Assessing Consumers' Acceptance of AR Wayfinding for Indoor Shopping Navigation in Singapore

AHMAD SAID[1], ZUN ER ANG[2], YULITA HANUM P. ISKANDAR[2]
[1]International Business Management Program, Management Department,
Bina Nusantara University,
Jakarta,
INDONESIA

[2]Graduate School of Business,
Universiti Sains Malaysia,
Penang,
MALAYSIA

Abstract: - This study investigates consumers' acceptance of Augmented Reality (AR) Wayfinding for indoor shopping navigation toward consumer behavioral intention. This study suggested a conceptual model investigating major determinants of users' behavioral intention through the UTAUT model. In this study, 175 respondents were selected using a purposive sampling technique, and a survey method distributed via Google form was used to collect data, then analyze the collected data from the respondents via SmartPLS (Partial Least Squares Structural Equation Model. The results revealed that two determinants have a positive and significant relationship with behavioral intention to use the indoor AR wayfinding system application; they are facilitating conditions and performance expectancy. Furthermore, Effort expectancy (EE), social expectancy (SE), and privacy risk (PR) were found to have an insignificant relationship with the behavioral intention of adopting an AR wayfinding system. Software development in Singapore has reliable, secure technologies and policies that protect personal information, which would lower consumers' perceived privacy risks.

Key-Words: - Augmented reality; Wayfinding; Indoor Navigation; shopping navigation, Unified Theory of Acceptance and Use of Technology, Technology

Received: May 12, 2022. Revised: August 16, 2023. Accepted: September 17, 2023. Available online: October 19, 2023.

1 Introduction

Navigation in indoor commercial buildings can be difficult due to the complexity of physical environments, lack of visual access to particular landmarks, incongruent floor layouts, incomprehensible signage, and disorienting staircases. Indoor augmented reality (AR) wayfinding application systems can overlay the directional signs onto the real-world setting captured from the mobile camera sensors and recommend the most time-saving and efficient route options. The accuracy of the application allows users to avoid routes with crowds such as in the airport so the user can reach the specific gate smoothly or to the specific bed or department in a hospital. Wayfinding navigation system-related studies on different locations have been conducted their research in the Czech Republic at Ostrava, [1], meanwhile in Austria, [2], and in Iran at Tabriz, [3].

Indoor AR technology is not only able to help the user find their direction, destination, and

location with less time but also with less cognition load. The majority of consumer-based research on AR in retail concludes that most of the consumer has a positive response towards retail with AR technology, [4]. The shopping experience has significantly enhanced with the AR technology, many promoting relevant such as marketing outcomes help to reduce uncertainty from consumer's decision, [5], [6], [7], and boosting the inclination to purchase, [8], [9], develop stronger customer loyalty to the services and products, [10], and facilitate consumer to perceive the brand value and positive relationships, [11], [12]. AR can improve the consumer's shopping experience by giving them a hedonic and utilitarian value, and also further enhance their decision-making process, and lead to the ultimate positive behavioral intentions, [5], [13], [14], on any stages of the consumer shopping journey throughout the day, [15], [16]. Nonetheless, consumer adoption of AR technology in retail is slow. This is due to the fact that most businesses from big corporation groups to small retailers are still cautious and observing the market, [17], [18]. With current findings, technical limitations and privacy risk concerns might hurt AR wayfinding on the shopping experience, [8], [10], [13], [19].

From this context, this study seeks to clarify the direct effect between the independent variables and the user's behavioral intention to use, aiming to assess the purpose of adopting this service to face the wave of AR technology in indoor wayfinding. This study is different from other authors as the UTAUT base theory will be used as a starting point. To meet the technological challenges and structure the market, assessing the intention of the consumers in adopting new technology is crucial. The lack of research about behavioral intention to use indoor AR wayfinding system applications is understandable. The wave of AR technology only started in recent years, and the idea of wayfinding is still fairly niche. Thus, researchers have an opportunity to study this phenomenon. Hence, to explain and fill in the gaps in the existing findings, UTAUT theory and privacy risk variable are used to evaluate the relationship between the user behavioral intentions to use the indoor AR wayfinding system application.

2 Literature Review

According to the Singapore Tourism Board, [20], AR Wayfinding will debut as a personal guide to direct visitors to specific destinations while also providing relevant information and customized virtual ad billboards directly to their mobile devices. This might make navigating, purchasing, or playing gaming more enjoyable for customers. The upgrade generates a good and effective style of consumer contact by meeting the instant needs of users innovatively. As most of the current studies have concentrated on AR only, particularly in wayfinding, there isn't much information that has been released about factors affecting consumers' behavioral intention to use indoor AR wayfinding applications.

A study identified the factors that influence wayfinding in complex environments and developed an AR-based wayfinding system based on user experience and requirements, [21]. AR-based navigation systems have been found to enhance human indoor cognitive map development and wayfinding performance, [22]. A navigation and AR system has been developed for visually impaired people, which includes a localization system based on ARKit and a machine learning identification mechanism, [23]. An adaptive wayfinding information system based on real-time cognitive load measures has been found to be effective for emergency indoor wayfinding, [24]. The correlation between spatial ability skills and wayfinding performance using AR-based wayfinding systems has been explored, [21]. AR-based wayfinding systems can be effective in reducing navigation time in complex environments and enhancing wayfinding performance. Additionally, AR-based systems have been developed for visually impaired people and emergency indoor wayfinding.

With reference to the top (20) twenty free application traffic and GPS navigation apps in the

year 2022, Google Maps is the Top 1 among the rest of the applications. The strength of Google Maps is its ability to work both online and offline. Google Maps allows users to check their route with options from a location to a destination, featuring real-time traffic conditions such as accidents, roadblocks, floods, and other interruptions you might face during the journey or giving an alternative option to reroute your journey. Just recently, Google Maps' Live View feature is now available in Singapore, and it can auto-update from most of the iOS and Android smart mobile devices platforms. You can get directions in the actual world and on a tiny map at the bottom of your screen using Live View. During the walking portion of any trip, you can use Live View navigation. Enter a destination in the search field or tap it on the map. To assist Maps in finding your location, follow the on-screen instructions. Therefore, this is a good time to examine the variables that may gain insights into the importance of AR wayfinding usage in consumers' indoor shopping navigation experience.

2.1 Research Hypothesis

There is a wide range of theoretical models that have been developed to evaluate consumers' usage intentions with regard to new technology and the actual use of new technology. An example is Davis' Technology Acceptance Model (TAM), which is a well-known model introduced in 1989. The TAM model has been validated and is often used in mobile, wearable health-care-related technology, [25], [26], [27], [28], and also in Management Information Systems, [29]. However, the TAM alone is still unable to determine the reception of new advancements on the grounds, and certain crucial factors such as social effect in genuine circumstances are left out of the model, [30].

Then, in 2003 Venkatesh theorized an enhanced and more comprehensive model for this called the Unified Theory of Acceptance and Use of Technology (UTAUT). This is a new IT acceptance theory consisting of 4 independent variables that will influence a user's behavioral intention to use technology: performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating expectancy (FE). In this research, the aforementioned factors will help to examine the consumer's intention on AR wayfinding. As a starting point, performance expectancy refers to the degree of perception of the technology's usefulness for improving the performance of usage. Next, an effort expectation is a measure of the ease with which a technology can be used. Third, social influence refers to the degree to which the individual believes that significant others are expecting him or her to use a new technology. A facilitating condition, on the other hand, can be defined as the probability that an organization and technical infrastructure exist to provide the capability to use technology. UTAUT has been introduced to explain information technology adoption and usage and also has been applied to examine the consumer's intention to use Global Navigation Satellite System, [2], Location Based System, [29], and Medical Wearable Devices, [30]. Nevertheless, the key concern in the study is that UTAUT may be unable to completely account for the consumer's behavioral intention.

The study, [31], justified that there is a trend and also increased the use of variables and external theories in the studies to explain the adoption and use of technology alongside the UTAUT framework. A few studies utilized all constructs but without considering the moderating factors and many others merely partially utilized some constructs, while others applied all constructs but without considering the moderating factors. Moreover, a majority of the articles that cited the model did so to support an argument and not to use it effectively. Moderators in UTAUT were frequently dropped from most of the studies from, [32] because most of the previous researchers found that there may not be any variations in the moderator for the use of new technologies. However, [32], suggested that future researchers can also include perceived risk along the UTAUT model as an additional variable to examine the direct effect of new technology adoption which is aligned with the comprehensive literature review, [33].

When it comes to mobile technology such as AR or LBS, privacy remains a key concern to consumers.

The study, [34], expressed that because of the misuse of location information, location-based services technology has increased the possibility of privacy violations. In an AR technology and application context, the perceived and real violations of privacy concerns remain strong from consumers, [35]. Hence, integrating the UTAUT theoretical framework with Privacy Risk would offer a more comprehensive view of consumer behavioral intention to use indoor AR wayfinding systems. Therefore, this study will follow UTAUT as the key theoretical foundation in the formation of a theoretical model that examines the behavioral intention to use the indoor AR wayfinding system.

2.2 Facilitating Conditions

The term facilitating conditions is used to describe an individual's belief in the technical infrastructure to use technology. It reflects the perceptions of external constraints on behavior created by resource and technology-facilitating conditions, [36]. Support staff and guidance availability were highlighted as assisting users in overcoming technology issues, [37]. The facilitating conditions for this finding constructed and focused on a technological environment that is designed to reduce the obstacles and allow users to use the AR wayfinding system application capabilities and features more easily. Also, the AR wayfinding system in the smart mobile device may be considered an assistant in the shopping mall. This would benefit from facilitating conditions that are linked to user behavioral intent. Therefore, the following proposition can be formulated:

H1: Facilitating conditions positively influence the behavioral intention of adopting an AR wayfinding system.

2.3 Performance Expectancy

Performance Expectancy ranks as the most significant factor to influence consumers' behavioral intention in using AR shopping applications, [38]. In the absence of an AR wayfinding application in Singapore, the results will not be manifested. The empirical findings of this study reveal that user performance expectations are the most important element in deciding whether or not to use AR Wayfinding technology from other AR-based applications such as mobile games and shopping apps. Therefore, the following proposition can be formulated:

H2: Performance expectancy positively influences the behavioral intention of adopting an AR wayfinding system.

2.4 Effort Expectancy

Another strong predictor in the UTAUT model is effort expectancy to analyze user behavioral intention for new technology adoption. As per findings from, [39], using new technology tends to increase individuals' effort expectations, and they believed that the easier the individuals believed in the smartwatch usage, their intention to use this new technology device would get as well. A study from [30], also concludes that if one's effort expectancy for smartwatches is greater, the individual's behavioral intention to use the smart watches as their own fitness and health monitoring device will increase. As effort expectancy is directly related to the fact that the user is using an AR-based application, [38]; minimizing the cognitive overload is a key factor in the AR wayfinding system. Therefore, the following proposition can be formulated:

H3: Effort expectancy positively influences the behavioral intention of adopting an AR wayfinding system.

2.5 Social Influence

The layman's term for social influence means the user perceives importance from other people such as family, friends, and artists. In recent years, location-based social network platforms have been gaining popularity. A positive relationship between social influence factors in the prediction of behavioral intention, [39]. The qualitative interviews from, [40], revealed that location-based social networks not only tend to change users' mobility patterns but also able to influence how other users experience technology. As a result, individuals are more likely to decide to use new technologies after considering other people's opinions and the following

proposition can be formulated:
H4: Social influence positively influences the behavioral intention of adopting an AR wayfinding system.

2.6 Privacy Risk

In this context, privacy risk is the degree to which the individual believes he or she has control over the gathering and use of their personal information, even after it has been exposed. There have been studies that looked at the effects of privacy risks on behavioral intentions in the context of location-based services, but only a small amount of research especially in the leisure and shopping malls context have been conducted on the effectiveness usage of the augmented reality and also the privacy concerns. One of the AR Google Glass research from, [41], points out that society is already moving in the direction of data sharing, and it eventually must adopt a new privacy policy stating, 'I think that is where we are going anyway, and people will get used to it. In the e-commerce context, privacy concerns have a negative impact on behavioral intention, [42]. As AR wayfinding systems are also part of the location-based services (LBS), [29]. Due to the need to disclose a user's location information to use LBS, [29], believes that LBS may pose a significant risk of privacy infringement. Having identified four categories of privacy, [43], categorizes them as location privacy, electronic communication privacy, individual Info information privacy, and public place privacy. As people use their devices in public, there is a risk of being filmed or recorded in public by random people and it has become an extremely inevitable issue. Therefore, the following proposition can be formulated:
H5: Privacy risk negatively influences the behavioral intention of adopting an AR wayfinding system.

3 Research Method

3.1 Research Design/Sampling Procedure

The current study aims to explore the user behavioral intention to use AR wayfinding applications. The literature review was used to find the existing gap in the literature, to explore and define the variables, and to develop the hypothesis. The theoretical research framework considers facilitating conditions, performance expectancy, effort expectancy, social influence, and privacy risk as the independent variables (IVs), and behavioral intention as the dependent variable. A quantitative approach is adopted for this research. To determine the sample size for this study, the G*Power software was utilized and it indicated that the minimum sample size for the current study is 138 (effect size: 0.15; power: 95; number of predictors: 5). Google forms were distributed to the target respondents via WhatsApp and Facebook. The data collection for this study was carried out from 2nd February 2022 until 2nd May 2022. The study successfully gathered a total of 175 valid responses from shoppers in Singapore.

3.2 Measurement

All of the measurement items used in this study were adapted from the previous related studies to ensure the validity of the constructs. Construct validity is a critical measurement concept in research methodology that assesses the quality of how the theoretical construct is measured. It demonstrates that the research method or test measures the concept it claims to measure. To ensure the validity of a construct, researchers use several measurement items. Researchers articulate a set of theoretical concepts, develop ways to measure the constructs proposed by the original theory, and test the theory empirically, [44]. It is important to recognize and counter threats to construct validity for a robust research design. The most common threats are poor operationalization, experimenter expectancies, and subject bias, [45]. Poor operationalization refers to the failure to define the construct clearly and to measure it accurately. Experimenter expectancies

refer to the researcher's expectations influencing the results. Subject bias refers to the participants' expectations influencing the results, [45].

Section 1 collects demographic data of the respondents and helps to ensure the respondents are shoppers in Singapore who are aged 18 years and above and have not experienced augmented reality wayfinding applications. Section 2 is related to the variables respectively. Privacy risk was adapted from, [46], and the questionnaires incorporated a five-point Likert scale ranging from one to five, where 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. Meanwhile, variables for Performance Expectancy, Effort Expectancy, and Social Influence were adapted from [47], Facilitating Conditions, [39], and Behavioral Intention, [48], incorporating a seven-point Likert scale ranging from one to seven, where 1 = Strongly Disagree, 2 = Disagree, 3 = Slightly Disagree, 4 = Neutral, 5 = Slightly Agree, 6 = Agree, and 7 = Strongly Agree. The items used to measure the variables are presented in Table 1 (Appendix). After completing the data collection process, SPSS and SMART-PLS were used to analyze the data collected. The partial least squares-structural equation modeling (PLS-SEM) approach was chosen for this research.

4 Research Findings

4.1 Demographic Profile of Respondents

This study adopted a qualitative approach. Purposive sampling was used to filter and ensure the respondents live in Singapore, are 18 years old and above, and have not experienced augmented reality (AR) navigation applications previously. There were in total 175 respondents who responded to the research survey that was distributed via Google Forms. Table 3 summarizes the demographic profile of the respondents. This research received 68% of responses from males and 32% of responses from females, 49.2% had at least a bachelor’s degree or higher, meanwhile, 38.3% of the respondents had a diploma and only 12.6% had a secondary school qualification. More than half of the respondents used non-AR navigation applications at least once a day (70.9%), and only 17.1% of

The respondents used the non-AR navigation application multiple times weekly, and 12% of respondents used the non-AR navigation application less than once weekly. In terms of smart devices, 50.3% of the respondents used Android, 41.7% were iOS device users and 8% used a Microsoft device. Regarding confidence in mobile applications, almost all of the respondents (98.9%) have confidence in the mobile applications they use, and (1.1%) of the respondents are not confident about the mobile applications that they use. Table 2 (Appendix) summarizes the demographic profile of the respondents in Singapore.

4.2 Measurement Model

Discriminant validity and convergent validity are the measurement models that were assessed in the study. HTMT is a method to evaluate discriminant validity, which is one of the most significant components of model evaluation, [49]. If the HTMT value is below 0.85, it demonstrates that discriminant validity has been established between two reflective constructs. The result of the HTMT ratio for data tabulated in Table 3 shows that all the upper threshold values are less than 0.85. Therefore, discriminant validity was ascertained. The HTMT ratio values shown in Table 3 range from 0.261 to 0.779. Furthermore, the highest HTMT ratio has a value of 0.779, which comes from PerEx and Behan, and the lowest HTMT ratio is owned by PriRis and PerEx, with a value of 0.261.

Factor loadings, average variance extracted (AVE), and composite reliability (CR) were used to determine if the measurement model had convergent validity. In the following Table 4, we can find that the factor loadings were all greater than 0.7, which were undertaken, [50]. Next, Composite Reliability above 0.7 or above was considered satisfactory, and AVE obtained 0.5 or higher is acceptable, [50]. As a consequence, all the convergent validity criteria were met in this finding. In general, the Loading

value of convergent validity ranges from 0.7 to 0.9, with the highest Loading value being in the PriRisk variable. Then, the lowest value is in the SocInf variable. Cronbach's Alpha, rho_A, and Composite Reliability (CR) values range from 0.9 to 0.9, with the highest value being the BehInt variable and the lowest value being the PerExp variable. Then, the Average Variance Extracted (AVE) value has a lower value range than the others, namely 0.7 to 0.8, with the highest value being in the BehInt variable 0.841 and the lowest being 0.728 in the PerExp variable.

Table 3. Discriminant Validity Using HTMT Ratio

	BehInt	EffExp	FacCon	PerExp	PriRisk	SocInf
BehInt						
EffExp	0.689					
FacCon	0.699	0.610				
PerExp	0.779	0.771	0.561			
PriRisk	0.299	0.386	0.449	0.261		
SocInf	0.614	0.614	0.766	0.573	0.365	

4.3 Common Method Bias

SPSS 22.0 common method bias with Harman's single factor has been used in the study to test all the questionnaire findings to ensure that there is no common method bias in the findings. Typically the measurement bias in the questionnaire is due to not measuring the construct directly, but rather the measurement method. The threshold level of 50% and based on the finding there is only 45.345% (less than 50%) of variance for the first factor as shown in Table 5, [51]. In general, the variance value varies from 0.076% to 45.345%, with a total component of 20. In addition, the Cumulative value also has a value range from 45% to 100%. The variance value is the opposite of the cumulative value. In other words, the greater the variance value, the smaller the cumulative value. However, this does not apply to the variation and cumulative values of component 1. For instance, the variation value of component 2 is 13.79, which is a high value and has a small cumulative value of 59.14%.

4.4 UTAUT Structural Model

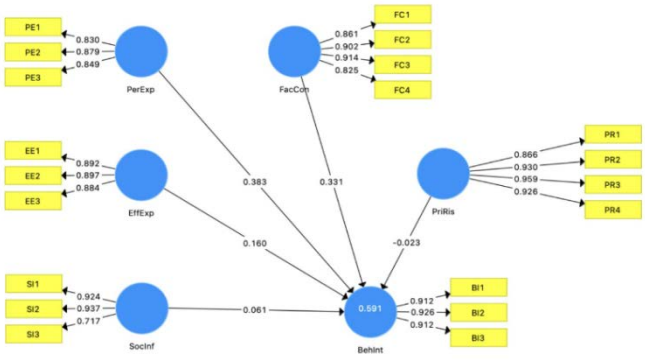

Fig. 1: Structural Model

Bootstrapping procedures were tested with a resample of 5,000 to assess all the relationships between the structural model (Figure 1), and its corresponding beta (β) and T values, [52]. As seen in the results in Table 3 (Appendix), facilitating conditions (β = 0.331, t = 0.092, p = 0.000) and performance expectancy (β = 0.383, t = 0.097, p =0.000) were found to have a positive and significant relationship with intention to use indoor AR wayfinding system application. However, effort expectancy, privacy risk, and social influence showed no significant relationship to the use of indoor AR wayfinding system applications.

Studies have shown that AR-based wayfinding systems can significantly reduce the time required for navigation in complex environments, [21]. Additionally, research has explored the correlation between spatial ability skills and wayfinding performance using AR-based wayfinding systems, [48], [49], [53]. Other studies have investigated the impact of navigation aids on wayfinding performance and perceived workload in indoor-outdoor campus navigation, [54]. Overall, while the intention to use indoor AR wayfinding system applications may not be influenced by certain variables, the use of AR-based wayfinding systems is effective in reducing navigation time in complex environments. This gives support for Hypothesis 1 and Hypothesis 2, whereas Hypothesis 3,

Hypothesis 4, and Hypothesis 5 were rejected (Table 7, Appendix).

5 Discussion

Facilitating conditions (FC) show a positive and significant relationship between behavioral intentions to use the indoor AR shopping wayfinding application. This positive result gives an explanation that the indoor AR wayfinding system results from not only the degree of technical resources or knowledge but also whether the consumer tries to solve the problem on his or her own or relies on others should be considered in solving technical problems.

On the other hand, performance expectancy (PE) likewise has an incredible effect impact the consumer's behavioral intention to use the indoor AR shopping application which is also aligned with the finding of [38]. This implies that promoting the function and convenience of indoor AR wayfinding systems should be paramount. Therefore, retailers and operators should develop strategies to promote the benefits of AR wayfinding not only to individual consumers but also to other stakeholders who may affect them.

Nonetheless, effort expectancy (EE) was viewed not as fundamentally related to behavioral intention to adopt an indoor AR wayfinding system application, which contrasted with the finding of [30], and the outcome could be additionally explained that the majority of the respondents are tech-savvy and have an elevated degree of information on media innovation. According to the data collected, they perceived that the AR wayfinding system application was simple and didn't require a lot of exertion.

Furthermore, social expectancy (SE) was found to have an insignificant relationship with the behavioral intention of adopting an AR wayfinding system. This means that respondents' family and friends' opinions will not influence them to adopt an indoor AR wayfinding system application. Individuals change their attitudes to increase opinion differences to negatively evaluate others, [55].

The added variable of privacy risk (PR) was also found to have an insignificant relationship with the behavioral intention of adopting an AR wayfinding system. The studies of privacy risk on users for new technology acceptance have limitations in integrating various types of risks into a single concept and measuring their influence. In this respect, this study contributes to a more complete understanding of Singaporean consumers on AR wayfinding navigation usage by extending the UTAUT model by focusing on privacy risk. Software development in Singapore has reliable, secure technologies and policies that protect personal information which would lower consumers' perceived privacy risks. Moreover, the benefit from that is Singapore has a robust regulatory framework for intellectual property (IP) protection, [56]. This can help protect consumers' personal information from being misused or stolen by unauthorized parties. Singapore has a Model Framework for AI Governance that guides to helps organizations navigate the complex ethical questions that often arise when AI technologies and solutions are deployed, [57]. This can help ensure that consumers' personal information is used ethically and responsibly.

Finally, two of the Hypothesis statements are accepted. Those can be associated with AR-based wayfinding systems can provide clear and legible environmental information, and facilitate the cognitive process of route strategy by overlaying the routing. This can make it easier for users to navigate complex environments, such as shopping centers and airports, [21]. This can save time for users and make the navigation process more efficient. In addition, the use of AR-based wayfinding systems can enhance visitors' overall experience in indoor shopping malls and other public spaces, [58]. This can create a positive perception of the technology and increase the likelihood of adoption. This can create a positive perception of the technology and increase the likelihood of adoption. Moreover, AR-based wayfinding systems can improve wayfinding performance in existing healthcare facilities, [59]. This can help patients and visitors navigate healthcare facilities more easily and efficiently.

Wayfinding can help create a more equitable environment and improve social cohesion by supporting local amenities and designing information to be accessed by all, [60]. This can benefit the community as a whole.

6 Implications

The objective of this research was to identify the direct effect between the independent variables and the user's behavioral intention to use the indoor AR wayfinding technology. In terms of theoretical contributions, this study helps the readers or new researchers to better grasp the general factors affecting the intention to use the indoor AR wayfinding system application by using the UTAUT theory. To the best of the researcher's knowledge, this research is one of the first study in of indoor AR wayfinding system applications in Singapore by using a base theoretical framework to investigate the market. This study could also serve as a reference for future researchers with the technology topic related to location-based services, mobile banking services, augmented reality, and wayfinding services.

This research helps to provide insights into the strategic development of digital leaders in Singapore to lead and ensure the success of the digital transformation aligned with the ultimate goal of making Singapore a regional market producer. As a leader, marketers, and brand managers in developing technology systems, there is a need to establish market positioning not only based on the current trends but also include useful niche markets that will potentially allow them a competitive advantage over other businesses or countries. Hence this study will help to raise the awareness of the indoor wayfinding application in Singapore. Service providers and/or application developers can design the application system to have more innovative features and also include the factors that have been established in the results to enhance and fulfill consumers' demands.

7 Conclusion

This study endeavored to analyze the direct connection between factors affecting the intention to use the indoor AR wayfinding system application by using the UTAUT theory. The findings have uncovered that facilitating conditions, and performance expectancy have a significant positive relationship to influencing user's behavioral intention to use indoor AR wayfinding system applications. Along with providing the necessary assistance, these aspects will particularly enhance the likelihood of adopting the AR wayfinding system in an indoor retail context.

8 Limitations and Future Studies

Three limitations can be identified in this study. First, there are not many AR wayfinding navigation applications available on the app store. It is recommended that researchers use qualitative and quantitative techniques as a mixed method to have a more in-depth understanding. Next is about the location. The current study is in Singapore but without any particular focus area. Future research could be based on a specific location such as a central business district or central area of an upscale shopping area in Singapore to compare AR wayfinding across different demographics of users (business use versus casual use) to increase the variety of perspectives and to improve validity. Lastly, the current study primarily collected data from people living in urban areas who were able to operate the AR wayfinding application with their ICT knowledge and skills. To capture a more holistic view, future studies should also include respondents who live in rural areas.

References:

[1] J. Ženka, J. Macháček, L. Krtička, P. Michna, and P. Kořízek, "Acceptance of a smartphone navigation application by hospital patients and visitors: the role of gender, age, and

education," *Hungarian Geographical Bulletin,* vol. 70, no. 2, pp. 149-161, 2021.

[2] J. Saretzki, J. Pretsch, G. Obertaxer, and R. Lesjak, "Security that Matters: General Knowledge and Correlations in the Context of Applied Satellite Navigation, Specific Interference-Events and the Use of the GNSS-Technology," *European Journal of Social Sciences,* vol. 5, no. 1, pp. 27-44, 2022.

[3] Y. A. Sekhavat and J. Parsons, "The effect of tracking technique on the quality of user experience for augmented reality mobile navigation," *Multimedia Tools Applications,* vol. 77, no. 10, pp. 11635-11668, 2018.

[4] R. Chen, P. Perry, R. Boardman, and H. McCormick, "Augmented reality in retail: a systematic review of research foci and future research agenda," *International Journal of Retail Distribution Management,* vol. 50, no. 4, pp. 498-518, 2022.

[5] S. G. Dacko, "Enabling smart retail settings via mobile augmented reality shopping apps," *Technological forecasting social change,* vol. 124, pp. 243-256, 2017.

[6] K. Chopra, "Indian shopper motivation to use artificial intelligence: Generating Vroom's expectancy theory of motivation using grounded theory approach," *International Journal of Retail Distribution Management,* vol. 47, no. 3, pp. 331-347, 2019.

[7] F. Baytar, T. Chung, and E. Shin, "Evaluating garments in augmented reality when shopping online," *Journal of Fashion Marketing Management: An International Journal,* vol. 24, no. 4, pp. 667-683, 2020.

[8] D. Plotkina and H. Saurel, "Me or just like me? The role of virtual try-on and physical appearance in apparel M-retailing," *Journal of Retailing Consumer Services,* vol. 51, pp. 362-377, 2019.

[9] A. Javornik, "'It's an illusion, but it looks real!'Consumer affective, cognitive and behavioral responses to augmented reality applications," *Journal of Marketing Management,* vol. 32, no. 9-10, pp. 987-1011, 2016.

[10] A. Poushneh and A. Z. Vasquez-Parraga, "Discernible impact of augmented reality on retail customer's experience, satisfaction and willingness to buy," *Journal of Retailing Consumer Services,* vol. 34, pp. 229-234, 2017.

[11] J. Scholz and K. Duffy, "We ARe at home: How augmented reality reshapes mobile marketing and consumer-brand relationships," *Journal of Retailing Consumer Services,* vol. 44, pp. 11-23, 2018.

[12] A. R. Smink, E. A. Van Reijmersdal, G. Van Noort, and P. C. Neijens, "Shopping in augmented reality: The effects of spatial presence, personalization and intrusiveness on the app and brand responses," *Journal of Business Research,* vol. 118, pp. 474-485, 2020.

[13] T. Hilken, K. de Ruyter, M. Chylinski, D. Mahr, and D. I. Keeling, "Augmenting the eye of the beholder: exploring the strategic potential of augmented reality to enhance online service experiences," *Journal of the Academy of Marketing Science,* vol. 45, pp. 884-905, 2017.

[14] M. Y.-C. Yim, S.-C. Chu, and P. L. Sauer, "Is augmented reality technology an effective tool for e-commerce? An interactivity and vividness perspective," *Journal of interactive marketing,* vol. 39, no. 1, pp. 89-103, 2017.

[15] A. Jessen *et al.*, "The playground effect: How augmented reality drives creative customer engagement," *Journal of Business Research,* vol. 116, pp. 85-98, 2020.

[16] B. Romano, S. Sands, and J. I. Pallant, "Augmented reality and the customer journey: an exploratory study," *Australasian Marketing Journal,* vol. 29, no. 4, pp. 354-363, 2021.

[17] M. Y.-C. Yim and S.-Y. Park, "I am not satisfied with my body, so I like augmented reality (AR)": Consumer responses to AR-based product presentations," *Journal of Business Research,* vol. 100, pp. 581-589, 2019.

[18] M. Chylinski, J. Heller, T. Hilken, D. I.

Keeling, D. Mahr, and K. de Ruyter, "Augmented reality marketing: A technology-enabled approach to situated customer experience," *Australasian Marketing Journal*, vol. 28, no. 4, pp. 374-384, 2020.

[19] P. A. Rauschnabel, J. He, and Y. K. Ro, "Antecedents to the adoption of augmented reality smart glasses: A closer look at privacy risks," *Journal of Business Research*, vol. 92, pp. 374-384, 2018.

[20] S. T. Board. (2021). *Building Immersive Worlds with AR* Available: https://www.stb.gov.sg/content/stb/en/trade-events-and-resources/Tcube/stories/technology/tech-ar.html (Accessed date: 28/09/2023)

[21] M. J. Kim, X. Wang, S. Han, and Y. Wang, "Implementing an augmented reality-enabled wayfinding system through studying user experience and requirements in complex environments," *Visualization in Engineering*, vol. 3, pp. 1-12, 2015.

[22] J. Zhang, X. Xia, R. Liu, and N. Li, "Enhancing human indoor cognitive map development and wayfinding performance with immersive augmented reality-based navigation systems," *Advanced Engineering Informatics*, vol. 50, p. 101432, 2021.

[23] A. Lo Valvo, D. Croce, D. Garlisi, F. Giuliano, L. Giarré, and I. Tinnirello, "A navigation and augmented reality system for visually impaired people," *Sensors*, vol. 21, no. 9, p. 3061, 2021.

[24] T. Zhou, P. Xia, Q. Zhu, and J. Du, "Cognition-driven navigation assistive system for emergency indoor wayfinding (CogDNA): proof of concept and evidence," *Safety Science*, vol. 162, p. 106100, 2023.

[25] A. S. Ahadzadeh, S. P. Sharif, F. S. Ong, and K. W. Khong, "Integrating health belief model and technology acceptance model: an investigation of health-related Internet use," *Journal of medical Internet research*, vol. 17, no. 2, p. e3564, 2015.

[26] S. Nasir and Y. Yurder, "Consumers' and physicians' perceptions about high tech wearable health products," *Procedia-Social Behavioral Sciences*, vol. 195, pp. 1261-1267, 2015.

[27] G. Becker, "The age of human capital. Education in the Tweny-First Century," ed: Retrieved from the World Wide Web: http://economics, 2010 (Accessed date: 28/09/2023).

[28] E. Park, K. J. Kim, and S. J. Kwon, "Understanding the emergence of wearable devices as next-generation tools for health communication," *Information Technology People*, vol. 29, no. 4, pp. 717-732, 2016.

[29] H. Yun, D. Han, and C. Lee, "Extending UTAUT to predict the use of location-based services," 2011.

[30] P. K. Beh, Y. Ganesan, M. Iranmanesh, and B. Foroughi, "Using smartwatches for fitness and health monitoring: the UTAUT2 combined with threat appraisal as moderators," *Behaviour Information Technology*, vol. 40, no. 3, pp. 282-299, 2021.

[31] R. de Sena Abrahão, S. N. Moriguchi, and D. F. Andrade, "Intention of adoption of mobile payment: An analysis in the light of the Unified Theory of Acceptance and Use of Technology (UTAUT)," *RAI Revista de Administração e Inovação*, vol. 13, no. 3, pp. 221-230, 2016.

[32] Y. K. Dwivedi, N. P. Rana, A. Jeyaraj, M. Clement, and M. D. Williams, "Re-examining the unified theory of acceptance and use of technology (UTAUT): Towards a revised theoretical model," *Information Systems Frontiers*, vol. 21, pp. 719-734, 2019.

[33] M. D. Williams, N. P. Rana, and Y. K. Dwivedi, "The unified theory of acceptance and use of technology (UTAUT): a literature review," *Journal of enterprise information management*, vol. 28, no. 3, pp. 443-488, 2015.

[34] I. A. Junglas and R. T. Watson, "Location-based services," *Communications of the ACM*, vol. 51, no. 3, pp. 65-69, 2008.

[35] A. Rahman, A. Khan, and A. A. Raza, "Parkinson's disease detection based on signal processing algorithms and machine learning,"

CRPASE: Transactions of Electrical, Electronic Computer Engineering, vol. 6, pp. 141-145, 2020.

[36] I. Ajzen, "The theory of planned behavior," *Organizational behavior human decision processes*, vol. 50, no. 2, pp. 179-211, 1991.

[37] V. Venkatesh, M. G. Morris, G. B. Davis, and F. D. Davis, "User acceptance of information technology: Toward a unified view," *MIS Quarterly*, pp. 425-478, 2003.

[38] C. Schapsis, L. Chiagouris, and N. C. Pham, "Are Consumers Ready for Augmented Reality? Factors Influencing Online Footwear Purchasing Intentions Using AR Technology," *Journal of Marketing Development Competitiveness*, vol. 15, no. 2, pp. 21-36, 2021.

[39] V. Venkatesh, J. Y. Thong, and X. Xu, "Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology," *MIS Quarterly*, pp. 157-178, 2012.

[40] J. Frith, "Turning life into a game: Foursquare, gamification, and personal mobility," *Mobile Media Communication*, vol. 1, no. 2, pp. 248-262, 2013.

[41] D.-i. D. Han, M. C. Tom Dieck, and T. Jung, "Augmented Reality Smart Glasses (ARSG) visitor adoption in cultural tourism," *Leisure Studies*, vol. 38, no. 5, pp. 618-633, 2019.

[42] X. Guo, Y. Sun, Z. Yan, and N. Wang, "Privacy-personalization paradox in the adoption of mobile health service: the mediating role of trust," 2012.

[43] P. Samuelson, "Information law and policy video lectures," *UC California, Berkeley, Berkeley, CA*, 2008.

[44] D. E. Team. (2023, September, 2023). *What is construct validity?* Available: https://dovetail.com/research/construct-validity/ (Accessed date: 28/09/2023)

[45] P. Bhandari, *Construct validity, definition, types & examples*. Scribbr, 2022.

[46] Q. Yang, C. Pang, L. Liu, D. C. Yen, and J. M. Tarn, "Exploring consumer perceived risk and trust for online payments: An empirical study in China's younger generation," *Computers in human behavior*, vol. 50, pp. 9-24, 2015.

[47] Y. Gao, H. Li, and Y. Luo, "An empirical study of wearable technology acceptance in healthcare," *Industrial Management Data Systems*, 2015.

[48] L.-H. Wu, L.-C. Wu, and S.-C. Chang, "Exploring consumers' intention to accept smartwatch," *Computers in Human Behavior*, vol. 64, pp. 383-392, 2016.

[49] J. Henseler, C. M. Ringle, and M. Sarstedt, "A new criterion for assessing discriminant validity in variance-based structural equation modeling," *Journal of the Academy of Marketing Science*, vol. 43, pp. 115-135, 2015.

[50] J. F. Hair Jr, M. Sarstedt, C. M. Ringle, and S. P. Gudergan, *Advanced issues in partial least squares structural equation modeling*. Sage Publications, 2017.

[51] P. M. Podsakoff, S. B. MacKenzie, J.-Y. Lee, and N. P. Podsakoff, "Common method biases in behavioral research: a critical review of the literature and recommended remedies," *Journal of applied psychology*, vol. 88, no. 5, p. 879, 2003.

[52] S. Streukens and S. Leroi-Werelds, "Bootstrapping and PLS-SEM: A step-by-step guide to getting more out of your bootstrap results," *European Management Journal*, vol. 34, no. 6, pp. 618-632, 2016.

[53] N. A. A. Shamsuddin and S. C. Din, "Spatial ability skills: A correlation between Augmented Reality (AR) and conventional way on wayfinding system," *Environment-Behaviour Proceedings Journal*, vol. 1, no. 2, pp. 159-167, 2016.

[54] R. Tahir and J. Krogstie, "Impact of Navigation Aid and Spatial Ability Skills on Wayfinding Performance and Workload in Indoor-Outdoor Campus Navigation: Challenges and Design," *Applied Sciences*, vol. 13, no. 17, p. 9508, 2023.

[55] K. Takács, A. Flache, and M. Mäs, "Discrepancy and disliking do not induce

negative opinion shifts," *PloS one,* vol. 11, no. 6, p. e0157948, 2016.

[56] Designveloper. (2023, September, 20th). *Top 5 App Development Companies in Singapore*. Available: https://www.designveloper.com/blog/app-development-in-singapore/ (Accessed date: 28/09/2023)

[57] C. L. Charlotte Trueman. (2019, September, 20). *How Singapore is using artificial intelligence*. Available: https://www.cio.com/article/221994/how-singapore-is-using-artificial-intelligence.html (Accessed date: 28/09/2023)

[58] U. Project. (2023, September, 20th). *Augmented reality wayfinding: The future of indoor navigation*. Available: https://untitledproject.sg/augmented-reality-wayfinding-the-future-of-indoor-navigation/ (Accessed date: 28/09/2023)

[59] A. Al-Sharaa, M. Adam, A. S. Amer Nordin, A. Alhasan, R. Mundher, and O. Zaid, "Enhancing Wayfinding Performance in Existing Healthcare Facilities Using Virtual Reality Environments to Revise the Distribution of Way-Showing Devices," *Buildings,* vol. 12, no. 6, p. 790, 2022.

[60] Seattle. (2023, September, 20th). *Pedestrian Wayfinding Program*. Available: https://www.seattle.gov/documents/Departments/SDOT/UrbanDesignProgram/PedestrianWayfindingProgram/Wayfinding%20Strategy_July2019_SDOT%20Edit.pdf (Accessed date: 28/09/2023)

APPENDIX

Table 1. Measurement Items in Questionnaire

Variable(s)	Measurement Items	Adopted from
Performance Expectancy	I find the AR wayfinding application useful for indoor shopping navigation.	[47]
	Using an AR wayfinding application would enable me to take action related to my indoor shopping navigation more quickly.	
	Using the AR wayfinding application improves the quality of my indoor shopping navigation.	
Effort Expectancy	Learning how to use AR wayfinding applications for indoor shopping navigation is easy for me.	[47]
	I find it an easy-to-use AR wayfinding application for indoor shopping navigation.	
	It is easy for me to become skillful at using AR wayfinding applications for indoor shopping navigation.	
Social Influence	People who are important to me would think that I should use an AR Wayfinding application for indoor shopping navigation.	[47]
	People who influence me would think that I should use an AR Wayfinding application for indoor shopping navigation.	
	People whose opinions are valued by me would prefer that I use an AR Wayfinding application for indoor shopping navigation.	
Facilitating Conditions	I have the resources necessary to use AR wayfinding applications for indoor shopping navigation.	[39]
	I have the knowledge necessary to use AR wayfinding applications for indoor shopping navigation.	
	AR wayfinding application is compatible with other technologies I use.	
	I can get help from others when I have difficulties using AR wayfinding applications for indoor shopping navigation.	
Privacy Risk	By using an AR wayfinding application, I am at risk of infringement of my privacy.	[46]
	By using an AR wayfinding application, I am at risk of my personal information being collected excessively.	
	By using an AR wayfinding application, my personal information is at risk of being accessed by unauthorized people.	
	By using an AR wayfinding application, my actions are at risk of being tracked and monitored.	
Behavioral Intention	I would be willing to use an AR Wayfinding application for indoor shopping navigation.	[48]
	I would be willing to use an AR Wayfinding application for indoor shopping navigation if I possess one.	
	I would be willing to let an AR Wayfinding application help me navigate indoor shopping.	

Table 2. Summary of Demographic Profile of the Respondents

Variables	Category	Frequency	%
Gender	Male	119	68.0%
	Female	56	32.0%
Age	18 - 29	58	33.1%
	30 - 39	92	52.6%
	40 - 49	21	12.0%
	50 and above	4	2.3%
Education	Secondary	22	12.6%
	High School or Diploma	67	38.3%
	Bachelor's Degree	61	34.9%
	Postgraduate Qualifications	25	14.2%
What kind of smart devices do you use often	iOS	73	42%
	Android	88	50%
	Microsoft	14	8%
Navigation Application Use Frequency (Non-AR)	Multiple Times Daily	57	32.6%
	Once Daily	67	38.3%
	Multiple Times Weekly	30	17.1%
	Once Weekly	11	6.3%
	Once A Month	10	5.7%
Confidence in Mobile Application Use	Extremely Confident	64	36.6%
	Confident	79	45.1%
	Somewhat Confident	30	17.2%
	Not Confident	2	1.1%
	Extremely Not Confident	0	0.0%

Table 4. Convergent Validity

Variable(s)	Items	Loading	CA	RhoA	CR	AVE
BehInt			0.905	0.908	0.941	0.841
	BI1	**0.912**				
	BI2	**0.926**				
	BI3	**0.912**				
EffExp			0.871	0.871	0.921	0.794
	EE1	**0.892**				
	EE2	**0.897**				
	EE3	**0.849**				
FacCon			0.899	0.899	0.930	0.768
	FC1	**0.861**				
	FC2	**0.902**				
	FC3	**0.914**				
	FC4	**0.825**				
PerExp			0.813	0.812	0.889	0.728
	PE1	**0.830**				
	PE2	**0.879**				
	PE3	**0.849**				
PriRisk			0.940	0.960	0.957	0.848
	PR1	**0.866**				
	PR2	**0.930**				
	PR3	**0.959**				
	PR4	**0.926**				
SocInf			0.828	0.875	0.898	0.748
	SI1	**0.924**				
	SI2	**0.937**				
	SI3	**0.717**				

Table 5. Total Variance Explained using Principal Component Analysis (PCA)

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cum %
1	9.069	45.345	45.345	9.069	45.345	45.345
2	2.759	13.797	59.141	2.759	13.797	59.141
3	1.620	8.100	67.241	1.620	8.100	67.241
4	1.053	5.267	72.508	1.053	5.267	72.508
5	0.861	4.303	76.811	0.861	4.303	76.811
6	0.717	3.587	80.398	0.717	3.587	80.398
7	0.595	2.975	83.372	0.595	2.975	83.372
8	0.529	2.646	86.018	0.529	2.646	86.018
9	0.405	2.024	88.042	0.405	2.024	88.042
10	0.379	1.893	89.935	0.379	1.893	89.935
11	0.318	1.588	91.523	0.318	1.588	91.523
12	0.270	1.350	92.873	0.270	1.350	92.873
13	0.254	1.269	94.143	0.254	1.269	94.143
14	0.245	1.225	95.368	0.245	1.225	95.368
15	0.222	1.110	96.478	0.222	1.110	96.478
16	0.206	1.028	97.505	0.206	1.028	97.505
17	0.167	0.837	98.342	0.167	0.837	98.342
18	0.130	0.651	98.993	0.130	0.651	98.993
19	0.126	0.628	99.622	0.126	0.628	99.622
20	0.076	0.378	100	0.076	0.378	100

Table 6. Direct Effects

	Beta	Sample Mean (M)	Standard Deviation (STDEV)	T Values	P Values	Decision
FacCon -> BehInt	0.331	0.337	0.092	3.599	0.000	Supported
PerExp -> BehInt	0.383	0.378	0.097	3.960	0.000	Supported
EffExp -> BehInt	0.160	0.140	0.099	1.623	0.052	Not Supported
SocInf -> BehInt	0.061	0.068	0.100	0.608	0.272	Not Supported
PriRisk -> BehInt	-0.023	-0.011	0.070	0.325	0.373	Not Supported

Table 7. Hypotheses Testing Results

Hypothesis	Structure Path	Hypothesis Statement	Finding
H1.	FC → BI	Facilitating Conditions positively influence the Behavioral Intention of adopting an AR wayfinding system.	Accepted
H2.	PE → BI	Performance Expectancy positively influences the Behavioral Intention of adopting an AR wayfinding system.	Accepted
H3.	EE → BI	Effort Expectancy positively influences the Behavioral Intention of adopting an AR wayfinding system.	Rejected
H4.	SI → BI	Social Influence positively influences the Behavioral Intention of adopting an AR wayfinding system.	Rejected
H5.	PR → BI	Privacy Risk negatively influences the Behavioral Intention of adopting an AR wayfinding system.	Rejected

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The authors equally contributed to the present research, at all stages from the formulation of the problem to the final findings and solution.

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

Bina Nusantara University supported this study.

Conflict of Interest

The authors have no conflict of interest to declare.