about the product. However, it is interesting to note that there is a low significant but positive correlation with DOUBT, leading to the suggestion that perhaps excessive ease of use may raise doubt rather than convey confidence in the product. This ambiguous role of PEOU is sometimes found in the literature, especially in areas where security is an issue (Al-Sharafi et al., 2016), suggesting that something too easy can be interpreted as risky in the perception of the users.

PE shows a high correlation with BI and PD, indicating that enjoyment in using the technology increases alongside the perception of its effectiveness in explaining product details, making enjoyable experiences more likely to lead to purchase intentions. PE also shows a correlation with TRUST, that is, people who feel happy and engaged when using beauty apps are more inclined to be confident about the technology and the product. This has also been found in other studies on the use of online banking systems (Rouibah et al., 2016), mobile wallets (To and Trinh, 2021), and online shopping (Marza et al., 2019; Gao and Wu, 2010). Finally, PE also correlates with MI, suggesting that enjoyment and engagement in makeup use tend to grow side by side, consistently with other studies (e.g., Shiau and Luo, 2013).

BI correlates with PI and PE, in line with much of the literature in this area (e.g., Oyman et al., 2022), and shows that the intention to purchase products presented via the AR app is related to how much people believe they will receive adequate information about the products themselves (Hameed et al., 2024), and how much people enjoy using the technology (Ramayah and Ignatius, 2005; Bashir and Madhavaiah, 2015). BI also correlates with PEOU and although the relationship between these two variables provides two-faced results (Li and Chu, 2024; Kim and Kang, 2012), some literature still confirms that purchase intention tends to increase with the perception of ease of use (Ramayah and Ignatius, 2005).

PD correlates very strongly with PI, PEOU, PE and BI and interestingly also with TRUST. Therefore, our ability to evaluate and understand the quality of products increases with the perceived ease of use and enjoyment of the app, as well as with our purchase intention (Cheng et al., 2022) and trust in the product (Avnet et al., 2012).

TRUST shows strong correlations with PI, PD and BI, indicating that the informativeness about the product allows users to have confidence in it and to be sure that the AR app provides the appropriate information that allows to give a clear idea of how to make the purchase (Alalwan et al., 2018).

DOUBT shows only a mild yet significant positive correlation with PEOU and PE, indicating that it is not simply the inverse of TRUST but a distinct dimension with different behavior, despite both being key factors for technology acceptance (e.g., Rese et al., 2017). For a cosmetics app to be fully embraced, it should strike a balance - neither too easy to use nor overly playful - since consumers may become suspicious if the experience feels too simple or too entertaining.

The path analysis reveals key findings, starting from the strong positive associations between PI and TRUST, BI and PD. This suggests that obtaining product information influences trust, purchase intention, and the clarity of consumer perceptions about the product. Therefore, H1a for PE, BI, PD, and TRUST is confirmed.

PI also shows a negative association with DOUBT, indicating that clear, detailed product information reduces consumer doubts about whether the product will meet expectations, confirming H1b.

PEOU shows a positive association with PE, confirming that ease of use leads to enjoyment and relaxation. However, PEOU is negatively associated with TRUST and positively associated with DOUBT. This supports the idea that if something is too easy to use, it can cause skepticism. Therefore, H2a is confirmed only for PE, while H2b is not.

PE correlates positively with BI, PD, TRUST, and MI. This suggests that enjoyment while using the app positively impacts purchase intention, product trustworthiness, and engagement with the product, fully supporting hypothesis H3a.

However, PE also correlates positively with DOUBT, indicating that if the app is too playful, consumers may perceive it more as a game than a shopping tool, increasing doubts about the purchase process. Thus, H3b is rejected.

Regarding the mediator role of PE, PI has both direct and indirect effects (via PE) on BI, PD, and TRUST, but no direct effect on MI. This contrasts with previous findings (Kim et al., 2010), suggesting that clear product information alone does not lead to product involvement. However, when information is conveyed in a playful manner, it does increase consumer involvement. Additionally, information reduces doubt, but when presented in an enjoyable way, it can increase skepticism. This is consistent with the correlation results and highlights that doubts arise when an app feels too playful. Therefore, PE mediates the relationship between PI and BI, PD, MI, and TRUST, confirming H4a. The mediation of PE between PI and DOUBT is positive, emphasizing that enjoyment should be balanced.

As for PEOU, it has no direct influence on BI, PD, or MI, indicating that ease of use alone does not impact behavioral intention or perceptions about the app's effectiveness. However, when PE mediates, ease of use positively impacts purchase intention, product quality perception, and involvement with cosmetic products. The playfulness of the app significantly impacts all these outcomes, suggesting that if the app offers a hedonic experience, the pleasure derived from it boosts purchase intention, involvement, and the perception that the app helps form a clear opinion about the product. However, ease of use needs to be carefully measured, as PEOU has a direct negative impact on trust, with users tending to perceive the app as untrustworthy. If pleasure mediates this relationship, trust increases. Therefore, PE mediates the relationship between PEOU and BI, PD, MI, and TRUST, confirming H4b. PEOU also has a direct and indirect positive effect on DOUBT, confirming that doubts about product trustworthiness increase when the app is too simple, supporting earlier correlations. This suggests that for a cosmetics app to be effective and reliable, it should not appear too simple.

This study provides three notable insights. First, PE plays a critical role in AR app usage. Enjoyment has been a consistent driver of attitudes toward AR adoption (Won et al., 2023) and a predictor of purchase intention (Holdack et al., 2022). Although results are sometimes less clear (Iranmanesh et al., 2024), PE remains decisive in the TAM model (Alalwan et al., 2018; Balog and Pribeanu, 2010), contributing to positive evaluations of both the app and the brand, motivating users, and encouraging future use (Kim and Forsythe,

2008). It also frequently acts as a mediator in many TAM-based models (Basari and Dewanti, 2024; Hasan et al., 2021).

The second insight is the role of DOUBT, particularly in relation to PE and PEOU. While enjoyment boosts decision-making, PE shows a dual nature when DOUBT is considered. Correlations confirm that if the app feels too much like a game, consumers will doubt its reliability and may not use it for shopping. The indirect effects, where PI's negative association with DOUBT turns positive through PE, support this. Although detailed product information helps reduce doubt and positively influences decision-making, a playful interface may undermine the app's seriousness. Furthermore, DOUBT is significant in its relationship with PEOU, suggesting skepticism towards AR increases when the app is too easy, confirmed by the negative association between PEOU and TRUST. Future research should explore the relationship between TRUST and DOUBT, which was not significant in this study.

The last insight involves PI, particularly its relation to PE. PI is a critical component in TAM-based studies and a reliable predictor of attitudes and purchase intention (Rese et al., 2017; Smink et al., 2019; Kim et al., 2010). It is the only variable that negatively correlates with DOUBT, highlighting its key role in reducing uncertainty and resistance to purchase. In this study, PI serves as a strong cognitive predictor, interacting effectively with all outcomes. PE mediates the relationship between PI and the outcomes, suggesting that product information is crucial for behavioral intention, trust, and PD.

5 Implications

Since this study focused on the user/consumer experience rather than on technical aspects of AR apps, we believe it offers valuable insights for both the cosmetics industry and the academic community.

Previous research has shown that gamification elements in AR applications can increase user enjoyment, especially in public spaces (Noreikis et al., 2019). However, gamification should not be the primary feature of an app, nor should ease of use be the sole focus, as excessive playfulness or simplicity may lead users to question the app's purpose and increase uncertainty. Cosmetics companies should aim to balance enjoyment and ease of use in app development to avoid user frustration and ensure the app remains engaging and practical (Dirin and Laine, 2018). Continuous attention to user experience is essential to encourage repeat use of the app or platform. The academic community should further explore the role of perceived enjoyment (PE) in AR applications across various sectors to better understand their adaptability, as demonstrated in the tourism industry (Aburub, 2023).

The study also underscores the importance of informativeness in influencing purchase intentions, as shown in previous research (Tabaeeian et al., 2024). Companies should prioritize providing detailed product information in their AR applications to facilitate consumer decision-making. From an academic perspective, the study reinforces the significance of informativeness in B2C contexts and raises the question of whether AR technology could be applied similarly in B2B contexts, such as through interactive presentations that engage potential clients.

6 Limitations

While this study presents promising implications, it is important to acknowledge its limitations. Future research should address the non-probabilistic sample used in this study. Although it includes various age clusters, it is slightly skewed toward women and younger individuals, who are the primary cosmetics users (Ramshida and Manikandan, 2014). To validate the findings across different demographics, future studies should include a more uniform sample, in both age and gender variables.

Since it included only Italian consumers, further research examining European and non-European populations is suggested. From a cross-cultural perspective, this research would provide a clearer view of consumer behavior regarding AR technology.

The study did not compare the AR experience with a traditional product test without AR. Such a comparison could offer deeper insights into the added value of AR in consumer decision-making.

Since the data are only based on self-reports, the results may be subject to potential biases, as participants' perceptions and behaviors might not fully reflect their actual experiences.

Finally, as conducted within the beauty and cosmetics, the findings may not be directly applicable to other market sectors. Thus, there is a need for more comprehensive studies to explore the potential and limitations of AR applications across various contexts.

7 Conclusion

This study explored how the complex interaction of multiple factors (identified as antecedents, mediators or outcomes) influences the use of cosmetics Virtual Try-On (VTO). Dimensions of the Technology Acceptance Model (TAM) and additional constructs were evaluated through a path analysis based on a Structural Equation Model (SEM).

The results confirm, first, the robustness of TAM in assessing AR-based apps, consistent with the literature (Rese et al., 2017; Oyman et al., 2022). Furthermore, Perceived Informativeness (PI) and Perceived Ease of Use (PEOU) were identified as predictors, while Perceived Enjoyment (PE) acted as a mediator, influencing multiple outcomes related to app usage, product evaluation, and decision-making (Iranmanesh et al., 2024). The interaction of these factors offers a more comprehensive understanding of the consumer experience with AR apps. PI emerged as a strong predictor of Behavioral Intention (BI), highlighting the importance of information in consumer decision-making, while PE was a critical mediator. Furthermore, moderate levels of PE and PEOU were found to enhance TRUST and reduce DOUBT. Both Perceived Diagnosticity (PD) and BI were positively impacted by the AR experience, with their coexistence being essential for effective app usage.

AR provides a multisensory simulation that enhances the shopping and entertainment experience (Huang and Liao, 2015). Therefore, Perceived Enjoyment (PE) is essential for understanding the use of cosmetics apps. Throughout this study, PE has been shown to be a key element of the customer experience in the digital environment. The hedonic experience consumers enjoy can be both pleasant and engaging, complementing the cognitive experience associated with

product information. This combination allows consumers to perceive the AR app as useful for understanding the product and making a purchase, while also fostering engagement with the products and enhancing their perception of reliability. Finally, attention must be given to the activation of DOUBT, as it acts as a barrier to both purchase and app usage. Therefore, it is crucial to consider it when developing a cosmetic AR app, to prevent resistance and ensure a smoother user experience.

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 humans were approved by the IULM University Ethics Committee of the University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

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Conflict of interest

The 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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