Understanding mobile augmented reality apps in Pakistan: an extended mobile technology acceptance model

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Abstract

Purpose – *Augmented reality (AR) adoption has boomed globally in recent years. The prospective of AR to seamlessly integrate digital information into the actual environment has proven to be a challenge for academics and industry, as they endeavor to understand and predict the influence on users' perceptions, adoption intentions and usage. This study investigates the factors affecting consumers' behavioral intention to adopt AR technology in shopping malls by offering the mobile technology acceptance model (MTAM).*

Design/methodology/approach – *This conceptual framework is based on mobile self-efficacy, rewards, social influence and enjoyment of existing MTAM constructs. A self-administered questionnaire, constructed by measuring questions modified from previous research, elicited 311 usable responses from mobile respondents who had recently used AR technology in shopping malls. This analysis was performed using SmartPLS3.0.*

Findings – *Grounded on the findings of the study, it was found that, aside from factors such as mobile usefulness, ease of use and social influence, the remaining independent variables had the most significant impact on adopting AR technologies. Considering the limitations of this study, the paper concludes by discussing the significant implications and insinuating avenues for future research.*

Originality/value – *To better investigate mobile AR app adoption in Pakistan's shopping malls, the researchers modified the newly proposed MTAM model by incorporating mobile self-efficacy theory, social influence, rewards and perceived enjoyment. However, the extended model has not been extensively studied in previous research. This study is the first to examine the variables that affect an individual's intention to accept mobile AR apps by using a novel extended MTAM.*

Keywords *Augmented reality, Adoption, MTAM, Mobile commerce, Shopping malls, Pakistan*

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1. Introduction

With the innovative use of information technology (IT) companies and organizations have achieved and maintained sustainable competitive advantages (Opazo-Basáez *et al*., 2022; Yin *et al*., 2023). The advancement of IT has certainly spurred many groundbreaking innovations in the business landscape, as well as communication avenues, reshaping business paradigms, and shortening product life cycles across a wide range of sectors and fields (Cho *et al*., 2023; Kowalkowski *et al*., 2022), whereby AR adoption in shopping malls is no exception. Malls are experiencing unprecedented growth, expansion, and metamorphosis owing to digital technological advancements. Therefore, augmented reality technologies have significantly improved the realism of shopping malls, bringing them further into the realm of reality. AR is defined as a system "AR is a system that seamlessly blends 3D virtual entities into real-time 3D environments using technologies developed for virtual reality" (Azuma, 1997). Augmented reality (AR) technology has renovated our proficiency of goods and services. Consequently, individuals are more inclined to amalgamate with virtual objects in real-life environments (Izard and Méndez, 2021).

Several sectors, including healthcare and education, are adopting and integrating augmented reality (AR) into their existing offerings (Madden and Carstensen, 2019), defense, engineering, aviation (Karczmarz *et al*., 2017), and oil and gas (Garcia *et al*., 2019). As a result of AR, individuals can perceive virtual objects within the context of their actual surroundings, thus enhancing their sense of sight (Saleem *et al*., 2022). The omnipresence of smartphones and tablets has increased interest in augmented reality among companies and developers (Daponte *et al*., 2014). In recent years, augmented reality has moved from the laboratory to the consumer market on a large scale (Rese *et al*., 2017). Moreover, the shopping mall sector recognizes that augmented reality has significant potential to improve consumers' in-person shopping experiences as well as drive sales. Researchers have found that augmented reality dynamically influences consumers' purchase intentions (Huang and Hsu Liu, 2014; McLean and Wilson, 2019; Ng-Thow-Hing *et al*., 2013). Saprikis *et al*. (2021) stated that the future of shopping malls depends heavily on augmented reality. To date, little research has been directed to determine how AR apps influence consumer behavior. Only a limited amount of research has reconnoitered the factors and implications of AR in the setting of shopping.

All these factors guide to the necessity of better understanding the factors of augmented reality app adoption. This study investigates the factors inducing users adoption of augmented reality apps using a unique extended Mobile Technology Acceptance Model (MTAM). This investigation focuses on a service associated with mobile devices; thus, MTAM was selected for the main model. This study extends the model because it is based on only two factors (MEOU and MU). This study intends to develop a novel research framework that will significantly contribute to the academic background by improving our understanding of consumer adoption behavior. Additionally, the results of this research provide valuable insights into how to enhance industrial operations. The research objectives are twofold: (1) "What factors derive consumers' BI from adopting mobile AR apps in shopping malls"? (2) "Is the modified MTAM robust in terms of analyzing customers' BI to adopt mobile AR apps in shopping malls."

2. Status of mobile augmented reality in Pakistan

AR is a distinctive fusion of interactive technology breakthroughs that smoothly incorporate virtual elements into a physical environment. This increases the chances of a user interacting with virtual objects (Poushneh and Vasquez-Parraga, 2017). AR uses videos, images, visual overlays, and textual information to present computer-created digital content. By using this feature, users can read, listen to, and view in real time. By using modern gadgets such as smartphones, tablets, headsets, projectors and fixed interactive displays, users can engage simultaneously with two distinct worlds commonly referred to as "the virtual and physical worlds." (Javornik, 2016). Azuma (1997) and Yim *et al.* (2017) described AR as represented by three attributes. First, AR merges the virtual and actual worlds; as a result, it provides users with a dynamic "new experience" to explain their unique behavior. Second, in addition to being interactive in real time, augmented reality offers an engaging experience. Third, AR accompanies a three-dimensional simulation, creating a "vivid visual" experience. However, the concept of AR is not new. The perception was commenced by Morton Heilig in 1950 and is insinuated to as "Sensorama" (Carmigniani *et al*., 2011; Uruthiralingam and Rea, 2020b). Given smartphones' lack of technical progress, users cannot easily access augmented reality until up-to-date software and hardware innovations arrive on the market (Kosa *et al.*, 2019). Originally, AR was not well established, cost-effective, or familiar enough to use features that could change over time (Qian *et al*., 2019; Zhang *et al*., 2019). It later became commonplace for businesses and individuals to use it for positive experiences. Since the early 1990s, when augmented reality was in its infancy, considerable technological advancements have been made (Yim *et al*., 2017). The majority of previous studies on mobile AR have been conducted in developed countries, according to an analysis of the current research (Qin *et al*., 2021; Rauschnabel, 2021; Saprikis *et al*., 2020). Currently, the primary emphasis of research is on factors that shape customers' adoption of mobile AR technology in Pakistan's shopping malls. Specifically, there is a drought of research examining the factors shaping MAR adoption in

developing nations, including Pakistan. To date, research on augmented reality usage in Pakistan has been restricted to a single point of view, such as the retail sector (Alam *et al*., 2021; Khan *et al*., 2021; Ul Haq and Farooq, 2019) but no attention has been paid to AR adoption in the shopping mall context. Addressing this research gap, this study discourses the gaps by assaying the acceptance of AR mobile applications in Pakistani shopping malls, a relatively new phenomenon for users. This research suggests that augmented reality applications disrupt the conventional methods of obtaining information about items, processing user data, and boosting user experience by offering a virtual experience of a brand outlet in a real-time setting.

3. Theoretical and conceptual underpinnings

AR systems embed virtual objects in real-world environments through interactive technological transformations. Heightening users' curiosity increases their desire to intend virtual objects (Poushneh and Vasquez-Parraga, 2017). The AR system presents digitally generated virtual items by combining videos, images, overlays, and texts. In this way, users will be able to watch, listen, and read content in an authentic environment. A smartphone, tablet, head mount, projector, or fixed interactive screen can simultaneously give users a sense of "the virtual and real worlds" (Javornik, 2016). Azuma (1997) and Yim *et al*. (2017) delineated three things that make AR awesome: first, it seamlessly integrates the virtual and physical worlds, providing users with dynamic, personalized experiences; second, AR provides an interactive experience as it is "interactive" in real-time. Third, in addition to AR, a three-dimensional experience is delivered, catering a "lively visual" experience. AR is not an innovative technology. Morton Heilig invented it in 1950 under the name "Sensorama," In cinematography, it has been used for a long time (Carmigniani *et al*., 2011; Uruthiralingam and Rea, 2020a). It has been difficult for individuals to utilize augmented reality because of the dearth of technological innovation in smart devices until recent advancements in software and hardware have enabled individuals to do so (Kosa *et al.*, 2019). Initially, augmented reality did not have a sufficiently mature, cost-effective, or inherent intrinsic feature at the time of launch, with significant potential for dynamic functions (Qian *et al*., 2019). As companies and users gain a better understanding of technology, they are able to use it to enhance their experiences (Ibili and Billinghurst, 2019). The technological world has made notable advances since the 1990s, when augmented reality was nascent (Yim *et al*., 2017).

The retail sector worldwide is adopting augmented reality (Alam *et al*., 2020; Fan *et al*., 2020; Kang *et al*., 2023). Through augmented reality applications, consumers can view and interact with the specific features of a virtual product in the physical world (Park and Yoo, 2020) to replicate the simultaneous shopping experience, reduce returns, and increase conversions. Ul Haq and Farooq (2019) regained that Pakistan's retail sector is undergoing constant technological transformation. A recent empirical study directed in Pakistan by Khan *et al*. (2021) found that augmented reality allows users to engross with mutually the physical and virtual worlds simultaneously, so they're engaged without feeling disconnected. Accordingly, augmented reality apps have not been sufficiently adopted in shopping malls in developing countries, such as Pakistan. According to an article published by StartUp Pakistan, consumer engagement and entertainment are being enhanced with the use of AR technology in Pakistan's media, telecommunications, and fashion industries (StartUP, 2020). The majority of Pakistani consumers are unacquainted with AR applications for personal or shopping purposes because of the country's limited technological advancement and understanding of augmented reality (Tribune, 2021).

3.1 Mobile technology acceptance model

Ooi and Tan (2016) established MTAM with the aim of remedying the limitations of the fundamental TAM (Davis, 1989). The classic TAM is one of the furthermost widely adopted and commonly cast-off frameworks for assessing the factors that manipulate a company's willingness to adopt a new technology (Villa *et al*., 2018). However, this method has certain

limitations. In addition to perceived usefulness (PU), perceived ease of use (PEOU) is also contemplated a part of these constraints. PEOU refers to the poise that an instance system can be implemented easily, whereas PU insinuates to the belief that adopting a system will improve one's job performance (Davis, 1989). PU and PEOU are depicted as part of an organizational framework. Across different realms, the use of technology outside the workplace varies significantly, encompassing different job roles and complexities (Brown *et al*., 2006). In addition, several researchers have argued that the adoption of mobile technologies is induced by a variety of factors (Ooi and Tan, 2016). MU and MEOU were incorporated into this model. Specific to MU are mobile devices that enhance efficiency, and MEOU are mobile payments that are seamless (Ooi and Tan, 2016). By modifying each of these structures, a more realistic representation of the AR world was achieved, resulting in a larger viewpoint. Across a variety of academic disciplines, the Mobile TAM has been applied to areas such as mobile social media marketing (Wong *et al*., 2022), cyberbullying (Ooi *et al*., 2019), fashion shopping (Ng *et al*., 2022), and mobile social learning (Loh *et al*., 2019). As part of the MTAM, the core variables MU and MEOU are versatile across a wide range of mobile technologies. Thus, MTAM proves to be highly effective in analyzing the intention to adopt AR in shopping mall settings. As a result, MTAM does not account for additional influential factors in the adoption of new mobile technologies, since it focuses only on two constructs. In this study, an extended MTAM was applied to investigate whether AR correlates with the intention to use the device. Furthermore to this methodology, other researchers have suggested that supplementary factors must be considered to fully grasp the determinants of technology adoption, especially mobile technology (Yan *et al*., 2021). As part of this method, non-technical factors that manipulate consumer decision-making are also considered. As part of the study, MTAM is used to integrate factors for instance self-efficacy, social influence, reward, and perceived enjoyment to estimate how mobile AR apps will be adopted within the shopping mall environment (Table 1).

4. Hypotheses development

4.1 Mobile usefulness

MU is related to usefulness subconstructs, such as relative advantage and extrinsic motivation, in that it describes how they contribute to improved work performance for a specific person (Ooi and Tan, 2016). Likewise, in this study, MU refers to consumers' perception of how much their performance improves when they use mobile technology (Davis, 1989; Ooi and Tan, 2016). A multitude studies have investigated the relationship concerning usefulness and intention to adopt mobile technologies within diverse environments in the realm of mobile technology. For example, Loh *et al*. (2019) investigated the association between MU and intention to adopt wearable payments. In accordance to this study, the main factor influencing the general willingness to use wearable payments is mostly MU. de Luna *et al*. (2019) assessed the impacts of usefulness on three forms of mobile payment. The study findings indicate that the level of usefulness significantly influences the adoption of mobile payment technology, since people are more motivated to adopt new mobile services that make their lives easier. Like this, we insinuate the following hypothesis:

H_1. MU has a significant and positive relationship with BI.

4.2 Mobile ease of use

MEOU states to the ease of learning and using mobile technologies or services for consumers (Ooi and Tan, 2016). Several prior studies have demonstrated that MEOUs play a critical role in encouraging BI to adopt mobile technology. For example, Arvidsson (2014) examined Swedish consumers' attitudes towards mobile payments. In 2015, Nyaboga *et al*. (2015) conducted a questionnaire study among customers of the top mobile carriers in Kenya. The purpose of the survey was to identify the variables that impact the consumers' probability of adopting mobile services. Moreover, Shankar and Datta (2018) studied the factors assuming the BI for mobile

Table 1 An overview of theoretical outcomes of MTAM

Author	*Domain*	*MTAM variable*	*Dependent variable*	*Finding*
Ooi and Tan (2016)	Smartphone credit card	MEOU, MU	Adoption	MU positively influences behavioral intention to adopt smartphone credit cards, while MEOU was found to have an insignificant influence on BI
Lew *et al*. (2020)	Mobile wallet	MEOU, MU	Adoption	MTAM constructs are significant factors of behavioral intention toward mobile wallet adoption
Sharmin *et al*. (2021)	smartphone- relying social media for sustainable destination marketing	MEOU, MU	Adoption	Mobile Technology Acceptance Model (TAM) components like MU and MEOU had a direct impact on satisfaction, notably determining the likelihood of implementing these factors for sustainability
Yan *et al*. (2021)	QR code and mobile payment	MEOU, MU	Adoption	Mobile usefulness directly impacts BI to adopt, while mobile ease of use does not
Witjaksono *et al*. (2021)	QR Code payment method on digital wallet	MEOU, MU	Adoption	The research indicates that the perception of MEOU and MU BI affect QR Code use (actual usage) on digital wallet applications in Indonesia
Lau *et al*. (2021)	Mobile taxi booking	MEOU, MU	Adoption	Mobile usefulness was a significant factor in adopting mobile taxi booking, while MEOU was not
Khoiroh and Pangestuty (2022)	QR Indonesian standard	MEOU, MU	Adoption	MU and MEOU positively and significantly influence behavioral intention
JosephNg *et al*. (2022)	Mobile payment uses in the Middle East	MEOU, MU	Adoption	Mobile TAM constructs indicate the user's acceptance of mobile payment
Wong *et al*. (2022)	Mobile social media marketing	MEOU, MU	Adoption	The results indicate that mobile MEOU and MU play a significant role in mobile social media marketing
Tew *et al*. (2022)	NFC mobile payment	MEOU, MU	Adoption	MTAM has a positive effect on BI to accept mobile payment
Zhang *et al*. (2023)	NFC mobile payment	MEOU, MU	Adoption	Mobile usefulness positively affects behavioral intention toward adopting NFC mobile payment, while MEOU has an insignificant effect on behavioral intention

Source(s): Table by authors

payments distributed to prospective users in India via web-based and offline surveys. In addition, Pipitwanichakarn and Wongtada (2019) study also verified the momentous influence of user-friendly design on the effectiveness and purpose of mobile commerce, regardless of whether consumers are early or late adopters. This leads to a scenario in which the least effort required to utilize mobile-related services is a tremendous facilitator of their adoption. Accordingly, we hypothesize the following:

H_2. MEOU has a positive and significant association with BI.

H_3. MEOU is positively associated with MU.

4.3 Reward

Contemporary marketing places a premium on businesses and organizations to establish close customer ties. Morgan (2000) observed that a customer's commitment to an enterprise or product is based on their unique capabilities. As fundamental benefits for strengthening robust connections in the mobile world, the inherent characteristics of mobile technology are highlighted, including its widespread availability, personalized content based on individual interests and hobbies, tailored information tailored to users' location, time-sensitive customization options, and tailored information tailored to their location. The ability to utilize mobile features whenever necessary is one of the most impressive features of this device (Kannan *et al*., 2001; Yu and Buahom, 2013), and everywhere (Nysveen *et al*., 2005; Pentina *et al*., 2011) provides a significant benefit for consumers in retrieving location-based and time-sensitive materials and services through their mobile devices at a point customized for their identification (Doyle, 2001; Kannan *et al*., 2001; Nysveen *et al*., 2005). Consequently, MAR apps make shopping at malls more enjoyable by providing digital information to consumers as they search for items throughout the mall. An alluring promotion, time-sensitive discount, or special membership offer could encourage patrons to make purchases at a shopping center. Jang *et al*. (2013) highlight the beneficial effects of discount coupons on the long-term use of commerce networks. Additionally, one may contend that reward activities make the features of an app more appealing. For instance, the 'Pokémon Go' app relies heavily on the reward aspects of its gameplay. Thus, we indicate the next hypothesis:

H_4. Rewards are positively related to BI.

H_5. Rewards are positively related to PEJ.

4.4 Perceived enjoyment

PEJ refers to the degree to which something is perceived as enjoyable regardless of the expected outcome of the interaction (Venkatesh and Davis, 2000). According to (Baabdullah, 2018; Tan and Ooi, 2018), intrinsic motivation or hedonism drives this. This includes enjoyment, relaxation, amusement, and joy and is decisive for the successful implementation of modern applications and systems for customer BI (Baabdullah, 2018; Venkatesh and Davis, 2000). Several studies have demonstrated the outcome of PE on the acceptance of AR applications to address the augmented reality environment. Haugstvedt and Krogstie (2012) illustrated that using a mobile AR app for cultural heritage leads to positive engagement with Pokémon Go. Balog and Pribeanu (2010) found that PE contributes to a positive behavioral intention towards AR teaching platforms. Like this, we indicate the next hypothesis:

H_6. PEJ is positively associated to BI.

4.5 Mobile self-efficacy

Essentially, mobile self-efficacy (MSE) raises to the level of self-assurance consumers have in their ability to understand and effectively use particular technologies (Loh *et al*., 2019). Self-efficacy is an essential component in evaluating the use of innovative technologies, especially within the realm of mobile technology. Keith *et al*. (2015) stated that it was important to establish individual self-efficacy frameworks that are tailored to each specific context, especially in mobile technology, which requires diverse skills such as manual dexterity. In the mobile context, several previous studies have exposed that MSE is a vital variable in persuading BI to embrace mobile technology. For example, MSE has a significant positive effect on BI to adopt m-payments in India (Shankar and Datta, 2018) and Korea (Kim *et al*., 2016). Furthermore, self-efficacy positively influences MU and MEOU (Bailey *et al*., 2017; Molina-Castillo *et al*., 2016). Hence, a high MSE level leads to a greater desire to use MAR applications, improving the insights of both MU and MEOU for MAR apps. Accordingly, we hypothesize the following:

H_7. MSE is positively related to MU.

H_8. MSE positively relates to the MEOU.

H_9. MSE has a positive and significant relationship with BI.

4.6 Social influence

SI is non-entity more than how likes or dislikes of their environment Influence a person's perspective (Saprikis *et al*., 2021). SI is critical for comprehending the significance of technology in daily life. Although this factor is important, it has not been expansively studied by counting it into MTAM to evaluate the adoption of MAR app technology. Within mobile AR apps, SI is distinct as the extent to which users comprehend the importance of adopting an AR application (Saprikis *et al*., 2021). Research on technology adoption has shown that SI affects the decision to accept a technology (López-Nicolás *et al*., 2008). Society instills confidence in individuals regarding the use of technology and serves as a positive indicator of adoption through perceived usefulness (Lu *et al*., 2005). The simplicity and comfort of use are based on the user's aptitude and technology, and perceptions of the local community may also have an effect. Haaker *et al.* (2006) found that most consumers used services influenced by social contact. Social influence is a significant aspect that molds and modifies an individual's perspective and willingness to accept technology. Future consumers may feel that adopting this service and technology is easy if others attest to its ease of use (Chen *et al*., 2007; Griffy-Brown *et al*., 2011). The influence of social circles shapes behavior regarding new technology adoption and has an indirect effect. We anticipate that SI will be critical in this context. It is possible that a user may easily accept a mobile augmented reality application when influenced by social influence. SI positively affects PEOU and PU (Cheung and Vogel, 2013; Mun *et al*., 2006). Grounded on these results, the following is proposed:

H_{10}. SI is significantly and positively associated to MU.

H_{11}. SI is positively related to MEOU.

Generally, the use of breakthrough technology has been seen as a public good; it may be significantly influenced by people around it (Hong and Tam, 2006; López-Nicolás *et al*., 2008). The influence of society has been shown to predict the behavior and intentions of inexperienced individuals (Taylor and Todd, 1995). Venkatesh and Davis (2000) have expressed that "social influence has a crucial impact on behavioral intention." "SI influences positive attitude and BI in various studies" (Deng *et al.*, 2014; López-Nicolás *et al*., 2008; Sun and Zhang, 2006). Grounded on these results, the following hypothesis is anticipated:

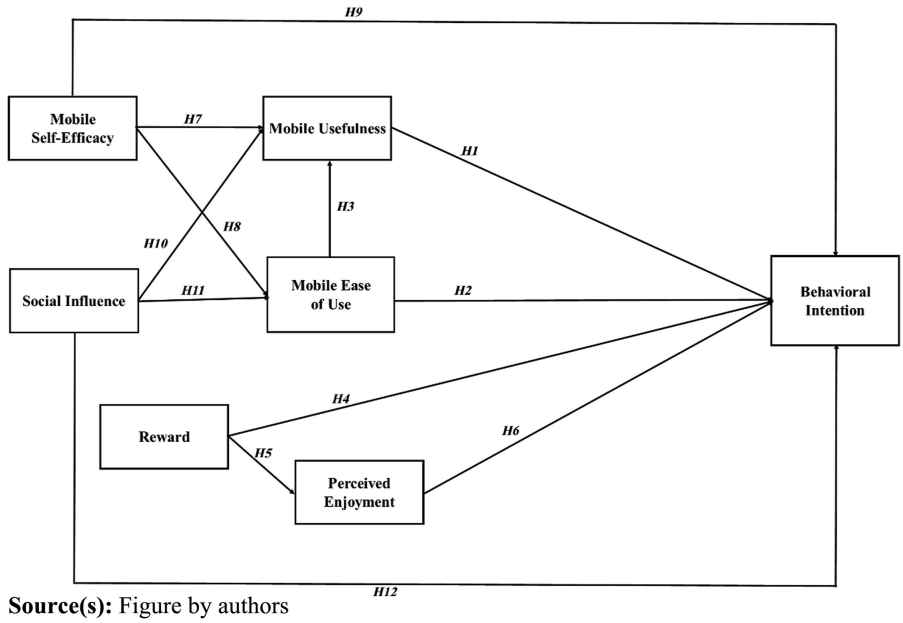
H_{12}. SI has a positive and significant relationship with behavioral intentions.

Figure 1 describes the theoretical framework of the study, determined on the hypotheses put forward in this research.

5. Research methodology

Data were collected between January and February 2022 in Karachi, Lahore, and Islamabad, Pakistan. Convenience sampling was used because it could be the most practical choice for achieving a suitable sample size given the limitations of time, money, and human resources (Leiner, 2014). In this study, individuals with relevant expertise or experience were selected based on the sampling technique described by (Saprikis *et al*., 2021). The survey was executed at the top shopping malls in Karachi, Lahore, and Islamabad. As a result, Pakistanis from diverse demographic backgrounds have a significant presence in shopping malls (Gu *et al*., 2019). Based on previous research, this study exhausted a self-administered questionnaire (Hunt *et al*., 1982). The measurement items were scored on a seven-point Likert scale, spanning from strongly agree (1) to strongly disagree (7) (See Supplementary File). Questionnaires were handed to participants by hand utilizing the mall-intercept approach. This technique is appropriate because it is fast, random, and impartial in light of the study setting (Tan and Ooi, 2018). A courteous survey

Figure 1 Proposed research model



Source(s): Figure by authors

invitation was left at the shoppers' exits using this method, inviting them to participate. Potential respondents were asked whether they were currently using an augmented reality app or had prior experience with a mobile app before being invited to participate in the study. Participants who did not have previous MAR experience were excluded from the sample. An analysis of 470 survey questionnaires was conducted to collect 311 valuable answers, validate the adopted theoretical framework, and examine the hypotheses. Table 2 outlines the sample's demographic information.

Table 2 Demographics

Demographic characteristics (n = *311)*	*Frequency*	*Respondents*	*Percentage*
Gender	Male	195	62.7%
	Female	116	37.3%
Age	15–19	30	9.6%
	20–24	60	19.3%
	25–29	70	22.5%
	30–34	50	16.1%
	35–39	31	10.0%
	40–44	27	8.7%
	45–49	25	8.0%
	50 and above	18	5.8%
Qualification	High School	145	46.6%
	Undergraduate	90	29.0%
	Graduate	55	17.7%
	Doctorate	21	6.7%
Experience using AR apps in the shopping mall	<= 3 Years	121	39.0%
	3–5 Years	105	33.7%
	More 5 Years	85	27.3%

Source(s): Table by authors

6. Analysis of data and findings

In addition to evaluating and validating the construct, PLS-SEM was used to determine the hypothesized model. PL-SEM is a desegregated method that evaluates the reliability and validity of research frameworks by decisive the relationships between variables (Hair *et al.*, 1998). The PLS-SEM technique has received significant attention in AR application research (Wu and Lai, 2021). Furthermore, PLS-SEM can be used to predict intricate models without relying on assumptions about distributions (Hair *et al.*, 2014). Using Partial Least Squares (PLS), a method that has been deemed suitable for analyzing relationships within structural models, particularly within the Information Systems domain (IS), we investigated the factors affecting consumer acceptance of mobile AR apps. The Smart-PLS 3 software package was used for this study.

6.1 Common method bias (CMB) and data normality

As the questionnaire was constructed using self-report methods, it is important to acknowledge the possibility of CMB affecting the validity of the results. Currently, the Harman single-factor examination is used in research (Podsakoff *et al.*, 2003). Statistically, if a factor's test result indicates a significance of 40% or higher, it indicates that a confounding variable may exist in the dataset. The cumulative explained variance in this study was 36.54%, below the threshold of 40%, due to all factors being loaded and anchored to Factor 1. Thus, the present data appear to be free of interference from the CMB. The skewness and kurtosis values fell within the acceptable range of ±2, indicating that the data were normal, as suggested by (George and Mallery, 2010).

6.2 Measurement model

We evaluated the proposed model using CFA (Hair *et al.*, 1998). We evaluated the proposed model based on composite validity, average variance extracted (AVE), and Cronbach's alpha. The outer loading of each construct was determined using the PLS algorithm. Table 3 highlights the results of

Table 3 Measurement model

Construct	*Items*	*Factor loading*	*α*	*rho_A*	*CR*	*AVE*	*Skewness*	*Kurtosis*
BI	BI1	0.746	0.834	0.837	0.89	0.669	−0.553	0.799
	BI2	0.862						
	BI3	0.85						
	BI4	0.808						
MEOU	MEOU1	0.895	0.851	0.868	0.91	0.771	−0.628	1.267
	MEOU 2	0.825						
	MEOU 3	0.912						
MU	MU1	0.893	0.741	0.87	0.84	0.643	−0.752	1.115
	MU 2	0.866						
	MU 3	0.617						
PEJ	PEJ1	0.822	0.695	0.72	0.827	0.616	−0.676	1.230
	PEJ2	0.819						
	PEJ3	0.708						
RE	RE1	0.893	0.849	0.869	0.907	0.764	−0.864	1.383
	RE2	0.862						
	RE3	0.867						
MSE	MSE1	0.808	0.755	0.801	0.84	0.574	−0.193	0.539
	MSE2	0.55						
	MSE3	0.841						
	MSE4	0.75						
SI	SI1	0.657	0.761	0.775	0.847	0.582	−0.483	−0.179
	SI2	0.788						
	SI3	0.842						
	SI4	0.753						

Source(s): Table by authors

CV; α constructs' loadings traversed the acceptable threshold of 0.7 (Hair *et al.*, 2021; Nunnally and Bernstein, 1978b), and the AVE variance outstripped the 0.5 thresholds (Hair *et al.*, 2021, 2014). Ground on the CFA results, all item-loading factors exceeded 0.7. Based on the results of the CFA presented in Table 2, the CA, CR, and AVE values are higher than 0.7, 0.7, and 0.5, respectively, suggesting convergent validity (Fornell and Larcker, 1981; Hair *et al.*, 1998; Nunnally and Bernstein, 1978a).

We evaluated discriminant validity in three ways, indicating how one variable differed from the other (Henseler *et al.*, 2015). The first step was to examine the correlation between variables, as proposed by Fornell and Larcker (1981), to determine whether they aligned with the AVE of all hypotheses. According to Table 4, the square root of AVE is significantly more significant than the correlation coefficients across all constructs, which suggests robust discriminant validity.

Second, we assessed item loadings and cross-loadings and found that in Table 5, item loadings are more significant than cross-loadings for other latent variables, indicating a high degree of discriminant validity (Hsu and Lin, 2016).

Finally, we analyzed discriminant validity using a heterotrait-monotrait ratio method (HTMT). Table 6 shows that all variables exhibit satisfactory discriminant validity as each value falls below 0.85, which is the standard threshold for the HTMT approach.

6.3 Structural model results

We evaluated the hypothesized relationships between variables using the bootstrapping technique with 2000 iterations using a standardized path analysis (Henseler *et al.*, 2009). Based on the assessment of standardized model fit (SRMR), we achieved a solid model fit. Currently, the value is 0.07, which is just below the threshold value of 0.08 (Henseler *et al.*, 2014). This study investigated both the direct and indirect effects associated with the independent variable, providing practitioners with the potential to better understand the relationships between them. Table 7 presents the results. We estimated the significance level (Ringle *et al.*, 2015) by performing bootstrap resampling 2000 times, providing the most anticipated results with zero change (Hair *et al.*, 2021). Conferring to Table 7 and Figure 2, only nine hypotheses were supported out of the 12 proposed; in particular, H3 ($\beta = 0.098, p < 0.01$), H4 ($\beta = 0.207, p < 0.001$), H5 ($\beta = 0.349, p < 0.01$), H6 ($\beta = 0.268, p < 0.01$), H7 ($\beta = 0.18, p < 0.01$), H8 ($\beta = 0.191, p < 0.01$), H9 ($\beta = 0.276, p < 0.001$), H10 ($\beta = 0.197, p < 0.01$), and H12 ($\beta = 0.154, p < 0.01$) significantly support mobile AR app adoption. H1 ($\beta = 0.069, p > 0.05$), H2 ($\beta = 0.089, p > 0.05$), H11 ($\beta = 0.003, p > 0.05$), are insignificant.

7. Discussion

The results show that H1 is unsupported because MU has an insignificant relationship with BI. Although mobile usefulness has constantly been shown to be a significant predictor of mobile

Table 4 Discriminant validity

Construct	*AVE*	*CA*	*BI*	*SI*	*MEOU*	*MSE*	*MU*	*PEJ*	*RE*
BI	0.669	0.834	*0.818*						
SI	0.582	0.761	0.252	*0.763*					
MEOU	0.771	0.851	0.309	0.006	*0.878*				
MSE	0.574	0.755	0.446	0.019	0.191	*0.758*			
MU	0.643	0.741	0.282	0.201	0.124	0.201	*0.802*		
PEJ	0.616	0.695	0.484	0.214	0.23	0.268	0.241	*0.785*	
RE	0.764	0.849	0.46	0.104	0.464	0.308	0.245	0.349	*0.874*

Note(s): BI = Behavioral Intention; MEOU = Mobile Ease of Use; MU = Mobile Usefulness; PEJ = Perceived Enjoyment; MSE = Mobile Self-Efficacy; SI = Social Influence; RE = Reward
Source(s): Table by authors

Table 5 Cross-loading

	BI	*SI*	*MEOU*	*MSE*	*MU*	*PEJ*	*RE*
BI1	*0.746*	0.185	0.271	0.335	0.152	0.318	0.402
BI2	*0.862*	0.214	0.265	0.407	0.192	0.356	0.364
BI3	*0.85*	0.224	0.251	0.357	0.309	0.447	0.37
BI4	*0.808*	0.201	0.228	0.359	0.257	0.453	0.371
PEJ1	0.404	*0.212*	0.192	0.156	0.189	0.822	0.24
PEJ2	0.434	*0.223*	0.189	0.287	0.252	0.819	0.348
PEJ3	0.276	*0.027*	0.159	0.169	0.095	0.708	0.211
SI1	0.237	0.657	*0.075*	0.069	0.101	0.139	0.167
SI2	0.15	0.788	*0.001*	−0.074	0.088	0.108	0.029
SI3	0.22	0.842	*−0.04*	0.056	0.209	0.226	0.053
SI4	0.136	0.753	*−0.01*	−0.034	0.187	0.149	0.055
MEOU1	0.277	0.023	0.895	*0.135*	0.09	0.169	0.427
MEOU2	0.247	0.009	0.825	*0.133*	0.109	0.25	0.388
MEOU3	0.288	−0.012	0.912	*0.224*	0.125	0.194	0.409
MSE1	0.374	0.075	0.052	0.808	*0.174*	0.227	0.128
MSE2	0.184	0.047	0.017	0.55	*0.037*	0.165	0.068
MSE3	0.405	0.026	0.176	0.841	*0.173*	0.266	0.337
MSE4	0.334	−0.064	0.263	0.795	*0.174*	0.154	0.312
MU1	0.295	0.211	0.129	0.222	0.893	*0.245*	0.225
MU2	0.213	0.178	0.085	0.126	0.866	*0.198*	0.208
MU3	0.112	0.026	0.07	0.102	0.617	*0.084*	0.141
RE1	0.372	0.098	0.422	0.258	0.209	0.305	*0.893*
RE2	0.484	0.091	0.391	0.291	0.22	0.337	*0.862*
RE3	0.318	0.081	0.405	0.252	0.211	0.259	*0.867*

Source(s): Table by authors

Table 6 HTMT results

Construct	*BI*	*SI*	*MEOU*	*MSE*	*MU*	*PEJ*	*RE*
BI							
SI	0.306						
MEOU	0.367	0.072					
MSE	0.539	0.12	0.212				
MU	0.32	0.22	0.146	0.244			
PEJ	0.616	0.268	0.3	0.355	0.291		
RE	0.533	0.123	0.546	0.343	0.298	0.433	

Source(s): Table by authors

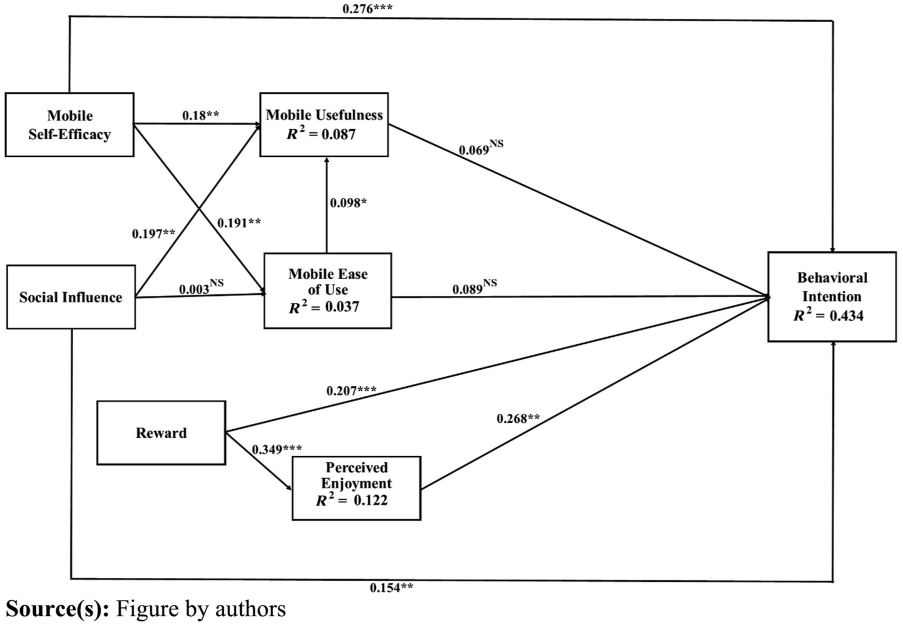
commerce (Lau *et al.*, 2021; Lew *et al.*, 2020; Ooi and Tan, 2016), our findings reveal that MU is not significantly associated with BI. This insignificant association may exist because people have genuine experience using AR technology. Users may use this experience to make other users' decisions depending on the value they obtain from utilizing the MAR application. However, it was found that the MEOU hypothesis had contradictory findings. More precisely, H2 was found to be unsupported, given that MEOU did not have a statistically significant relationship with BI, while H3 was supported, as MEOU has a significant relationship with MU. This finding is similar to those of previous studies (Lau *et al.*, 2021; Loh *et al.*, 2019; Ooi and Tan, 2016; Wang *et al.*, 2020) and may be associated with the enhanced digitalization of mobile devices (Vogels, 2019). In general, consumers' familiarity with the usage of mobile AR apps and the developer's concentration on producing simple-to-use AR apps reduces the effect of MEOU on BI. Despite this, the results advocate that users continue to perceive MEOU as an obvious advantage in terms of the ease with which the MAR app can be learned and used. Additionally, the study showed a positive association between rewards and BI, indicating that users have also been attracted to AR apps because of rewards, confirming H4. This finding gained empirical support from (Saprikis *et al.*, 2021) in their

Table 7 Hypotheses testing results

Hypotheses	*Path coefficient*	*Standard error*	*T-value*	p	*Results*	*Support*
H1: MU → BI	0.069	0.054	1.277	0.202	Insignificant	No
H2: MEOU → BI	0.089	0.07	1.265	0.206	Insignificant	No
H3: MEOU → MU	0.098	0.048	1.836	0.060*	Significant	Yes
H4: RE → BI	0.207	0.052	3.958	***	Significant	Yes
H5: RE → PEJ	0.349	0.059	5.938	***	Significant	Yes
H6: PEJ → BI	0.268	0.092	2.906	0.004**	Significant	Yes
H7: MSE → MU	0.18	0.059	3.038	0.002**	Significant	Yes
H8: MSE → MEOU	0.191	0.065	2.935	0.003**	Significant	Yes
H9: MSE → BI	0.276	0.072	3.83	***	Significant	Yes
H10: SI → MU	0.197	0.066	2.98	0.003**	Significant	Yes
H11: SI → MEOU	0.003	0.062	0.041	0.967	Insignificant	No
H12: SI → BI	0.154	0.054	2.84	0.005**	Significant	Yes

Note(s): ***$p < 0.001$, **$p < 0.01$, NS $p > 0.05$
Source(s): Table by authors

Figure 2 Model with results



Source(s): Figure by authors

study on AR adoption in shopping malls. Furthermore, rewards have a substantial relationship with PEJ. As a result, H5 is supported, and the results enhance the emerging MAR technology. The findings corroborate several prior studies that established the influence of enjoyment on the behavioral intention of mobile augmented reality apps in settings other than shopping malls, including cultural heritage (Haugstvedt and Krogstie, 2012), education (Balog and Pribeanu, 2010), and game industries (Ghazali *et al*., 2019). PEJ has also been shown to be significantly associated with BI. These results are similar to those of previous research on mobile technology adoption (Lew *et al*., 2020; Tan and Ooi, 2018), where users have a certain incentive or hedonic motivation during the entire process of utilizing the new technology; thus, H6 is not supported. Furthermore, MSE had a statistically positive effect on MU, MEOU, and BI. Thus, H7, H8, and H9 are supported. Mobile self-efficacy significantly affects mobile usefulness, as it mentions to a

person's belief in their aptitude to achieve a particular task. A high level of mobile self-efficacy is associated with users' engagement with and effective use of mobile technology. When they perceive themselves as competent in using mobile devices or applications, the likelihood of utilizing them effectively increases. As a result of this increased confidence, mobile features can be explored, understood, and mastered more effectively, ultimately improving the perceived usefulness of mobile devices. Accordingly, the positive correlation between mobile self-efficacy and usefulness indicates that user confidence plays a significant role in mobile technology use effectiveness. Individuals with higher mobile self-efficacy believe in their ability to use mobile devices effectively, which explains the positive relationship across mobile self-efficacy and ease of use. A high level of confidence is likely to lead to greater exploration, learning, and adaptation, thereby improving the perception of ease of use of mobile devices. This study corroborates previous findings (Lew *et al*., 2020). In addition, our results indicate that SI does not significantly influence MEOU. Therefore, H11 did not have any statistical support. These results contradict (Rajak and Shaw, 2021). Finally, SI positively affected MU and BI, confirming H10 and H12, respectively. The findings were corroborated empirically (Rajak and Shaw, 2021) in a study on mobile health technology. Mobile usefulness can be enhanced through social influence through several mechanisms. First, social recommendations can point users toward valuable apps or features by leveraging collective insights. Furthermore, social interactions within apps enhance user engagement and satisfaction by creating a sense of community. Collaborative features and content sharing also contribute to a better user experience, demonstrating how social influences can improve mobile device usability. The significant relationships identified in the current study underscore the important areas that require further investigation and the significance of our study in influencing the direction of future research in this field. This study predicts that the next 10 years will see a greater transformation in the travel and tourism industry in standings of more advanced applications, tailored experiences, and tourist engagements that will facilitate the discovery of new cultural destinations, Pakistan's historical sites, and the nation's natural beauty. According to the study, the integration of cutting-edge tourism technologies, virtual visits, online experiences of destinations, technologies for cultural preservation, and tourism education will advance over the next 20 years and provide more immersive experiences that will help highlight Pakistan's rich cultural heritage and diversity. According to the study's findings, the regular businesses that matter are smart destinations, sustainable tourism, and enhanced cultural exchanges.

7.1 Theoretical contributions

The findings of this study underwrite to our considerate of MAR acceptance and adoption dynamics of mobile AR in shopping malls from the perspective of developing countries by making several valuable contributions. A comprehensive understanding of what persuades people to use evolving technological applications, such as MAR Apps, requires consideration of several key themes. First, to the best of our knowledge, this is the first research to look at the adoption process of MAR apps in shopping malls from the viewpoint of a developing country. Consequently, this study pays significantly to the body of scholarly knowledge on shopping malls. Second, this study explored specific variables to understand the emerging phenomenon of MAR applications; however, many of these variables have not been explored previously in developed and developing countries. These variables were examined for their impact on the BI to adopt MAR in shopping malls. There is a lack of relevant variables in the IS literature that appear to influence the acceptance and adoption of MAR applications. A piece of new quantitative knowledge has been generated regarding the factors that determine the intention of users in a developing country, such as Pakistan, to use mobile AR apps in shopping malls. Third, this study incorporated four highly pertinent determinants into a single model to forecast BI to adopt AR mobile apps. Using a theoretically driven approach, we extend information systems adoption research into more appropriate modeling frontiers by mounting a model that explains 0.434% of the variance in the adoption intentions of mobile-enabled AR apps. Fourth, the perception of social influence and rewards was critical in enhancing the intention to adopt mobile AR apps. Following empirical studies conducted in various contexts and settings regarding the adoption, acceptance, and

diffusion of various technological innovations, the results of this study align with and confirm the conclusions drawn from empirical research (Saprikis *et al*., 2020; Tew *et al*., 2022; Wong *et al*., 2022). A substantial amount of research has not been piloted regarding the perceptions of social influence and rewards related to the adoption process of AR mobile AR Apps, especially in developing countries. Therefore, the findings reported in this study contribute to our understanding of the role of social influence and rewards in the acceptance and adoption of MAR applications. Fifth, constructed on the study's findings, perceived ease of use and perceived usefulness negatively impacted the intention to use mobile augmented reality applications. Perceptions of MEOU and MU have been reported in the literature as being associated with negative attitudes toward technological innovation adoption dynamics (Zhang *et al.*, 2023). Finally, the present analysis suggests that perceived enjoyment and mobile self-efficacy play essential roles in intensifying the intention to adopt AR apps. In contrast, these findings are absent from the relevant IS literature concerning the assumption of mobile AR apps in shopping malls. This study strongly suggests that enjoyment and mobile self-efficacy are the most critical determinants of the intention to adopt AR mobile apps.

7.2 Managerial and practical contributions

The study findings have significant implications for practitioners, notably application developers, mobile marketing managers, mobile product/service providers, and researchers interested in examining consumers' TAM and behavior in mobile-augmented settings. Furthermore, the findings are envisioned to assist shopping mall owners and managers in developing target-oriented business strategies that will allow them to provide consumers with superior shopping and entertainment experiences as well as more comprehensive and up-to-date information through the use of mobile applications. Additionally, the findings of this study may provide retailers with a new perspective on attracting consumers and improving their shopping experience. Moreover, it may compel shopping malls and their stores to undergo continual IT and business changes and follow developments to adapt to customers' acceptance of new technological advancements, thereby altering their buying and entertainment behaviors. The comprehensive conceptual framework also draws on marketing viewpoints to evaluate one technological acceptability element and incorporates previously overlooked aspects, such as enjoyment, reward, mobile self-efficacy, and social influence. Additionally, it examines alternative marketing strategies based on mobility features and possibilities for augmented reality. Specifically, MSE had a positive impact on behavioral intention. This shows that the public is familiar with MAR applications. In addition, enjoyment has a positive impact on BI. Notably, mobile solution providers can leverage the connections amid mobile AR activities and users through optional tailored information that customers can obtain at any time and from any location when approaching a shopping mall and using an app. Consequently, such applications should have features that enhance user enjoyment and satisfaction. To demonstrate, users of IKEA's augmented reality catalog may expedite decision-making by pulling an item from the brochure, repositioning it anywhere in the replicated environment on their mobile device, and instantly capturing a snapshot of their pick, which increases enjoyment (Ashforth, 2000). In addition, rewards have a positive impact on BI. The concept of equating an AR app's adoption intention in shopping malls with relationship ties such as special offers, discounts, loyalty points, and location-based marketing activities likely to be formed due to their use is pioneering. This requires highly specialized features of the underlying technology. These customers often associate the mall shopping experience with an innovative money- and time-saving purchasing channel (Saprikis *et al*., 2018). This clarifies why rewards have been shown to be a good predictor of behavioral intention. The survey findings may shed light on how mobile augmented reality applications can be built to correspond with users' behavioral intentions in shopping malls. Thus, businesses involved in mobile apps, m-commerce, and mobile marketing should use the study results as a guide when developing mobile strategies and adopting such apps to encourage shopping mall visitors to use their unique features and capabilities. To promote the use of such applications, they should provide substantial inducement (Guo and Barnes, 2009) and guarantee that the technologies offer distinct benefits and values (Chiou and Shen, 2012).

7.3 Limitations and future study

Regarding the significance of the initial findings, this study can be further strengthened by addressing several critical shortcomings. Initially, further data from multiple samples will be collected to verify that the correlations remain consistent across a broad range of demographic variables, including gender, age bracket, educational attainment, income levels, residency status, occupation, and family situation. This study provides important information. Put differently, it might indicate that factors such as MU, MEOU, SI, and enabling factors do not directly affect BI. Secondly, there is a need for ethnographic research in various countries in order to identify disparities in cultural perspectives, and for data to be collected for a cross-cultural analysis to be able to be generated. The users' cultural context might help establish a suitable environment for developing and establishing such augmented reality applications. Further research will be needed to examine the validity of the proposed framework using samples from a variety of cultural backgrounds and outcomes relevant to the proposed behavioral framework. This might benefit the mobile augmented reality sector, which focuses on producing multicultural applications for commerce and entertainment. Undoubtedly, AR technology is here to stay and is set to significantly impact shopping and entertainment experiences at malls worldwide in the near future. Finally, we contextualized the factors and selected those that were most relevant to retail and shopping environments. The decision to choose was made after a thorough assessment of the most relevant literature and consultation with relevant specialists. Nonetheless, future research should examine additional variables that may have been neglected, depending on their relevance in their respective settings.

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(The Appendix follows overleaf)

Supplementary material

Table A1 Questionnaire

Constructs	*Measurement item*	*Source*
Mobile Usefulness	MU1: I think that using an AR app in a shopping mall would help me accomplish tasks more quickly MU2: I think that using an AR app in a shopping mall would increase my chances of achieving what is important to me MU3: I suppose an AR app in a shopping mall is useful	Ooi and Tan (2016)
Mobile Ease of Use	MEU1: I think that learning how to use an AR app in a shopping mall would be easy for me MEU2: I think that it would be easy for me to be able to use an AR app in a shopping mall MEU3: I think that I would find an AR app in a shopping mall easy to use	Ooi and Tan (2016)
Reward	REW1: I would use an AR app in a shopping mall if provides information on special offers REW2: I would use an AR app in a shopping mall if it provides me with loyalty points and rewards REW3: I would use an AR app in a shopping mall if it provides information on discounts	Shaikh *et al.* (2021), Tan and Lau (2016)
Mobile Self-Efficacy	MSE1: I feel confident when using mobile AR app MSE2: I could figure out a way to implement mobile AR apps in our business MSE3: I feel confident to use mobile AR app even if no one guides me MSE4: I am confident of using augmented reality if I have never used such a system before	Mahat *et al.* (2012)
Social Influence	SI1: People who are important to me think that I should use an AR app in a shopping mall SI2: People who influence my behavior think that I should use an AR app in a shopping mall SI3: People whose opinions I value prefer that I should use an AR app in a shopping mall SI4: People around me have encouraged me to use mobile health services	Saprikis *et al*. (2021)
Perceived Enjoyment	PEJ1: I think using an AR app in a shopping mall would be fun PEJ2: I think using an AR app in a shopping mall would be a pleasure process PEJ3: I think using an AR app in a shopping mall would be enjoyable	Nysveen *et al*. (2005)
Behavioral Intention	BI1: Given the chance, I am going to use an AR app in a shopping mall I intend to use an AP app in a shopping mall BI3: I expect I will use an AR app in a shopping mall in the future B4: I will use an AR app if available in a shopping mall	Ooi and Tan (2016)

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