Research investigations on the Use or Non-Use of Hearing Aids in the Smart Cities

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Abstract

This study aims to explore factors influencing behavioral intention to adopt hearing aids among old adults in smart cities. It argues that trust is a moderator to influence the relationship between attitude, subjective norm and individual's behavioral intention in smart cities. This study tests hypotheses using a sample of 103 respondents from six smart cities in China. The results reveal that attitude is main factor influencing individual's behavioral intention. Subjective norm and trust are both not statistically significant at the 95% confidence interval in the model of multiple-regression. Interestingly, it finds that trust moderates the relationship between subjective norm and individual's behavioral intention. It means that the audiologists' advice can positively affect person's behavioral intention in smart cities. The findings imply that the Theory of Reasoned Action can be partially used to explain the person's behavioral intention in Chinese context. This study contributes to encourage old people to use smart hospitals to consult audiologists about hearing loss and hearing aids rehabilitation. Hence, hearing aids can improve their quality of life (QoL), which can be reflected by the improved standard of living, better access to treatments and also the positive sentiment about their life, including comfort, friendship, happiness and a closer connection to the society.

Keywords: hearing aids; hearing aids in smart cities; measurement of older generation's quality of life in smart cities

1. Introduction

Age-related hearing loss is a progressive hearing loss among old adults (SNHL; ISO, 2000). It typically begins at 40 years old but sharply rises at ages above 80 years (Cruickshanks et al., 1998). World Health Organization (WHO) defined that hearing loss greater than 40 dB HL between two ears means significant hearing loss (WHO: Deafness and hearing loss, 2015). Depending on this definition, almost 30% of people aged 65 and over are influenced by a significant hearing loss (WHO: Prevention of blindness and deafness: Estimates, 2012). The severe prevalence regions are in Asia Pacific, South Asia and Sub-Saharan Africa, but are declining while incomes have increased (WHO: Mortality and burden of diseases, 2012). Age-related hearing loss is in top of 15 leading burden diseases by 2030 (Mahers and Loncar, 2006). It not only can cause issue of social engagement, social linguistic communication, mental health, activities limit and quality of life (Brink and Stones, 2007). It also influences people's successful aging (Wahl et al., 2013), healthy aging (Lustig & Olson, 2014) and productive aging. Additionally, hearing aids support technology and is a high-tech wearable device connected to online healthcare services (Wright and Keith, 2014). This allows users to have access to services such as hospitals, doctors and medical check-up. On the hearing aid devices, users' status of hearing and conditions of their hearing abilities can be measured in real-life. Hospitals can also track patients' hearing conditions and check their status of improvement when given the permission to do so. Smart wearable technology can transform the life of older generations in the smart cities. However, the proportion of wearing hearing aids adoption is still low. Only 23% of older Australians do not use hearing aids while 21% of them own hearing aids. Earlier studies have explored the factors that influence behavioral intention to adopt hearing aids or lower proportion of wearing hearing aids (Cobelli et al., 2014; Tomita et al., 2001). However, a great extent of literatures focuses on the foreign context and traditional ways to uptake and use hearing aids.

This study is related to smart cities, since users can get connected to the internet and access to online healthcare services via technology-oriented hearing aids. There are currently 100 millions of older people live in smart cities in China. To further explain the relevance to smart cities, Section 2 presents literature review based on technological backgrounds. Section 3 describes different theoretical models. Section 4 narrates hypotheses for the proposed conceptual mode. Section 5 explains the methodology including data collection and research method, as well as results and analysis. Section 6 sums up Discussion and Section 7 presents Conclusion and Future work.

2. Literature review and Related Work

Literature on Internet of Things (IoT), smart cities and their relation to hearing aids will be presented in this section. Based on the literature, we have proposed a three-layered framework to explain relationships, interconnections and dependencies between IoT, smart cities and hearing aids well.

2.1 Internet of Things (IoT)

The Internet of Things (IoT) is a network (wired or wireless) of smart and connected devices to collect data and communicate between devices and people in real time (Mital et al., 2017). "IoT" and "Smart" are terms used to describe that sensors can collect, monitor and control data from physical world into internet (Narm and Pardo, 2011).

The internet of things (IoT) technologies have strongly influenced the development of the feasibility of smart cities (Hashem et al., 2016). IoT allows the sensors and devices to be connected with real-world living in a smart environment. Several applications have been released, such as smart healthcare (Demirkan, 2013), smart transportation (Adeli and Jiang, 2009), smart grids (Chen et al., 2009) and smart whether (Fan & Bifet, 2013). The emerging technologies including wireless sensor networks (WSN) has reduced cost of smart cities. Smart cities have an amount of improvements compared with traditional cities. Such as governance, quality of life of citizen, intelligent management of natural resources and city public facilities (Al Nuaimi et al., 2015). A growing challenge is a large amount of data produced by computers, mobile phone sensors and global positioning systems (GPS). However, big data analytics has been employed to deal with generating information and enhance the development of smart environment (Al Nuaimi et al., 2015; Chang, 2017).

2.2 Smart cities

Smart cities have been defined as cities built on information and communication technologies, such as sensors and computing science, in order to improve citizens' quality of life. Private companies like IBM and Siemens, as well as governments have paid high attention to smart cities (M. Dohler et al., 2013). Amsterdam has set up smart cities which have living, working, mobility and public spaces to save energy costs and reduce the emissions of CO_2 (Solanas et al., 2014).

- **Electronic health (E-Health)**

Electronic health combines the computers, sensors, big data analysis and business together to help people suffering from diseases and reduce the cost of rehabilitation through preventing and monitoring technologies (Eysenbach, 2001). Information and communication technologies (ICT) is foundation for e-health. It has changed the traditional relationship between patients and physicians. For example, homecare, remote support to electronic diagnostic medical records, distant care and so on (Solanas et al., 2014). However, the use of mobile devices has started a big revolution. More mobile communication devices have provided more streaming data for data analysis.

- **Mobile health (M-Heath)**

Mobile health has been defined as part of e-health, since it requires using mobile communications and network technologies for healthcare systems (Istepanian et al., 2006). M-health has supplied an easy access to a number of services and user-oriented platform. It extends and strengthens the capabilities of indoor monitoring and early detection of emergency situations and abnormal situations and changes in health conditions as well.

Smart hospitals (S-Hospital)

Smart hospitals based on the old interactive environment with inserting high-end ubiquitous devices (M. Dohler et al., 2013). It has been developed by large companies including Siemens, IBM and Google, etc. it is addressed to solve the cost issues on healthcare. However, it just focuses on the efficiency of hospital for citizens instead of whole efficient usefulness of society's resources.

- **Smart health (S-health)**

The definition of smart health can be considered as a combination of m-health with the sensing capabilities of smart cities (Solanas et al., 2014). The differences between m-health and s-health are based on information sources and information flows. The data of m-health can be taken from patients, whereas the data of s-health can be extracted from the government's data sources. Moreover, m-health tends to adopt a user-oriented model. S-health is considered as a city-oriented model.

2.3 Hearing aids

China's population aged 65 and over stood at 9.5% in 2000 and rose to 16.5% in 2015 and 25.6% in 2050 (WHO,2015). It has been predicted that the total number of elderly people in China will increase to 332 million

in 2050 from 110 million in 2010 (WHO, 2015). The development of senior society will produce a great deal of requirement for public healthcare and hospitals. Thus, through smart interaction by using information communication technology (ICT) will provide a sustainable environment and a good quality of life (Solanas et al., 2014). Hearing loss is one of the most prevalent age-related chronic diseases (Kiely et al., 2012). Hearing difficulties, however, can be minimized by the use of hearing aids (Mantello et al., 2016). Cox &Alexander (2002) have found that hearing aids could improve hearing-related activity limitations and social participation restrictions. Smart cities could help people to uptake hearing aids (Solanas et al., 2014). About 'smart' area has been explored by academics, such as smart cities (Hashem, I. A. T et al, 2016), smart hospitals (M. Dohler et al., 2013), smart health (Sonas et al., 2014), electronic health (E-health) (Eysenbach, 2001), mobile health (Istepanian et al., 2006).

This prepared study aims to explore the factors influencing individual behavioral intention to adopt hearing aids in smart cities. Some expected contributions are shown as follows. First, it will be one of the first academic studies to investigate the factors that affect consumers' intention to adopt hearing aids in smart cities. Second, it will contribute to the gerontechnology healthcare, as China has entered into the aging society in 2000 and the population of aging hearing loss is increasing sharply. Thus, the aging healthcare is becoming more and more important. Third, the results of research will generate some policy implications about building smart healthcare and smart cities as well. That is because aging society has become both a social phenomenon and a social issue. Improving the quality of life of aging people is the key element for gerontology. Moreover, smart health supplies a convenient platform for hearing aids uptakes and uses among older population. This platform will combine smart hospitals, smart transportation, smart logistics and smart government together. Therefore, this paper is going to focus on exploring the deep factors that can influence the intention of adoption of hearing aids in smart cities.

2.4 Related work bases on our synthesis of literature review

Fig.1 illustrates the three-layered IoT-based e-health conceptual model of hearing aids adoption in smart cities. The foundation is "Big Data" to provide adequate data sources. This can be further achieved by the development of IoT, which provides platforms to collect different type of data through wireless sensors. Data may include healthcare data for hospital, education data for school, financial data for business transactions, weather data and some government data for the public and transportation for traffics. Smart cities are on the second layer,

since not all of the data can be directly used. It needs intelligent functions and algorithms to process and synthesize data, including further processing and analysis of data for better functions for the city. For example, medical services can link to patients' records, so that regardless of which hospitals that patients visit, doctors can see the historical medical records and make better judgement in their diagnosis. Patients can also get specific time for the appointments. On top of that, they can see their appointment queues live from their smart phones and reduce their waiting time before seeing doctors and reduce the obstacles of help seek of hearing loss, especially the people who live in the rural area. The distance between cities and rural areas in China can be above 500 kilometers which can be difficult for older generations with physical difficulties. In another example related to smart transportation, residents can know where traffic congestions happen and divert to the routes with better traffic or book tickets on the smart phone in order to reduce cost-effectiveness of hearing aids uptake. Both services linked to smart transportation and booking can be checked and seen live on their smart phones' apps. Additionally, citizens can also get their services (medical reimbursement, ID and so on) done by the smart government services, so that they need not go in person and smart government can reduce the obstacles of hearing aids use and encourage people to seek help and use hearing aids.
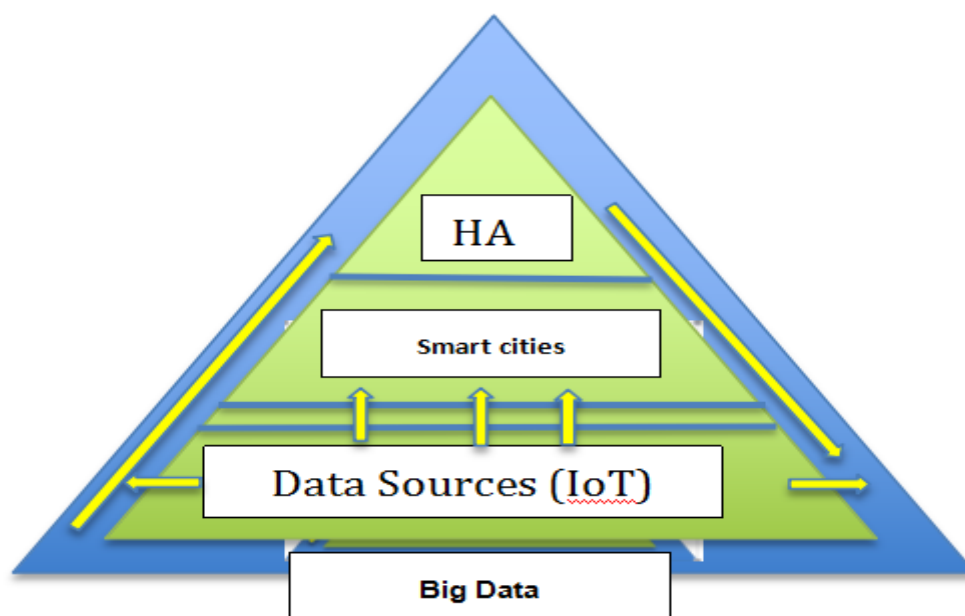

Fig.1 IoT-based E-health conceptual model of hearing aids adoption in smart cities

The top layer in Fig. 1 is the hearing aids adoption, which takes smart hospitals, smart health, smart logistics

and e-government services together, explained as follows. First, users of hearing aids can get their hearing checkups diagnosed in hospitals, to see whether they require hearing aids, and what kinds of hearing aid devices and services to meet their needs. Second, smart hospitals provide checkups and events suited to patients' needs at special prices and intention to improve their quality of life (QoL). Third, patients can get their live health data such as the hearing ability, eye sights, heart beats, blood pressure and other core health data on type. Hearing aid devices can be adapted for different types of hearing requirements and environmental changes. At the noisy cities, hearing aid devices can automatically adjust to the lower volume. If patients require a higher level of concentration in their work, then it can automatically adjust to the higher volume. Fourth, the government can work closely with hospitals and patients to understand their needs and provide instant medical services when patients need urgent medical services or treatments. Doctors can have live appointments through teleconferencing. Depending on the conditions and treatments, government can use either social welfare or insurance to cover parts or most of the medical expenses. Therefore, this three-layer framework has explained the relationships, interconnections and dependencies between IoT, smart cities and hearing aids well.

2.5 IoT in China

Apart from smart cities, IoT in China has been focused on 1) transportation with smart cars, 2) mobile payment and 3) artificial intelligence with robots. For the first area, there are developments of driverless cars. They have thousands of sensors embedded in each car. All the real-time data can be received through sensors. All the cars can detect movements of other cars on the road and decide for the best actions (Surden and Williams, 2016). Driverless cars have been in production for express delivery industry, which have a rapid growth in China. Additionally, smart transportation can also help improve the extents of accuracy to reduce errors caused by automated driverless cars.

Mobile payment in China has been growing rapidly. Alipay is a trusted third party payment vendor that blends business-to-business (B-to-B), business-to-consumer (B-to-C), consumer-to-business (C-to-B) and consumer-to-consumer (C-to-C) sales. Particularly in C-to-C sales, billions on transactions can happen in China on daily basis. Customers can pay goods and services via scanning QR code, in which money can be transferred from the sender's bank account to the recipient's bank account (Turban et al., 2018). Security is based on personal identity to the bank and Alipay and password authentication. IoT can provide fast and reliable networks, so that transactions can be completed within a few seconds. This has been very popular in China that a high majority of people have paid goods and services via Alipay, wechat and other trusted third parties.

Artificial intelligence (AI) has been growing its popularity in China as it can work with driverless cars, mobile payment (facial recognition), business intelligence and robotics. Manufacturers in China have used robots extensively to improve the efficiency of production, including the cars, smart phones and electronic products (Wu et al., 2015). Mr. Tai Ming Kuo, a Taiwanese CEO from Foxconn has used robots with AI intelligence extensively in China to rapidly increase productions for iPhone, iPad and Macbooks for Apple, since Foxconn is the largest manufacturer for the Apple company. IoT can get all robots and systems to connect, communicate and streamline their work together. If robots with AIs are the "brain", and then IoT is similar to neurons that can connect different parts of the body (different units in Foxccon) and the brain together. However, these three different ways of adopting and blending IoT for better quality of work is not the focus of this paper. Nevertheless, IoT has made significant impacts to the development of smart cities and related areas in China to help her on the way up rapidly in the last few years.

3. Theoretical Background: Theories for research of technological adoption

In this section, seven different types of theories for technological adoption will be presented. Critical evaluation will be given to justify the choice of our approach.

3.1 Theory of Planned Behavior (TPB)

Ajzen (1985) extended TRA (Fishbein and Ajzen, 1975) to explain the conditions where a person does not have complete control for usage of behavior. Behavior is determined by behavioral intention and perceived behavioral control. Behavioral intention includes attitude, which reveals the perceived feelings for performing an action; subjective norm, which reveals the referents influencing the person's performing an action; perceived behavioral control, which reveals the internal and external constraints on a person's behavior (Ajzen, 1985). Furthermore, perceived behavioral control embraces two components. The first one is "facilitating conditions" (Traindis, 1979), which reflects the capability of resources needed to be invested into a behavior, for example, money, time or other social resources. The second one is "self-efficacy" (Bandura, 1982), which is a reflection of self-confidence on a performing behavior. Those three determinants have been tested in different studies. Attitude performs on behavior to lead to a certain outcome. Subjective norm, to some extent, is not clear as a determinant to study

the usage of IT. For example, Davis et al (1989) did not find a significant relation between IT usage and subjective norm. Subjective norm indeed had a significant relationship with behavioral intention in the study of organizational settings and self-report usage of IT (Hartwick and Barki, 1994; Moore and Benbasat 1993). Perceived behavioral control may be a direct and indirect important factor in the study of IT. Perceived behavioral control has directly been found to have a significant relationship with behavior (Mathieson, 1991). In an indirect test, Moor and Benbasat (1993) revealed that perceived voluntariness was significantly related with usage. Some tests have proved that the Theory of Planned Behavior has a significant advantage than the Theory of Reasoned Action. For example, Hagger, Chatzisarantis and Biddle (2002) examined the goodness of behavioral intention through using TRA and TPB model to predict behavioral intention, found that TPB model can predict a variance of 44.5% instead of 37.27% in TRA. Although, TPB can explain some uncompleted control behavioral intentions, to some extent, TPB cannot be employed to predict the organizational technology usage in IT and smart cities.

3.2 Technology Acceptance Model (TAM)

Davis et al. (1989) created The Technology Acceptance Model (TAM), which is similar with self-efficacy theory (Bandura's, 1982), to explain the behavioral intention for technology acceptance and IT usage. In the TAM, usage behavior, which is different from the definition of usage behavior in the TPB, is constructed as a direct function of behavioral intention. Behavioral intention includes two constructors, namely perceived usefulness and attitude, which is determined by perceived usefulness and perceived ease of use. Perceived usefulness means a person believes that using a particular technology can enhance his or her performance and can help them perform better on the job (Davis et al, 1989). Perceived ease of use means a person believes that using a technology can free the effort, in other words, technology is useful and easier to use (Davis et al, 1989). Direct and indirect effects of perceived ease of use and perceived usefulness affect the personal behavioral intention (Taylor, 1995). TAM is considered as a special case of TRA with two determinants for attitude without considering subjective norm and the influence of social control factors on behavior. As Davis et al. (1989) found there was no significant relationship between subjective norm and behavioral intention in a study of IT. Thus, people positively intend to use the technology since it is easier to use and more useful as it is perceived to be (Taylor and Todd, 1995). TAM has been used to predict the usage intention in many studies. Taylor (1995) compared TPB, decomposed TPB and TAM in order to understand which model can be used to forecast intention to use of information technology and revealed that TAM performed well in terms of ability to explain behavior. Davis et

al. (1989) revealed that TAM was better than TRA in terms of predicting software usage intention. Mathieson (1991) found that TAM could predict the usage intention of spreadsheet package better than TPB. However, TAM is limited to predict the self-reported behavior (Taylor and Todd, 1995).

3.3 Unified Theory of Acceptance and Use of Technology (UTAUT1)

Venkatesh and Morris (2003) developed the model - Unified Theory of Acceptance and Use of Technology (UTAUT1) to analyze and predict the behavioral intention of employee technology acceptance in the organizational context. The first version of UTAUT includes four constructs such as performance expectancy, effort expectancy, social influence and facilitating conditions. Performance expectancy is defined as the degree of getting benefits from performing certain activities; effort expectancy is defined as the degree of using it technology easily or not; social influence is defined as the degree of the norms influencing usage behavior from the referents who is treated as important people for employee; facilitating conditions is a term defining the degree of perceived resources to support to perform certain behaviors (Venkatesh et al, 2003). "Technology use" can then be determined by behavioral intention and facilitating conditions. Behavioral intention has three variables, namely performance expectancy, effort expectancy and social influence. Age, gender and experience are to moderate the relationship between variables and behavioral intention as well as usage. UTAUT1 has been applied to study a great deal of technology acceptance in the organizational and non-organizational context (Venkatesh et al, 2003). Especially, some academics have used the UTAUT1 to study health information systems (Chang et al., 2007) and new cultural settings in China (Gupta et al., 2008). However, Sofega and Llamas (2009) mentioned that UTAUT1 maybe not be extended to other contexts, such as consumer technology acceptance.

3.4 Unified Theory of Acceptance and Use of Technology (UTAUT2)

Venkatesh et al (2012) added three constructs, which embrace hedonic motivation, price value and experience and habit, into UTAUT1 and used seven constructs to explain the human behavioral intention and technology usage in a consumer technology use context. Hedonic motivation is defined as the playfulness from adopting technology and is a key factor to predict consumer behaviors from the point of intrinsic aspects (Holbrook and Hirschman, 1982). The main difference between consumer technology use context in the UTAUT2 and organizational technology acceptance in the UTAUT1 is price value. Consumer bears the monetary cost whereas employees do not and also play an important role in predicting consumer technology acceptance

(Venkatesh et al., 2012), for example, Chan et al. (2008) found evidence that Chinese consumer prefers short message service (SMS) as it is cheaper compared with other mobile application; Experience and habit have been proven to be important variables to predict technology use in the consumer technology use context (Kim and Malhotra, 2005; Kim et al., 2005). In addition, there are several moderated factors including age, gender and experience. Lee et al. (2010) found that age, gender and experience moderated the innovativeness, which is similar with hedonic motivation. Bakan (1996) found women pay more attention to details including price than man. Venkatesh et al. (2012) found that older woman will be more sensitive on the price because their social roles in the family. Older people are likely to do automatic process's job instead of learning new knowledge (Hasher and Zacks, 1979; Jennings and Jacoby, 1993). However, UTAUT2 is limited to be used to study older objective group, as the mean age of their study was around 31 years old (Venkatesh et al., 2012).

3.5 Senior Technology Acceptance Model (STAM)

Chen and Chan (2011) used TAM to test the technology acceptance among old adults in Hong Kong and found that behavioral intention to adopt gerontechnology only can be predicted by age, education, gender, monthly income, health satisfaction, movement ability and social activities, whereas perceived usefulness, perceived ease of use and attitude towards usage were not significant to predict behavioral intention in three models. Thus, they depended on a qualitative study and combined TAM with UTAUT2 to develop another important theory called Senior Technology Acceptance Model (STAM), which includes more factors except perceived usefulness and perceived ease of use, such as gerontechnology self-efficacy, anxiety, facilitating conditions, self-reported health conditions, cognitive ability, social relationships, attitude to life and satisfaction and physical functioning, to explain the technology adoption in old adults in Hong Kong. The behavioral intention is determined by perceived usefulness, perceived ease of use and usage behavior. This model is more adaptable to explain the behavior on technology acceptance among old adults. However, STAM did not reflect the intrinsic motivation to influence the behavioral intention. Harter (1978) acknowledged that playful, curious and active states, even in the absence of rewords, still can support people to persist on the activities chosen by them even without perceived usefulness and perceived ease of use.

3.6 Self-Determination Theory (SDT)

Self-Determination Theory (SDT) is derived from psychology that explains people's motivation that employs extrinsic methods while combining the importance of human's evolved inner aspects for self-regulation (Ryan

and Deci, 1997). SDT includes two types of motivation, namely extrinsic motivation and intrinsic motivation. Extrinsic motivation means people make decision for a purpose. Intrinsic motivation means people do an activity for fun and enjoyable. Innate psychological needs which facilitate the natural optimal functioning of integration, as well as construct well-being and social development are competence, autonomy and relatedness (Ryan and Deci, 2000). SDT highlights that playfulness is one of the key intrinsic motivations in the absence of extrinsic rewards (Harter, 1978). Overall, SDT is normally used to research on-line shopping consumer's behavior, it is not reasonable to be used to study the adoption of hearing aids among old people.

3.7 The Theory of Reasoned Action (TRA)

TRA has been widely used to explain consciously individual's behavioral intention (Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975). To do this, TRA can highlight that behavioral intention to be driven by: (i) attitude, which is a person's performing feeling of behavior (Fishbein&Ajzen, 1975), and (ii) subjective norm, which is an individual's perception that others' opinion and thinking may influence their performing (Fishbein and Ajzen, 1975). According to TRA, attitudes are determined by salient beliefs about consciously performing behavior and external stimuli influence only affects the attitude toward a behavior through changing individual's beliefs (Ajzen and Fishbein, 1980); subjective norms normally functions by his or her normative beliefs. Thus, the researchers must identify the beliefs including nine types that are salient for subjects in terms of behavior under investigation (Davis, Bagozzi and Warshaw, 1986). Moreover, TRA has been applied to study a variety of subject areas, such as social psychology (Bagozzi, 1981), technology acceptance (Warshaw, 1980a) and health care (Cobelli et al., 2014). For example, Cobelli et al (2014) has used it to explain factors that influence behavioral intention of adoption of hearing aids in Italian old adults and found that trust between audiology and patients can increase the adoption of hearing aids in Italy. Overall, this study will use TRA model to investigate the consumer behavior on hearing aids adoption in the smart cities.

4. Hypotheses

This paper is aimed at identifying factors influencing hearing aids adoption among old adults in smart cities of China. To address this, research question is set as follows. Fig. 2 shows the conceptual model of hearing aids adoption in the smart cities.

RQ: What are the factors that influence the hearing aids adoption among old adults in smart cities of China?

4.1 Attitude

Attitude is one of the drivers in the theory of reasoned action has been successfully applied to predict the behavior in the health sector (Clarke and Aish, 2002). Attitude is significantly positively related with hearing aid uses (Gatehouse, 1994). In addition, Brooks and Hallam (1998) also showed that a person's attitude for hearing aids positively associated with hearing aid uses later. However, Jerram and Purdy (2001) did not find significant association between attitude toward hearing aid uptakes and use when they evaluated 10 weeks after hearing aid fitting. In summary, the majority of studies found that positive impact on attitude towards hearing aid uses. Just small studies addressed that there is no relationship between attitude and hearing aid uptake. There is no study to claim a negative relationship (Knudsen et al., 2010). Moreover, counseling in the period of post hearing aids fitting is important to enhance the hearing aid use. Eriksson-Mangold et al. (1990) conducted a hearing aid fitting program for 10 months in a Hearing Center by visiting those with post hearing aid fitting, they found that higher hearing aid uses in the visited group than non-visited group. This study developed the same hypothesis.

H1: A person's attitude towards hearing aid uptake and use are positively related to their intention to adopt a hearing aids.

4.2 Subjective norm

Subjective norm is another driver in the theory of reasoned action and has highlighted the strong impact on behavioral intention in many studies (Sheppard et al, 1998). Subjective norms are taken from family members, friends, pre-fitting counseling, professional or clinic. Kemker and Holmes (2004) conducted a trial in the United States and found that pre-fitting counseling led to higher levels of satisfaction significantly. Another experimental study in the Netherlands investigated by Kapteyn et al. (1997) found that home visits resulted in a beneficial effect on hearing aids adoption. Furthermore, Eriksson-Mangold et al. (1990) demonstrated that clinic visits before hearing aid uses can significantly increase hearing aid uses in a 10-month fitting program study. Whereas, Brickley et al. (1996) did not find significant difference towards hours of use between individual follow-up and group follow-up sessions among first time hearing aid users. Since a lot of hearing aid users feel that self-image and respect for others are important, they do not like to let others feel they are close to "disabled status", hence they have refused to think positively or only use hearing aids for a short time (Kemker and Holmes, 2004). Hence, we hypothesize that a consumer's behavioral intention can be influenced by perceived words which are from the people who think they are important to them.

H2: A person's subjective norm is negatively related towards their intention to adopt a hearing aid.

4.3 Trust

An extensive body of literature has found that trust in health professionals is a critical factor influencing treatment process and patients' satisfaction (Cook et al., 2004; Calnan and Rowe, 2008; Hallowell, 2008). According to the research of O'Malley et al (2002), trust influences patients to accept medical recommendations from audiologists. Kemker and Holmes (2004) conducted a trial and found that pre-fitting audiologist's counseling led to higher levels of satisfaction of hearing aids significantly in the U.S. Another experimental study in the Netherlands investigated by Kapteyn et al. (1997) found that doctor visiting patients at home resulted in a beneficial effect on hearing aid uses. Furthermore, Eriksson-Mangold et al. (1990) demonstrated that the clinic visits before hearing aid uses can significantly increase hearing aid uses in a 10 month fitting program study. In other words, if clients have strong trust for E-health products, they are probably to adopt it. In addition, if clients have strong trust to an audiologist, they are more likely to adopt the audiologists' recommendations and develop an intention to adopt hearing aids. Therefore, two hypotheses are as follows:

H3: A person's trust in E-health products positively influences the relationship between attitude and individual's intention to adopt a hearing aid (attitude*trust).

H4: A person's trust in the audiologists positively influence the relationship between subjective norm and individual's intention to adopt a hearing aid (subjective*trust).
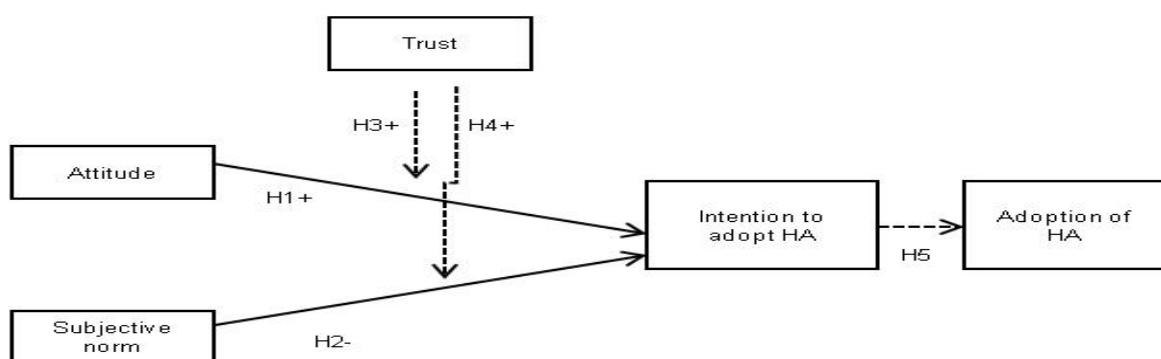

Figure 2: The proposed conceptual model for the smart cities

4.4 Adoption of hearing aids

Behavioral intention which is a better predictor than person's attitude has been found to strongly associate with individual's actual adoption (Weddle and Bettman, 1974). Many studies have included it to be a dependent variable to explore the factors that influence consumer's behavior (Sheppard et al. 1988; Armitage & Conner, 2001). A similar relationship between behavioral intention and adoption on hearing aid can be hypothesized.

H5: A person's behavioral intention is strongly related to the adoption of hearing aids.

Putting all five hypotheses, Figure 2 shows the relations on each hypothesis on the proposed conceptual model for our smart studies.

5. Methodology and Results

5.1 Data collection and demographics

This study data was collected in six smart cities in Shanghai, Jiangsu, Shanxi, Shaanxi, Gansu and Jilin by software of SoJump. The distribution of data is at the Northwest, Middle, Northeast and East of China, which correspond to the use of hearing aids for smart cities in China. Around 1,000 older people were sent for the survey questions. A substantial number of them refused to take part due to their belief of feeling embarrassed and losing their personal images. At the end, 103 full valid samples were collected without missing data.

Table 1 shows the sample's demographic information, which has 40.8% male and 59.2% female. Over 80% of the participants were younger old adults aged less than 70. 66% of respondents were less graduation under high school, and majority of them earned less than 30,000 RMB per year. 85.4% of them reported slight hearing difficulty.

Table 1 Sample demographics

Demographic variables	N=103	Percentage (%)
Gender		
Male	42	40.8
Female	61	59.2
Age		
50-59	57	55.3
60-69	29	28.2
70-79	9	8.7
80 and over	8	7.8
Education		
Less than elementary	10	9.7

Elementary	34	33.0
Middle/high school	35	34.0
College and over	24	23.3
Marital status		
Married	85	82.5
Widow	9	8.7
Divorced/separated	4	3.9
Never married	5	4.9
How many Children		
0	7	6.8
1	28	27.2
2	44	42.7
3 and over	24	23.3
Living alone	18	17.5
Not living alone	85	82.5
Working environment		
Very noising	17	16.5
Noising	32	31.1
Quiet	54	52.4
Annual income (RMB/year)		
Less than 4999	31	30.1
5000-9999	23	22.3
10000-29999	24	23.3
30000 and above	25	24.3
House owner	81	78.6
Hearing status		
Slightly	88	85.4
Moderate	11	10.7
Severe	4	3.9

5.2 About our Questionnaire

This questionnaire was conducted with confidential information disclosed. All answers of items were measured by a five-point Likert scale (1= completely agree to 5 completely disagree). Hearing status was measured by self-reported method. We asked "Do you hear others' words clearly?", "If no, how much difficulty do you have?". The answer included "slight", "moderate" and "severe".

Attitude was measured by six items, such as "The use of hearing aids will improve my quality of life."; "The use of hearing aids will make my daily activities easier".; "The use of hearing aids will improve communication with others".; "The price of hearing aids will get cost-effectiveness".; "The use of hearing aids will support daily activities".; and "The use of hearing aids can get benefits (Cobelli et al, 2014). Cronbach's α (total sample)

α= .90. Subjective norm was operationalized by using three items developed by Cobelli et al. (2014). For example, "Using a hearing aid will worsen other people's perception about me". Cronbach's α (total sample) α= .67. Trust was measured using three items adopted from Cobelli et al. (2014). A sample item was "Audiologist knows what products are suitable for me". Cronbach's α (total sample) α= .86.

5.3 Statistical analysis

SPSS 21 was used to analyze the data without any missing values. Cronbach's αlpha is commonly used to examine the reliability of scale (Bryman, 2012). Table 2 presents all items included in the questionnaire together with Cronbach's α. All measured items' Cronbach's α (total sample) values were greater than the suggested value of 0.8(Bryman, 2012) except subjective norm Cronbach's α (total sample) α= .71, which was also acceptable depending on the minimum level of α is 0.6 in ill-health research (p169, Berthoud, 2000b).

The least squares method estimated the multiple regression equation (Anderson et al., 2005), and will be used to assess the relationship between attitude, subjective norm and behavioral intention. In order to examine the moderator, we firstly centered the data, and then use two-step multiple regression. The regression coefficient means the odds rate (OR) of behavioral intention was caused by attitude, subjective norm, trust and moderated effects of trust on attitude and subjective norms. Statistical significance was set up $p<0.05$.

Regarding the evaluation of the overall multiple regression model, multiple coefficient of determination (R-sq.) is used to measure the goodness of fit for the estimated multiple regression equation ((Anderson et al., 2005). In the result of this research, with a coefficient of determination of R-sq = 37.5%, we saw that 37.5% of the variability in intention of adoption of hearing aids could be explained by the attitude, subjective norm, trust, attitude*trust and subjective*trust. Second, the F test is used to determine overall significance (Anderson et al., 2005). In this study, the F value of 3.34 and its corresponding p-value of 0.04 indicated that the regression model was significant. Last, bivariate correlation will be used to estimate the multicollinearity issue of the model. The threshold of it is the absolute value of the sample correlation coefficient to below 0.7 (Anderson et al., 2005). In Table 2, we found that multicollinearity was not a concern, as the correlation coefficient between attitude, subjective norm and trust was all below threshold of 0.7. The number of independent variables was increased from model 1 (R-sq. = 26.6%) including attitude, subjective norm and trust to model 2 (R-sq. = 37.5%) including attitude, subjective norm, trust, attitude*trust, subjective*trust). It supported that trust can be added as moderator into model to explain the behavioral intention.

Table 2 Bivariate correlation of independent variables and descriptive statistics and

	1	2	3	4	5
1.Attitude	1				
2.Subjective norm	0.33**	1			
3.Trust	0.47**	0.62***	1		
4.Attitude*Trust	0.82***	0.51***	0.83***	1	
5.Subjective norm*Trust	0.43**	0.79***	0.93***	0.82***	1
Mean	0	0	0	0	0
Standard deviation	0.88	0.82	0.79	3.3	4
Cronbach's a	0.94	0.71	0.86	_	_

***. Correlation is significant at the 0.001 level (3-tailed).

**. Correlation is significant at the 0.05 level (2-tailed).

*. Correlation is significant at the 0.1 level (1-tailed).

5.4 Multiple regression results

The results of the regression analyses employed to evaluate the relationship between behavioral intention and attitude, subjective norm, trust, attitude*trust and subjective norm*trust were shown in Table 3. The model revealed that, attitude had 1.52 (p<0.01, [0.19,1.22]) times odds for behavioral intention. Subjective norm*trust had 2.59 (p<0.02, [0.05,0.48]) odds for behavioral intention. In this regression model, subjective norm, trust and attitude*trust were all not significantly associated with individual's behavioral intention to adopt hearing aids.

Table 3 Multiple regression results

Independent variables	Odds ratio	95% CI	P
Attitude	1.52	[0.19,1.22]	0.01**
Subjective norm	-0.94	[-0.88,-0.05]	0.29
Trust	-0.75	[-0.84,0.06]	0.09*
Attitude*Trust	-1.79	[-0.45,0.01]	0.06*
Subjective norm*Trust	2.59	[0.05,0.48]	0.02**

***. Correlation is significant at the 0.001 level (3-tailed).

**. Correlation is significant at the 0.05 level (2-tailed).

*. Correlation is significant at the 0.1 level (1-tailed).

6. Discussion

6.1 Results and findings

Results of the present study revealed that the TRA model can be partially employed to describe individual's

behavioral intention to adopt hearing aids in Chinese context. Specifically, the findings supported extended TRA model adding trust and highlighted the importance of physicians in reducing the barriers grounded from social perceived norms that affect individual decision-making process. Therefore, audiologist should be positive and supportive to advice the people who have a specific need for hearing aids.

Additionally, the finding of model discovered that subjective norms, trust and attitude*trust were not statistically associated with behavioral intention to adopt hearing aids in Chinese context. This means the decision-making process can be strongly influenced by social perceived norms. The individual's behavioral intention cannot be significantly affected by the trust for products.

Earlier studies have found that TRA can be used to explain the behavioral intention in the health sector (Clarke & Aish, 2002). The findings of this study partially supported it. First, attitude has been found positive relationship with behavioral intention (Armitage and Cornnner, 2001). Hypothesis 2 and 3 failed to be assessed in multiple-regression model. It might be caused by our samples mainly selected from 50 and over years old. Those younger old adults are not the ages of severe hearing loss.

Our finding revealed that the function of hearing aids can minimize barrier of social engagement is likely to be a factor that influences consumers' behavioral intention on hearing aids, as one of terms in attitude is that 'a hearing aid can help my daily life'. Hearing loss has been found to negatively relate to everyday functioning (Dalton et al., 2003). People in China have a positive attitude for using hearing aids. Limited physical activities have also been reported to relate to hearing impairment or loss (World Health Organization, 2012). The limitations are in speech perception especially in a noisy environment or talking with someone without face to face; in understanding radio or television's signals; in confirming sound sources and in detecting environmental signals such as alarms. This study implied that the function of hearing aids was much more important than subjective norm and trust among Chinese older adults. Last, physician plays an important role to reduce the social norms that influence individual's behavioral intention.

6.2 Quality of life

This study also interviewed 15 people to get in-depth reasons influencing hearing aids adoption in smart cities. We found that participants had different attitudes for quality of life (QoL). They explained it from social engagement, linguistic communication and mood. Some participants paid a high attention to QoL. Thus, they believe hearing aids can improve their QoL through wearing better and connecting to the society better. In order

to validate our research contributions for QoL we use qualitative research method in this aspect of our research. Person A: "I do care about my quality of life. I know hearing loss can influence my daily life. One day, I will not communicate with others efficiently. Or I will not participate my previous social activities because of hearing loss. I guess, I will adopt and wear hearing aids when I really need it". While older generations in China can get the benefits of enhanced hearing aids, it allows them to have the better hearing, response and more access to online services for healthcare, government and transportation services. Hence, this can improve their QoL, which can be reflected by the improved standard of living and also the feelings about their life, including comfort and happiness as a result of receiving better hearing and better response to the people's conversations, calls and surroundings (Georgiou, 2008). However, the transportation costs from rural area to urban area influenced the uptake of hearing aids and QoL. Person B: "I need to wear hearing aid now, but I did not buy yet. That was because I heard some people who wearing hearing aid said it is very costly to remove battery every two or three months in order to make sure the device can function well. It is also difficult for me to update my battery since I live in a rural area distant from the city. I need to take bus about 8 hours to arrive at urban area. If I buy a hearing aid device, I will go to city not rural place. Here it does not have good quality of hearing aids."

The online government and healthcare services can serve better purposes as follows. First, the hospitals can offer appointment services online and track patients' hearing conditions and check their status of improvement through the apps and software by the hearing aid devices connected to the smart cities. Doctors can make remote diagnosis on their patients based on the real-time consultation. Second, the governments can provide e-government services with specific audio and video records to improve the quality of user experience among older generations. This can further improve the quality of health services.

The next interesting topic is to identify the correlation between hearing aids adoption and QoL. The impacts from those adopting hearing aids can be summarized as follows. First, patients need not travel extensively from rural areas to the cities, which may take up to one to two days for those with physical disabilities. Second, doctors can check the health status and state of the well-beings of the patients with options for them to follow up. Either the doctors can make tele-conference type of monthly appointments to save the time and travel for patients. If a medical examination is required, doctors can use smart cities to inform all their patients weeks in advance, so that patients can organize their visits. Third, smart cities allow the patients to organize their trips to visit their doctors and hospitals with ease and reduced waiting time. Patient C has stated her experience: "I need not wait for hours and everything could be arranged and done within a day". While older generations in

China can get the benefits of enhanced hearing aids, it allows them to have the better hearing, response and more access to online and smart healthcare, government and transportation services. Hence, this can improve their QoL, which can be reflected by the improved standard of living and also the feelings about their life, including comfort and happiness as a result of receiving better hearing and better response to the people's conversations, calls and surroundings (Georgiou, 2008). Additional interview summary can be provided as follows. Patient D: "Before and after the adoption of hearing aids, I can feel there is a huge improvement to my quality of life". Patient E: "Certainly using hearing aids in smart cities, my quality of life is better, as I feel happier, easier to access, and more importantly, doctors and hospitals care for me!". Other patients who have adopted hearing aids, have made similar comments after using hearing aids in smart cities, since they feel they are more connected to the people, smart services and the society. Patients even make new friends from those outside their usual networks and enrich their life extensively – they can travel together, join clubs together and spend quality time together, not feeling lonely but happy, committed and hopeful in their day-to-day activities.

6.3 Limitations and future research

This study has several limitations as following. First of all, the sample size was not enough, which may limit the reliability of results. In addition, we collected data from different areas of China. It may enlarge the inner-group variance of data. In the future, studies can be conducted based on more samples from different regions in China.

Second, this study selected respondents from 50 and over years old. It might lead to a decrease in the validity of this research. We hypothesized that subjective norm was negatively related with individual's behavioral intention. But, the finding did not support this hypothesis. It might be caused by our positive data selection. Future study can select participants' age over 65 years old, which age has been found to relate with age-related hearing loss (WHO: Deafness and hearing loss, 2015). Another possible reason is since some hearing aid users feel that self-image and respect for others are important, they do not like to let others feel they are close to "disabled status", hence negative intention may influence positive views in other data, resulting in situation that subjective norm is not sufficiently supportive. In our future research, wealth status, occupation, activities that patients are involved and their families' points of view will be taken for research question design.

Finally, quantitative analysis was criticized by lot of qualitative researchers because of epistemological bases (Bryman, 2012). This study examined the theory and not grounded theory from research. Some important factors in influencing intention might not be considered in this model. Future study can consider to adopt

qualitative research in the first phase to refine more on or research questions. Subsequently, developing quantitative study will be helpful in the long-term.

7. Conclusion and contributions

In this paper, we define the relationship between IoT, smart cities and hearing aids and present how they can be better developed. The conceptual three-layered framework has been explained, whereby hearing aids can take the benefits of smart cities. While there are demands for the rise of hearing aids to facilitate the growing older population and the improvement in QoL in smart cities, our research questions have been focused on factors influencing adoption of hearing aids and identifying what can be done better if adoption does not take place. We have examined several models and have proposed our own new and hybrid model that take all the critical factors for adoption of hearing aids. After collecting 103 valid data, our data analysis shows that our results support our hypotheses with explanations elaborated and justified. Our research contributions are to confirm the factors that determine adoption of hearing aids and the correlation between improvement of QoL and the use of hearing aids. The improvement of QoL has been seen in older generation adopting hearing-aids, since they can better interact with the people and services around them in smart cities. Their appointments, treatments and visits to hospitals can be more easily accessible than before using hearing aids. Additionally, they can make new friends with similar situations. Older generation can feel they can make their "services" and availability more valuable to the smart cities they live in different parts of China.

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Biography

Prof. Victor Chang is a Full Professor of Data Science and Information Systems at the School of Computing, Engineering and Digital Technologies, Teesside University, Middlesbrough, UK, since September 2019. He was an Associate Professor (Reader), Director of PhD and Director of MRes at IBSS, Xi'an Jiaotong-Liverpool University, Suzhou, China, after working as a Senior Lecturer at Leeds Beckett University, UK, for 3.5 years. Within 4 years, he completed Ph.D. (CS, Southampton) and PGCert (Higher Education, Fellow, Greenwich) while working for several projects at the same time. Before becoming an academic, he has achieved 97% on average in 27 IT certifications. He won a European Award on Cloud Migration in 2011, IEEE Outstanding Service Award in 2015, best papers in 2012 and 2015, the 2016 European award: Best Project in Research, Outstanding Young Scientist award in 2017 and numerous awards since 2012. He is widely regarded as a leading expert on Big Data/Cloud/IoT/security. He is a visiting scholar/PhD examiner at several universities, an Editor-in-Chief of IJOCI & OJBD journals, Editor of FGCS, Associate Editor of TII, founding chair of two international workshops and founding Conference Chair of IoTBDS http://www.iotbd.org and COMPLEXIS http://www.complexis.org since Year 2016. He was involved in different projects worth more than £12.5 million in Europe and Asia. He has published 3 books as sole authors and the editor of 2 books on Cloud Computing and related technologies. He has given 16 keynotes at international conferences.

Ms. Yuanyuan Wang is a master student at IBSS, Xi'an Jiaotong-Liverpool University, Suzhou, China. She has worked with Prof Victor Chang for this part of research. She graduated with MRes in Management. Prior joining IBSS, she has a master degree in Lanzhou University of Finance and Economics. She likes health care and statistical research.

Prof. Gary Wills is an Associate Professor, Electronics and Computer Science Department, University of Southampton. He is an expert in many areas, including security, cloud computing and information systems research involved with statistical analysis. He has more than 50 PhD completion up-to-date. He is a program chair of IoTBDS conference since Year 2016. He has received numerous funding and awards. He is a Principal Teaching Fellow from Higher Education Academy of UK.