Towards Perceived Playfulness and Adoption of Hearables in Smart Cities of China

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ABSTRACT

'Hearables' have become important in the aging population. This study investigates whether smart technologies help middle-aged and elderly people accept hearing aid devices in smart cities of China. The authors adopt the PLS-SEM framework to analyze the factors that affect behavioral intention towards adopting hearing aids in smart cities. In order to avoid common method bias, Harman's single factor method is also carried out to make sure the instrument does not introduce a bias. The findings suggest that perceived playfulness and perceived usefulness are principal determinants of hearing aids adoption. In contrast, perceived ease of use, a factor always stressed in literature, does not matter significantly. The results reveal that smart technologies enable patients to access professional services and instructions playfully, which reduces obstacles to adopt hearing aids. This study provides novel insights for policymakers and manufacturers to expand hearing aid adoption by facilitating smart infrastructure and technologies.

KEYWORDS

Hearing Aids, Hearing Aids Adoption, Perceived Playfulness, Perceived Usefulness, Technology Acceptance Model

1. INTRODUCTION

This study explores whether smart technologies, e.g., smartphones, internet of things (IoT) platforms, human-machine interactions, and mobile health, help people of typically healthy ages, such as adults of working age, adopt hearing aid devices. They can be summed up as 'hearables' or hearing aids that can reduce hearing difficulties and enhance patients' quality of life (Chisolm et al., 2007;

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Dalton et al., 2003; Ravneberg and Söderström, 2017). It is estimated that up to 25% of the global population may suffer from hearing loss at some level by the middle of this century (WHO, 2021). However, hearing aid devices make invisible hearing disabilities visible in public (Ellington and Lim, 2013; Van Vliet, 2005). Few studies examine how assistive technologies reinforce the stigma associated with hearing disabilities and reduce such counterproductive effects (David and Werner, 2016; Ruusuvuori et al., 2021).

Technological innovation and development provide consumers with perceived usefulness and greater ease of use, thus changing consumers' behavioral intentions (Davis and Venkatesh, 1996). In hearing aids, we propose that smart technologies provide more information and communication facilities and services, which transforms consumers' behavioral intentions. We are interested in the detailed mechanisms via which smart technologies reshape consumers' perceptions of hearing aid products, which have been extensively investigated using PLS-SEM analysis.

With technological innovation and development, manufacturers have significantly expanded the functions of hearing aids. For example, some hearing aid devices can connect with online healthcare services to enable the user to check hearing abilities and hearing status in real-time (Wright and Keith, 2014). Thus, such smart technologies can improve the quality of life for the urbaner who can access different electronic data collection methods facilitating information communication. Stigma avoidance is another dimension of smart technological innovation. Marti and Recupero (2019) report that smart hearing-aid jewels and avoid stigmatization problems beyond the conventional functionality view. The jewelry system contains hearing aids and mobile phone applications. The hearing aids can be designed to be a variety of fashionable pieces of jewelry like rings, brooches, necklaces, and armbands. Most participants in experimental marketing have given such products high ratings (Marti and Recupero, 2019).

We constructed a conceptual framework focusing on hearing aids adoption intentions and discerning the detailed interaction mechanisms between consumer behavior and smart technologies. Based on the results of an exploratory qualitative study, we chose the Partial least squares structural equation modeling (PLS-SEM) analysis as our benchmark. PLS-SEM also has been used to study health-related internet use (Ahadzadeh et al., 2015; Cheung et al., 2019). PLS-SEM procedures such as the PLS algorithm, model assessments, PLS predict, PLS goodness-of-fit, invariance assessment and multi-group analysis, and importance-performance map analysis are used in statistic analysis (Sohaib, 2021; Klačmer, 2022). The existing PLS-SEM studies have focused on the two mediating factors: perceived usefulness (PU) and perceived ease of use (PEOU), since the 1980s. We propose that technological innovation and behavior intention are interactively affected and explore whether smartization brings new mediating factors into the decision-making of adopting hearing aids. Thus, this study investigates how three motivators – PU, PEOU, and 'perceived playfulness' (PP) – affect the intention to use a hearing aids device.

This study was conducted in China's smart cities, where smart technologies have been widely accessible. The smart city concept combines IoT and Information and Communication Technology (ICT) to operate efficient services and connections to citizens (McLaren and Agyeman, 2005; Zanella et al., 2014). In China's main cities, such as Beijing, Shanghai, Shenzhen and Hangzhou, more than 95% of users access the internet using smartphones through wireless networks, which in turn drives the development of 'Smart Cities' (Wang et al. 2020). In order to test our model, an online survey was administered in those smart cities. The results of the empirical research are consistent with our model. In particular, perceived playfulness, which is generally overlooked in the existing literature, has become a significant determinant of hearing aids adoption with the integration of smart technologies. Thus, our study contributes to understanding the interactive relationship between smartization and consumers' behavior in general. Furthermore, our findings will be insightful to hearing aids manufacturers and policymakers who design healthcare policies concerning deafness and hearing aids use.

The remaining part of this paper is organized in the following way. It reviews consumer behavior in prior studies related to the adoption of technologies and justifies the research gap in section 2.

Section 3 introduces the theoretical framework and develops hypotheses. Section 4 explains data collection and methods. The following two sections then analyze data and discuss the results. Finally, Section 7 concludes the study.

2. LITERATURE REVIEW

2.1 Adoption of Technologies: Consumers' Perspectives

Extensive efforts in the technology acceptance models (Davis, 1985, 1989; Davis et al., 1989), as well as the unified theory of acceptance and use of technology (Venkatesh et al. 2003; Venkatesh, 2015; Venkatesh et al. 2016; Abdou & Jasimuddin, 2020), have enriched knowledge on acceptance of technologies. For example, Rehman *et al.* (2021) used the framework of the technology acceptance model, and a concept model is proposed that integrates health and technology attributes to confirm that smart wearable healthcare (SWH) devices have potential benefits for customer health. De Moya et al. (2021) investigated the perceived risks and benefits related to self-tracking technologies (SST) and evaluated the impacts of social, technological, and health factors on STT adoption through the use of the extended valence framework. The results show that the perceived benefits outweigh the risks, and health support is a significant factor of self-tracking devices. Xiao et al. (2021) also employed the valence framework to study the use intention of online health services in China. Their results show that social support value, convenience value, and utilitarian value are the facilitators.

The core mechanisms of technology acceptance have been identified as perceived usefulness (PU) and perceived ease of use (PEOU) from consumers' perspectives. PU is defined as how much a person's productivity is improved by a system, and PEOU is how easy or difficult a system is to use "(Venkatesh, 2015: p.1). Perceived usefulness has been found to be determined by factors such as image, job relevance, output quality, result demonstrability, and perceived ease of use (Venkatesh and Davis, 2000). Factors, including product self-efficacy, perceptions of external control, product anxiety and playfulness, perceived enjoyment, and objective usability, have been found to influence perceived ease of use (Venkatesh, 2000). Various factors, like performance expectancy, effort expectancy, social influence, motivation, habit, and so forth, affect consumer behavior, affecting technology acceptance (Venkatesh et al., 2012).

Some scholars hold the view that consumer opposition is the main reason for innovation failure. Therefore, it is essential to study the influential factors of technology acceptance. Many scholars have made contributions to identifying the factors that influence people's acceptance of technology. They studied a variety of perspectives related to technology acceptance, including innovation resistance, adoption, intention to use, late adoption and actual usage (Talwar, Kaur, & Dhir, 2020). The existing studies show that the usage and values of the products are the key variables that affect consumer attitudes and actions toward digital innovation (Talwar, Kaur, & Dhir, 2020). Other variables, such as risk and images, tradition, and socio-demographics, are also vital. For example, when considering whether to choose between online and mobile shopping, most of the consumer resistance is focused on internet banking (Habib & Hamadneh, 2021). The perceived security concerns can negatively impact customer engagement in mobile banking (Shankar, 2021). Furthermore, in the study of Dhiman (2019) on smartphone fitness app adoption intention, it is established that expected effort, social influence, perceived benefit, habit, and individual inventiveness are all significant determinates. It has been confirmed that there is a strong correlation between habit, self-efficiency, and effort expectation, as well as performance expectation (Dhiman et al., 2019). Yang (2021) explored the impact of several factors, such as facilitating conditions, lifestyle compatibility, and perceived trust, on both the intention to use an e-wallet and the adoption of an e-wallet among adults. As a result, factors including perceived usefulness, perceived ease of use, social influence, lifestyle compatibility, and perceived trust all had a significant positive effect (Yang et al., 2021). Moreover, in the study of Tsai & Tiwasing (2021) on last-mile delivery service, they combined the technology acceptance theory with the diffusion of innovation and found that compatibility, relative advantage, complexity, and perceived behavioral control have a positive relationship with Thai consumers' intention to utilize smart lockers.

Recent studies have suggested that usefulness and ease of use may not be sufficient to explain users' behaviors towards newly emerging information technologies. Perceived playfulness has increasingly gained attention in studies on the adoption of technologies, including the eWoM use for s-commerce post-adoption (Rouibah et al., 2021) and the use of mobile short video applications (Cui et al., 2022). Sun and Gao (2020)'s study of mobile devices in language learning stresses that perceived playfulness should be more critical as intrinsic motivation. In the study of Malodia et al. (2021), the reasons people adopt using Artificial Intelligence-enabled voice assistants were studied and the results show that perceived playfulness is significantly associated with both information seeking and task functions, which confirms that hedonic benefits can play a significant role in influencing consumers' choices when adopting new technologies. This usually requires devoting more effort to explore the antecedents of perceived playfulness. However, most prior literature focuses on entertainment products and services that are playfulness-based such as smartwatches (Baudier et al., 2020), online games (Cheung et al., 2021), and e-commerce (Hamari et al., 2019; Rouibah et al., 2021). Products in the healthcare domain like hearing aids are still conventionally portrayed in terms of their usefulness, ease of use, and functionality.

2.2 Hearing Loss and Hearing Aids

Hearing loss is one of the most common chronic health disorders, especially in elderly people (World Health Organization, 2017). In fact, it is estimated by the World Health Organisation (WHO) that approximately 466 million people worldwide (or just over 2021). The WHO predicts that this figure will rise to over 2.5 billion by 2050, or one in every ten people (WHO, 2021), while the proportion of older people increases. Davis et al. (2016) estimate that age-related hearing loss will be one of the top fifteen diseases by 2030. Consequently, then, age-related hearing difficulty can lower people's mental and physical well-being (Ravneberg and Söderström, 2017). Further, many people didn't seek or delayed getting timely treatment after hearing loss (Simpson et al., 2019). Factors to consider include age, the number of chronic health conditions to be impacted, and the delay in hearing aid adoption. As a result, adults with hearing loss significantly delay seeking treatment with hearing aids (Simpson et al., 2019). Using a hearing aid device mitigates the burden of hearing loss and can improve a person's psychosocial health and social communication abilities (Ravneberg and Söderström, 2017).

Much literature has focused on the influencing factors of hearing aid adoption. A host of factors include individuals' attitudes toward and trust in audiologists (Chang et al., 2020). Hearing sensitivity (Simpson et al., 2019), socioeconomic status (Simpson et al., 2019), and hearing loss may play a role when people decide to adopt hearing aids or not. In developing countries, such as China, there are some fundamental explanations beyond factors such as these. He et al. (2018) find that lack of knowledge and necessary information remains the main reason for not adopting hearing aids, based on a study of 1503 older adults in China. This finding is consistent with the situation experienced in developed countries, but it is much less significant (Davis et al., 2016; Hartley et al., 2010). But scholars rarely investigate stigmatization as a dynamic social process (Ruusuvuori et al., 2021).

3. HYPOTHESES DEVELOPMENT

Several factors determine whether a person will decide to accept and use a hearing aids device. Beyond cost, our qualitative results suggest three determinants that are especially relevant in influencing a person's decision about how and when to adopt new technologies (Davis, 1989; Moon and Kim, 2001). These factors are 'perceived usefulness' (PU), 'perceived ease of use' (PEOU), and 'perceived playfulness' (PP) (Chung and Tan, 2004; Moon and Kim, 2001). First, perceived usefulness captures how people believe that new technology will assist them in their daily lives or jobs. We propose that IoT may reduce the adverse effects of PEOU and increase individual motivation to seek and adopt a hearing aids device. For example, because of the increasing number of audiologists using online platforms, people prefer to make appointments to adopt hearing aids without making too much effort. Second, PEOU concerns the extent to which people believe a technology that might be useful to them can be used in a manner free from effort (Davis, 1989). We believe that ICT may strengthen PU's effects, which increases an individual's motivation to adopt a hearing aids device. For example, people can learn about hearing loss and hearing aids from online health communities (OHCs). As a result, people prefer to adopt hearing aids when they believe in their usefulness. Third, PP relates to how people believe that using new technology will be enjoyable (Moon and Kim, 2001). PU determines attitudes toward new technologies, whereas PEOU and PP function as secondary determinants. This paper applies this explorative thinking to hearing aids adoption and develops the following hypotheses.

3.1 Perceived Usefulness (PU)

As PU increases, we can assume that the user's attitude towards using a hearing aids device will become more positive and influence their intention to use this type of device. Previous research has also found that the items that make up this construct or factor fall into one of three categories or clusters (see Table 1). The first cluster (A in Table 1) is connected with job effectiveness, the next cluster (B) relates to productivity and time saving, and the third cluster (C) relates to the importance of the system (or technology) to one's job.

These items have been developed to research technology adoption; however, we assume that they apply equally well to technology usage in social settings, both of which will be experienced by a hearing aids user. Furthermore, some participants in our interviews said that they acquired knowledge about the benefits of using hearing aids from OHCs on their smartphones. Thus, they believe that the use of hearing aids can strengthen their quality of life (QoF). We, therefore, may hypothesize the following:

Hypothesis 1 (H1): PU has a positive relationship with the intention to adopt a hearing aid device in smart cities.

Table 1. Items in the Perceived Usefulness (PU) construct

Item	Cluster
Job difficult without	C
Job performance	A
Address my needs	C
Saves me time	B
Work more quickly	B
Critical to my job	C
Accomplish more work	B
Cut unproductive time	B
Effectiveness	A
Quality of work	A
Increase productivity	B
Makes job easier	C

Source: (Davis, 1989)

3.2 Perceived Ease of Use (PEOU)

In our study, PEOU relates to perceptions about how easy and convenient it is to fit the hearing aids device, how predictable the device will be when in use, the ease to which the functionality of the device can be recalled and applied, and how frustrating and confusing the device is to navigate. Consequently, we expect that the more an individual perceives that a hearing aid device will be difficult to use, the less likely it will be for them to have a positive attitude towards using it. Simultaneously, if a user has negative perceptions about ease of use, this may cause difficulty in identifying usefulness. Moreover, making an effort is a finite resource that an individual may need to complete different activities in life (Radner and Rothschild, 1975). All else being equal, an easy-use device is more likely to be accepted than those that are difficult to use. Again, prior research identifies various items that comprise PEOU, which fall into one of three clusters (Davis, 1989) (see Table 2). The first (A in Table 2) relates to physical effort, the second (B) to mental effort, and the third (C) to the support provided to the users, such as user manuals and other guidance. Furthermore, some participants of our exploratory interview said they could receive help from their family members, friends, or Online Health Communities if they do not know how to use and maintain a hearing aids device. Health service centers providing patients with a guide on the use of hearing aids as part of their care plan can also help patients adopt hearing aids and better fit (Kumar and Nidhya, 2021).

Based on this construct to hearing aids adoptions and on the assumption that higher PEOU values indicate perceptions of greater difficulty in use, we hypothesize as follows:

Hypothesis 2 (H2): PEOU has a positive relationship with the intention to adopt hearing aids in smart cities.

3.3 Perceived Playfulness (PP)

Beyond the extrinsic motives of PU and PEOU, PP has been argued as a fundamental intrinsic reason for technology usage (Chung and Tan, 2004; Moon and Kim, 2001). According to Moon and Kim (2001), PP is defined as how much a person feels that they are focused, curious, and feel enjoyment when interacting with the new technology. In other words, individuals are likely to use technology if they genuinely enjoy it. PP relates to how curious the user is in using a device, how focused their attention is, and how enjoyable the device is to use. One participant in our exploratory interview said that he hopes to enjoy using a hearing aids device in the future. Consequently, we expect that

Table 2. Items in the Perceived Ease of Use (PEOU) construct

Item	Cluster
Confusing	B
Frustrating	B
Dependence on manual	C
Mental effort	B
Rigid & Inflexible	A
Controllable	A
Cumbersome	A
Understandable	B
Ease of remembering	C
Provides guidance	C

Source: (Davis, 1989)

Table 3. Items in the Perceived Playfulness (PP) construct

Sub Category 1: Cognitive Aspects	Sub Category 2: Technology Characteristics
Individual Skills	Flexibility
Control	Experimentation
Challenge	Perceived Use Effectiveness
Focused Attention	Perceived Quality of Use
Playfulness	Feedback
Product Involvement	Variety
Curiosity	Technology Characteristics

Source: Chung and Tan (2004)

the more an individual perceives that a hearing aids device will be enjoyable to use, the more likely it will be for them to have a positive attitude towards using the product.

We apply this construct to hearing aids adoption. Assuming that higher PP values indicate perceptions of greater intention to use, we hypothesize as follows:

Hypothesis 3 (H3): PP has a positive effect on the intention to adopt hearing aids.

This study adopts the PLS-SEM framework to analyze the factors which affect behavioral intention toward adopting hearing aids in smart cities (see Fig. 1). Behavioral intention is associated with actual individual adoption (Weddle and Bettman, 1974). Therefore, we use behavioral intention as a dependent variable to investigate the actual adoption of hearing aids in smart cities.

4. METHOD

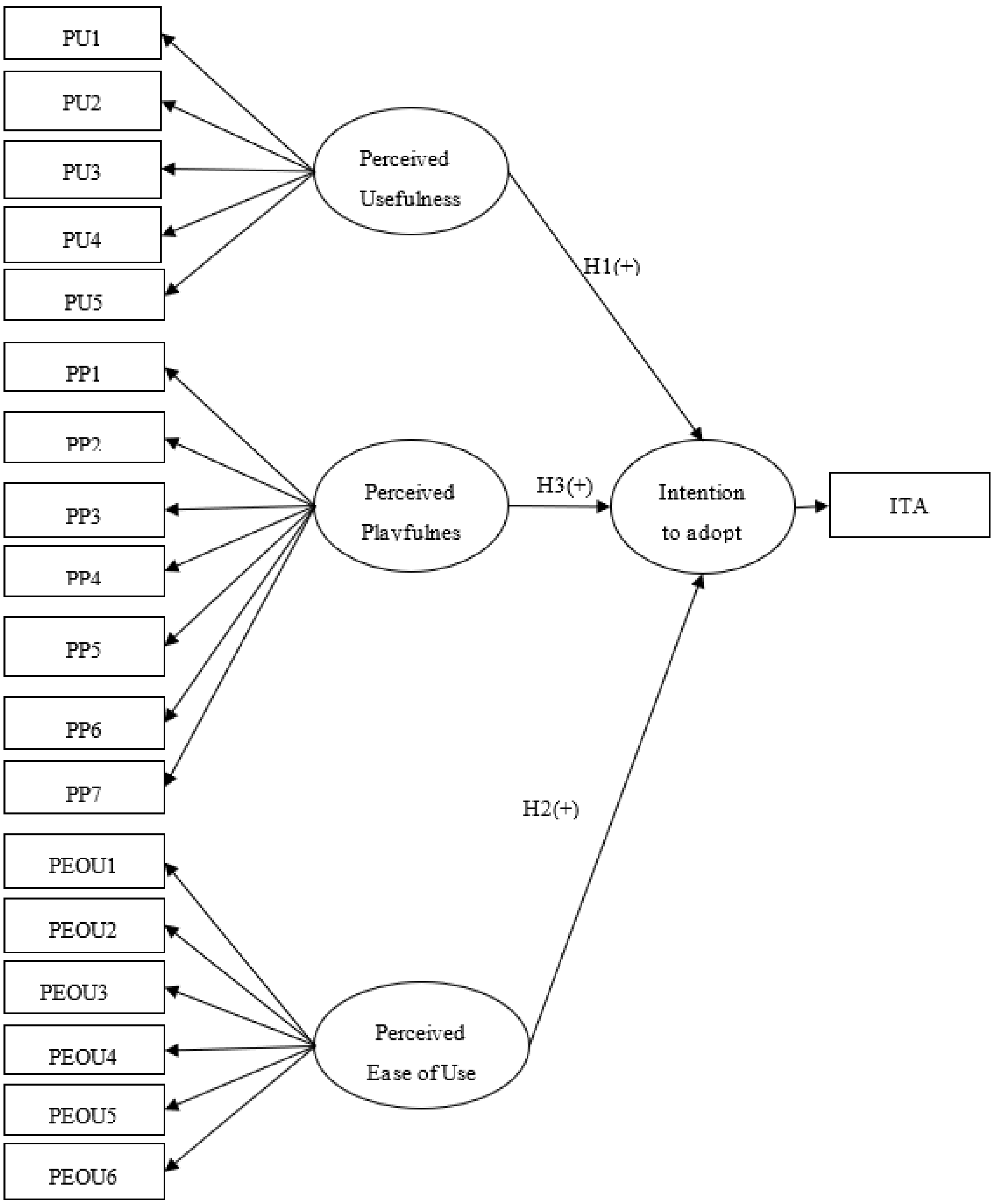
The methodology framework of our research is shown in Figure 2, which includes conducting an exploratory interview, identifying variables and developing a conceptual model, data collection and cleaning, exploratory data analysis, testing common method bias, measurement model assessment, structural model assessment and hypotheses testing.

In order to determine the appropriate variables and develop research hypotheses for our study, we first conducted an exploratory interview based on the literature reviewed, which was unstructured. In the exploratory interview, respondents were allowed to answer our pre-determined questions in their own way, which also allowed us to explore more information about their willingness to use hearing aids and to explore possible ways of collecting relevant data.

After conducting the interview, we identified the intrinsic and extrinsic constructs of consumers' behavioral intentions when adopting hearing aid devices. The extrinsic independent variables are 'Perceived Usefulness (PU)' and 'Perceived Ease of Use (PEOU)', and the intrinsic variable is 'Perceived Playfulness (PP)'. The dependent variable is 'Intention to adopt a hearing aid (ITA)'.

Secondly, to measure the latent variables, we design a survey that investigates participants' opinions on these topics in terms of the 5-Point Likert Scale. This study was approved by the Ethics Committee at the Xi'an Jiaotong-Liverpool University (XJTLU) and was based on standards of ethical practice for each participant. We designed an online survey in Sojump, which is a reputational data collection company in China. Snowball sampling, described in Bryman (2012), was used for the data collection. The reason for using this method is that the group of people experiencing hearing difficulties may have been difficult to contact due to relevant social stigmas. Moreover, people experiencing hearing difficulties generally have established social networks with others who have

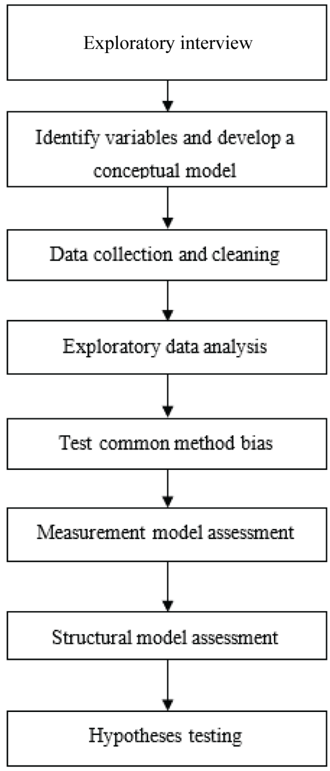
Figure 1. A conceptual model to investigate the behavioral intention to adopt hearing aids



similar problems. All participants were required to be at least 40 years old and have an age-related hearing loss (Cruickshanks et al. 1998). The survey asked participants to rank to what extent they agreed with the items of PU, PEOU, and PP, following the terminologies created in Davis (1989) and Chuang and Tan (2004). After data collection, we cleaned the dataset by removing the samples with missing values.

After that, we analyzed survey data with Exploratory factor analysis (EFA) (the third step) to obtain an understanding of the demographic features of the participants, as well as the distribution

Figure 2. Methodology framework



of the constructs and the correlations of the constructs. Through the EFA test, the constructs with factor loadings less than 0.5 will be removed from the analysis.

In this research, we employ the qualified components to construct the PLS-SEM model to measure the influence of intrinsic and extrinsic constructs on consumers' behavioral intention as they adopt hearing aid devices. In order to make sure that the data and the analysis results based on it are not affected by the common method bias, we carry out Harman's single factor test to test it in the fourth step.

In the fifth step, through the use of SmartPLS, the measurement model is assessed by evaluating its reliability using Cronbach's alpha and composite reliability (CR), and validity using average variance extracted (AVE) and the Fornell-Larcker criterion and heterotrait–monotrait (HTMT) ratio. In the sixth step, we evaluate the structural model through the multicollinearity assessment, model fit and predictive relevance of the model. Finally, we investigate the relationship between the intention to adopt a hearing aid and its antecedents and test the three hypotheses to identify the significant factors.

5. RESULTS

5.1 Demographic Feature of Samples

In total, we collected 187 responses used to evaluate our conceptual framework. After data cleaning, 12 samples with missing values were removed from the dataset and there are 175 samples left.

Sociodemographic variables include gender, age, annual income, working environment and education (See more details in Table 4.). Table 6 shows the details of demographics. 74.9% of respondents are under 60 years old. 55.4% of respondents have more than 30,000 RMB annual income.

5.2 Exploratory Factor Analysis (EFA) and Common Method Bias (CMB) Test

In order to test the hypotheses, first, exploratory factor analysis was used to investigate dimensionality. The factors are made clearer by using a principal component analysis (Fabrigar and Wegener, 2011). Significant variables are extracted from the original variables by employing varimax rotation (Russell, 2002). Finally, we used SPSS software to conduct the EFA, and a final result was found not including those items with loadings smaller than 0.5, as recommended by Hair et al. (2010).

When the first EFA was conducted, we found that instead of each item only appearing under one single factor, some items actually appeared under two different factors instead. One example of this is the item "Hearing aids can make life easy" which belonged to factor 1 and factor 4. This led us to conduct the EFA one more time, but with a limited number of factors, to three factors.

Table 5 shows the significant loading of all items for each factor. We attributed factor 1 as "PU", factor 2 as "PEOU", and factor 3 as "PP". Each of these factor loadings had a score greater than 0.5. The total variance of the 3-factor structure with the extracted factors is 58.117%.

For the purpose of avoiding the common method bias (CMB), which may undermine the validity of our results achieved by the PLS-SEM analysis in the next step, this study also carried out Harman's single factor test through factor analysis to evaluate this issue. The number of factors was restricted to one and if the factor's total variance is not greater than 50 percent, the CMB does not affect the

Table 4. Demographics in the quantitative study (N=175)

Demographics	Details	Percentage (%)
Gender	Male	54.9
	Female	45.1
Age	40-49	62.9
	50-59	12.0
	60-69	18.3
	70 and above	6.9
Education level	Middle school and below	35.4
	College	18.3
	Undergraduate	25.1
	Postgraduate and above	21.1
Annual income	20,000 and below RMB	32.0
	20,001-30,000 RMB	12.6
	30,001-40,000 RMB	12.0
	40,001 and above RMB	43.4
Working environment	Very quiet	9.7
	Quiet	52.0
	Very noisy	9.1
	Noisy	20.6
	Others	8.6

Table 5. The EFA loadings results

Variables	Measurement item	Varimax-rotated loadings factor		
		1	2	3
Perceived usefulness (PU)	PU1	0.785		
	PU2	0.661		
	PU3	0.593		
	PU4	0.568		
	PU5	0.542		
Perceived playfulness (PP)	PP1		0.789	
	PP2		0.770	
	PP3		0.740	
	PP4		0.726	
	PP5		0.654	
	PP6		0.532	
	PP7		0.500	
Percieved ease of use (PEOU)	PEOU1			0.759
	PEOU2			0.743
	PEOU3			0.685
	PEOU4			0.659
	PEOU5			0.651
	PEOU6			0.632

findings (Roni and Djajadikerta, 2021). According to Table 6, the factor's total variance is 39.31%, demonstrating that the analysis results in our study are free from the CMB.

5.3 Measurement Model Assessment

This study constructed the PLS-SEM model using SmartPLS 3.0. First of all, we assessed the measurement model by evaluating the reliability and validity of the latent variables. As shown in Table 7, the Cronbach's Alpha values of all variables are greater than 0.8, and the Composite Reliability values are all greater than the cut-off value of 0.6 (Bagozzi and Yi, 1988), which indicates high levels of internal consistency reliability among the reflective latent variables. The validity of the model was evaluated by the AVE and Discriminant Validity. As shown in Table 8, the values of AVE are all greater than 0.5, which demonstrates the convergent validity of the model. After that,

Table 6. Common method bias analysis

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.076	39.313	39.313	7.076	39.313	39.313
Extraction Method: Principal Component Analysis.						

Table 7. Measurement model analysis - Reliability

Variables	Reliability	
	Cronbach's Alpha	Composite Reliability
Intention to Adopt	1.000	1.000
Perceived Ease of Use	0.816	0.863
Perceived Playfulness	0.862	0.894
Perceived Usefulness	0.822	0.872

Table 8. Measurement model analysis - Validity

Variables	Convergent Validity	Discriminant Validity							
		Fornell-Larcker Criterion				Heterotrait-monotrait ratio of correlations			
	AVE	Intention to Use	PEoU	PP	PU	Intention to Use	PEoU	PP	PU
Intention to Adopt	1.000	1.000							
Perceived Ease of Use	0.514	0.245	0.717			0.249			
Perceived Playfulness	0.548	0.592	0.404	0.740		0.624	0.489		
Perceived Usefulness	0.581	0.369	0.493	0.732	0.762	0.372	0.622	0.844	

we used the Fornell-Larcker Criterion (Fornell and Larcker,1981) and the Heterotrait-monotrait ratio of correlations (HTMT) (Henseler et al.,2015) to check the discriminant validity of the model. The results show that the AVE value's square root is higher for every variable than other correlations among the variables, which confirms the discriminant validity. As Fornell-Larcker Criterion may not reliably detect discriminant validity problems, HTMT was employed as well in our study. According to Table 8, all the values are less than 0.9, confirming that discriminant validity is established in our model. In summary, the results in Table 7 and Table 8 indicate the reliability and validity of our model.

5.4 Structural Model Assessment and Hypothesis Testing

To measure the structural model, we first carried out a multicollinearity assessment to assess whether the collinearity problem exists among the variables. Variance Inflation Factor (VIF) values less than 5 indicate that a model is free from collinearity problems. According to Figure 3, the VIF values of all the measurement items are less than 3, which confirms that our model does not have a collinearity issue.

The "goodness of fit" of the model was measured by the values of SRMR, Normed Fit Index (NFI) and Stone-Geisser's (Q2) values. The acceptable value of SRMR is 0.1 suggested by Henseler et al. (2015). A lower SRMR value means a greater model fit, while a value of NFI greater than 0.9 implies a better model fit (Lohmöller,1989). Furthermore, a value of Q^2 greater than 0 confirms the predictive relevance of the inner model.

Table 9 summarises the values of the above indicators for our model. The results show that the three variables, Perceived Ease of Use, Perceived Playfulness and Perceived Usefulness, together explain 36.1% of Intention to Use. Although the value of NFI is less than 0.9 (0.725), the value of SRMR is less than 0.1(0.095), and the value of Q^2 is greater than 0 (0.323), which indicates the "goodness of fit" of the model and the predictive relevance of the model, respectively.

Table 10 reports the results and shows that PU (-0.159) and PP (0.691) significantly influence the uptake and use of hearing aids at a 10% level and a 5% level, respectively. Hearing aids adoption is function-based. As a result, the consideration of PU is a priority. Surprisingly, perceived playfulness

Figure 3. VIF values

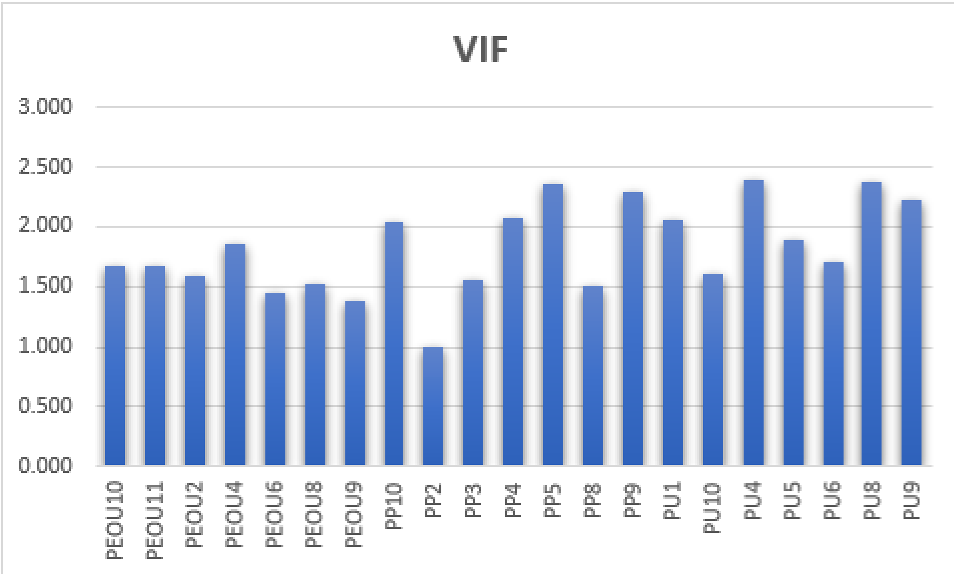


Table 9. Structure model analysis

Model	R^2	SRMR	NFI	Q^2
Intention to adopt	0.361	0.095	0.725	0.323

Table 10. Hypothesis testing results

Path	Coefficient (β)	P-values
Perceived Ease of Use -> Intention to Adopt	0.044	0.49
Perceived Playfulness -> Intention to Adopt	0.691	0
Perceived Usefulness -> Intention to Adopt	-0.159	0.059 (significant at 10% level)

plays a more critical role in consumer behavior intention with technological development. Interestingly, hearing aids adoption was not considerably affected by PEOU, meaning that PEOU does not produce significant effects on people's intention to adopt hearing aid devices.

6. DISCUSSION

This study employed PLST-SEM analysis by including PP, PU and PEOU as principal determinants of the intention of hearing aids adoption. Our model can explain 36.1% of the variance of the decision to take up hearing aids.

PU is significant at a 90% confidence interval but with an unexpected sign. Generally, PU has been found that it is one of the main factors that positively influence consumers' intention to adopt information technology (Dutot, Bhatiasevi, Bellallahom., 2019; Rauschnabel et al., 2016). Healthcare devices are especially perceived to be beneficial in improving consumers' health or quality of life

(Kim and Chiu, 2019). However, we found that our result is not consistent with existing literature. Several reasons may explain this finding. First, extensive research on the stigma leads to avoidance of hearing aids adoption. Hearing-disabled consumers can communicate with others much more comfortably by wearing a hearing aids device, but they have to reveal their disability due to the aiding device's visibility. Hence, product development and design should consider people's self-esteem when wearing the devices. Such concerns are more relevant for adolescents, such as adolescents (Kent and Smith, 2006; Van Vliet, 2005). Ellington and Lim (2013) argue that fashion has become an essential parameter in the lives of people with disabilities. Based on a sample of adolescents, they found that the adolescents wearing hearing devices understood the importance of the devices' functionality but were still influenced and embarrassed by others' perceptions, which in turn "resulted in a higher level of self-esteem" (p.16). Hence, if the devices have an atypical shape, are small and invisible, or are designed to be aesthetically pleasing, they may have a higher possibility of being adopted and perceived as hearing aid useful for improving their life quality (Burton, 2009).

Furthermore, until recently, hearing aid devices are still often associated with the elderly population and weakened cognitive competence (David and Werner, 2016; Ruusuvuori et al., 2021). This suggests that assistive hearing technologies should focus on the needs of adolescents, working-age people, and some professionals who have difficulties accepting such aids in their daily working environment. With these arguments, it is not difficult to understand, as Ng and Loke (2015) discuss, why digital signal processing technology while replacing the traditional amplification technology, has not increased hearing aids adoption since 1996. Not surprisingly, the authors suggest that non-audiological determinants, such as PP, subjectively perceived hearing problems, and satisfaction, matter more.

The significance of PP is the main finding of our study. In the computer case, computer playfulness is defined by Venkatesh (2000) as the amount of cognitive spontaneity that is present in microcomputer interactions. Perceived playfulness can be meaningful: (i) to explain the importance of intrinsic motivation for individual behavioral intention; or (ii) to reveal the individual behavioral change in smart cities. The ICT sector development enables people to make appointments with audiologists and order hearing aids online more quickly. As Ng and Loke (2015) point out, audiological technology progress matters less than non-audiological elements for adopting hearing aids. Stigmatization avoidance is becoming more feasible with general smart technological progress. McMullan et al. (2018) report that hearing aids self-efficacy and utility performance can be improved using appropriate user guides, which, for instance, are more readable and communicative. Furthermore, while seeking hearing aids, many people find it more enjoyable to interact with audiologists through OHCs. Importantly, our results highlight that PP is assigned a high degree of attention by people when they intend to adopt and use a hearing aids device in China's smart cities. This finding is along with the finding from our explorative interviews. For example, interviewees with high education levels reported PP as an incredibly important factor when adopting hearing aids. The urban high-education people with high income perceived using a hearing aids device to be enjoyable. This group of people is not satisfied with the usefulness of hearing aids, and they seek to enjoy being able to adopt hearing devices in smart cities. This opinion is consistent with the study of Lee and Gefen (2020), which considers education as a social determinant of health (SDOH) and can influence the quality of life.

Meanwhile, perceived ease of use does not significantly influence consumers' behavioral intention for adopting a hearing aids device in smart cities of China. This result represents a difference from the previous research where PEOU strongly relates to technology adoption (Davis, 1989; Venkatesh et al., 2003; Gefen and Straub, 2000). It suggests that smart technologies can reduce the significance of PEOU on the individual behavioral intention to adopt hearing aids by reducing stigma problems (see further examples in e.g. Wildenbos et al. 2019). In this study, over 70% of the respondents were below 60 years old. Nearly all of them can use smartphones and search for information from OHCs or reach professional consulting anonymously online. This may explain why PEOU does not significantly relate to individual behavioral intention for adopting a hearing aids device under a smartization context.

Our results suggest that social-economic variables do not influence consumers' decisions on whether or not to adopt hearing aids. Age and gender do not significantly influence hearing aids adoption, which was also found to be the case in previous studies (Hickson et al., 2014; Helvik et al., 2009; Humphrey et al., 1981; Lupsakko et al., 2005; Norman et al. 1994; Stark and Hickson, 2004;). Annual income, work environment, and education were also found not significantly influence hearing aids adoption (Helvik et al. 2009; Humphrey et al. 1981; Lupsakko et al. 2005). The logic may be straightforward since the adaption of hearing aids originates from overcoming hearing loss, which does not depend on other demographical factors.

7. CONCLUSION

This research explored the intrinsic and extrinsic factors that affected the behavioral intentions of adults aged 40 and over (especially most of them are working-age people) for adopting hearing aid devices and was based in smart cities in China. We employed the PLS-SEM analysis to examine the factors affecting individual behavioral intentions in smart cities. We found that PU and PP had a significant impact on consumers' behavioral intention to adopt a hearing aids device. Specifically, people intend to adopt a hearing aids device when they believe that: it is enjoyable to use hearables. Interestingly, the perceived effort of use was not significantly linked with individuals' decisions to use a hearing aids device. This implies that smart technologies could significantly reduce the barriers to hearing aids adoption.

For research contributions, this study demonstrated how the individual behavioral intention for hearable adoption changed in smart cities and how smart technologies improve people's quality of life with hearing loss by providing playfulness and reducing stigmatization. From a global information management perspective, the significance of perceived playfulness found in this study validates that users or potential customers of smart technologies are no longer satisfied with just usefulness and ease of use, but are beginning to focus on playfulness. Especially in smart cities, users are more open to new technology that satisfies their curiosity and makes them feel enjoyment when interacting with it. With the development of smart technology, more and more cities are becoming intelligent and the adaption of new technology is no longer a difficult task for people living in this era. Therefore, companies producing modern hearing aids, aware of the practicality and convenience of the devices, should turn their attention to the appearance of the devices and the variety of features to satisfy people's quest for fun.

Smart technologies also enable the accessibility of other high-tech functions (like smart music and smart translation) through hearing aids. Our model is suitable for studying consumers' behavioral intention for adopting hearing aids devices and understanding the factors and reasons behind it. The PLS-SEM model is used to measure the influence of intrinsic and extrinsic constructs on consumers' behavioral intentions. Significant variables are extracted from the original variables by employing varimax rotation professional services and reducing the barriers to hearing aids adoption. For example, internet technologies enable individuals to exchange information on hearing aids, treatment options for hearing loss, and hearing aids quality options. This study does not focus on specific smart technologies and cannot provide insights into how people react to the technologies in a concrete scenario. In addition, due to time constraints, we conducted the survey online. However, some people over 65 years of age may not use the Internet regularly. This factor contributed to the small size of our data set. In future research, we may conduct the survey offline by cooperating with communities that are mass-based institutions in China's cities. Moreover, future research may build a behavioral model looking at technological variables and individual behavioral intentions and contribute interactive perspectives to existing models and policymaking.

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