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A research model to explain acceptance of speech therapy devices by senior aphasia patients

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Abstract

In addition to health-related impairments of age such as poor health, cognitive disorders, and frailty, aging people also face the risk of encountering situations that can lead to social exclusion and have significant negative consequences for their independence and quality of life. The home healthcare initiative intends to reduce healthcare costs, enhance healthcare quality, and increase patient independence. Information technologies like healthcare smart-home-solutions become a significant role in this effort. For these to be successful and ensure the users' acceptance, the focus must be on them. Although particularly older adults could benefit from eHealth, they often feel unable to use the technologies. Drawing on the technology acceptance model and health belief model, we seek to understand if older people would use smart-home-environments for home-based therapy. This paper presents a research model on eHealth adoption in a speech therapy context.

Keywords: Older Adults, eHealth, Technology Adoption, Smart Speaker, Speech Therapy

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Introduction

Demographic change and the ageing of the population create new heterogeneous challenges for society and, in particular, for ageing people. In 2019, there were 703 million persons aged 65 years or over in the global population. This number is projected to double to 1.5 billion in 2050 [1]. Ageing is not just about getting old, but also about developing chronic illnesses and disabilities such as physical, hearing, and visual problems over time. Severe diseases and the dependency of older people have created a new area of research [2]. Chronic diseases, in particular, cause high costs in the health care system and burden the caregiver [3]. Empowering older people to live longer, self-sufficient lives are high on the list of policymakers worldwide.

One area of potential improvement is the use of new technology to enable senior citizens and enhance their well-being digitally. Specifically, solutions aimed at creating smart living environments for ageing people are promising. Internet of Things (IoT) and smart homes can provide users with sufficient information and actively support them in controlling and increasing their health and well-being. However, while technology is becoming more widespread, an age-related underutilization of IT remains observable. Older people, in particular, could benefit from eHealth, but often reject the use of new technologies. For example, older people use the Internet far less frequently than the average population [4]. Older people are hereby defined as 60+ years, because the age of 60, roughly equivalent to retirement ages in most developed countries, is said to be the beginning of old age. The WHO has not adopted a standard criterion but generally use 60+ years to refer to the older population [5]. This age-related digital divide is preventing many older people from using IT to improve their quality of life through tools such as the internet-based provision of services. Despite the importance of this phenomenon, the literature lacks widespread attention and explanation regarding the acceptance of technologies in general and the acceptance of digital technologies among older people in particular [6, 7].

In Germany, around 250,000 people suffer from stroke each year, almost 30% of whom initially have a speech disorder (aphasia). This is 80 percent of all language disorders in Germany in total [8, 9]. Speech functions normalized largely without therapeutic measures in the first four weeks. After that, spontaneous improvement in language decreases again. The language disorder persists in about 24,000 of these patients (40% of those initially affected). Speech therapy is, therefore, generally useful for patients with aphasia. Studies show that speech therapy can improve speech and understanding in about 60 percent of all stroke patients. The severity of the disorder and the size of the affected brain area is crucial for the prognosis [10]. Often every single word has to be learned again with much training. Constant repetitions and daily practice lead to an improved chance of recovery. During outpatient rehabilitation, in addition to individual and group therapy, independent training in their home environment can also be valuable. If exercises are started early, the healing results are best. Depending on the type of disorder, the areas of speaking, understanding, writing, and reading are on the therapy plan. In the post-acute phase, up to six months after the stroke, speech therapy should be continued for one hour three to four times a week. In this stage, specific symptoms of language disorder are treated. Depending on the severity and type of aphasia, speech therapists recommend treatment at six- to eight-week intervals even after one year. Ideally, relatives are involved in the therapy [11, 12].

However, due to the demographic change, societies develop towards a situation where more and more older adults will receive less professional external care and probably also less care from family and friends. There are simply not enough adults available to take care of older people [13, 14]. Therefore, solutions are needed, using innovative technological options that empower the senior to be able to adhere to medical and therapy guidelines and feel safe and comfortable. An IT-supported speech therapy via smart speaker can accommodate long-term inpatient therapies in hospitals or the high outlay for outpatient therapy. In the familiar home environment, the patient can actively and intensively support his therapy success at any time. Older adults can perform specially developed language exercises at home and do not have to stay in the hospital or take the risk of a long trip to the facilities to complete their therapy. An IT platform can remind patients of their exercises, track their progress, and provide guidance. Particularly developed language exercises could be integrated to work on language disorders. The recognition performance of automatic speech recognition technologies has improved significantly in the past ten years, as evidenced by various techniques that have recently appeared on the market and can be controlled by speech. The best-known examples of this are indeed the "intelligent loudspeakers" or dictation functions on smartphones. The most important technical innovations in the field of speech recognition are artificial neural networks, which are inspired by the processing of signals in the human brain. However, there were no training methods that determine the connection of the individual

neurons so that the overall system reliably learns the required function. Through the use of neural networks, speech recognition technologies have leaped out of product research in recent years, and the stability of speech recognition systems has been significantly improved [15].

From a clinical point of view, IT could accompany therapies in the home environment, record health data, which could be evaluated and controlled by doctors. Mobile health applications may also enable older adults to age-in-place more successfully by improving the self-management of their health. Although an IoT-based smart home solution can provide potential benefits and a better approach to healthcare management, there are challenges and barriers for this particular elderly user population in adopting them. A speech therapy supplied by a smart speaker connected to a mobile health application and monitored by the therapist can provide an improved and better approach to the rehabilitation of aphasia patients. However, its end-user adoption is shallow. With older adults as the primary target, these conservative users pose a serious challenge to the successful implementation of smart home healthcare services.

The objective of this research is to develop and empirically test a theoretical framework for determining the core factors that can affect elderly users' acceptance of smart home services for healthcare. To address the research gap, it would be required to gain more in-depth insight into the technology acceptance of older people concerning digital health technologies. This research-in-progress identifies personal preferences and usage behavior to explain under which circumstances older people with aphasia after a stroke use a smart speaker as home-based speech therapy to increase the training frequency and, therefore, the chances of recovery. Accordingly, the research object should be a smart speaker device working in cooperation with a smart home environment or a mobile health application. We build on the Technology Acceptance Model (TAM) [16] and Health Belief Model (HBM) [17] as a starting point for our investigation to understand how older people get convinced by the successful usage. TAM is defined as "the degree to which a person believes that using a particular system would be free from effort" [16]. The HBM, developed by social psychologists at the U.S. Public health Service in the 1950s, is a social psychological health behavior change model involved to explain and predict health-related behaviors, especially concerning the uptake of health services [17, 18]. Thus, we want to answer the research question: *What factors determine the adoption of speech therapy devices by elderly patients?*

In our study, we present a research model aimed to be tested with senior aphasia-patients after a stroke. The paper is structured as follows: A review of the literature is presented discussing relevant concepts like TAM and HBM and its applicability as a theoretical foundation of this study. After that, the hypotheses are developed, the research model explicated, and the research method described. The paper closes with a discussion of the expected contribution.

1. Literature Review

1.1. Technology Acceptance in the context of mobile health services for older adults

The technology acceptance of seniors is a field of interest due to the demographic change [19]. Despite this general acceptance among older people, the acceptance of mobile phones and other IoTs and their potential to use them to improve health services is considerably low [20]. The following section deals with the relevant research related to the acceptance of eHealth and technology acceptance.

Guo [21] maintained a study in China to fill the research gap caused by the lack of studies conducted to the barriers in adopting mobile health services. Prior studies on the electronic health technology acceptance behavior have focused more on the benefits such as the perceived usefulness and perceived ease of use. Based on the dual-factor model of technology adoption by Cenfetelli [22], they tried to investigate both the enablers and the inhibitors of technology acceptance behavior of seniors. The model is empirically tested using the data of 204 subjects. The results show that fear of technology negatively affects perceived usability, while resistance to change negatively affects perceived usefulness.

Another study focused on a similar topic. Sun [23] empirically compared different prominent technology acceptance models with each other like the technology acceptance model, the theory of planned behavior or the unified theory of use and acceptance of technology, and the protection motivation theory. Furthermore, Sun [23] claim that health behavior theories also need to be considered by researchers by adapting the model, specifically to the health care content. In this context, they name the health belief model, the protection motivation theory, the subjective expected utility theory, and the theory of reasoned action. These four health behavior theories have two fundamental

principles: expectancy-value theory and cost-benefit analysis. A field survey was conducted with 204 in Harbin, China. The results show that perceived vulnerability has a positive effect on the intention to adopt. Furthermore, the response efficacy is found to be an essential factor in the mobile health service adoption. The study showed as well that social influence, the expected expenditure, and the expected performance and the easing of the conditions have a positive effect on the acceptance. They found out that perceived ease of use and self-efficacy are two essential factors influencing user behavior. Besides, it showed that predicting health technology adoption is not as crucial as their coping skills.

Previous studies have not given particular attention to age-related health and related skills when examining the acceptance of technology by the ageing population. By including conventional technology acceptance constructs along with age-related health and ability characteristics, a study by Chen and Chan [24] was able to identify other factors that influence acceptance in the field of gerontechnology. Gerontechnology is defined as an inter- and multidisciplinary academic and professional area, combining gerontology and technology [25]. Gerontechnology aims to apply technology to assist in dealing with problems and difficulties arising from ageing to give older people the chance to lead lives that are healthier, more independent, and more socially engaging continually [26]. This study aimed to develop and test a Senior Technology Acceptance Model (STAM). The proposed STAM extended previous models and theories regarding the acceptance of technologies by age-related health and ability characteristics of older people. The proposed STAM was tested empirically using a cross-sectional questionnaire survey with a sample of 1,012 seniors aged 55 and over in Hong Kong. The result showed that the model can explain 68% of the variance in using gerontechnology. Individual attributes such as age, gender, education, self-efficacy, and fear of gerontechnology, as well as health and ability features and the relief of conditions that explicitly and directly influence the acceptance of the technology. These were better predictors of the usage behavior of gerontechnology than the conventionally used setting factors like usefulness and ease of use [24].

1.2. Health Belief Model

Following Sun [23], the health belief model should be taken into account, since the topic should not only be examined for technology acceptance, but also for health-related behavior in addition to the technology acceptance theories from the IS area. In the context of changing health behavior, the health belief model remains one of the best-known theories, according to Carpenter [27]. The theory has no relation to IS. Still, it addresses potential threats of a disease or cues to action (external or internal stimuli which may induce a particular behavior, such as warnings that smoking is not healthy).

The health belief model is based on the idea that the likelihood of illness depends on specific behaviors. Simply put, your conviction just needs to be big enough not to get sick. The Model was developed initially in the 1950s by social psychologists in the U.S. Public Health Service to explain the widespread failure of people to participate in programs to prevent and detect disease [17, 18, 27]. Later, the model was extended to study people's responses to symptoms and their behaviors in response to a diagnosed illness, particularly adherence to medical regimens [28]. The Model can be divided into four main parts. Self-efficacy is defined as "the conviction that one can successfully execute the behavior required to produce the outcomes" [29]. Perceived susceptibility refers to beliefs about the likelihood of getting a disease or condition. Perceived Severity is defined as the feelings about the seriousness of contracting an illness or of leaving it untreated, including evaluations of both medical and clinical consequences and possible social consequences. The combination of susceptibility and severity has been labeled as a perceived threat [28]. Expected effectiveness is the personal evaluation of benefits or barriers which occur when altering behavior. Cues to action are stimuli that induce individuals to behave in a certain way. For example, symptoms such as pain can be a sign of an internal indicator; media, social providers that promote a particular way of life can be an external indicator [27].

Interestingly, self-efficacy was not significant in a study by Mou and Cohen [30] related to online health addiction behavior. The intention to search for health information online has been significantly affected by potential threats and perceived benefits and/or obstacles. In addition to the research mentioned above, there are only a few studies that use the research method. However, the underlying potential for applying the research method to health-based contexts is more than given.

2. Research Model and Hypotheses Development

Based on the literature research, this study aims to evaluate the use of information technology by older people with mixed methods using the prism of existing critical models for the acceptance of technologies. As the research object, we want to use a smart speaker device working in cooperation with a smart home environment or a mobile health application. Voice-controlled devices have the benefit that they are easy to use, especially for older adults, who may have motoric difficulties to use devices such as smartphones. The first part will undertake a scoping review to access the breadth of evidence and literature related to the constructs of the Technology Acceptance Model (TAM) [16] and Health Belief Model (HBM) [17] frameworks. This part will investigate the use of these frameworks in the context of health care in general and aged care in particular. To answer the research questions mentioned, we need to take a look at the general technology acceptance of older people and combine them with a specific area of health care. We use the technology acceptance model as a basis and add the health belief model [16, 17]. The Technology Acceptance Model (TAM) does not provide an insight into the context-specific influences that are inevitable in the healthcare system. The health belief model is widespread, and one of the best-known models in health care [27]. We, therefore, believe that the combination of the health belief model, which deals with health behavior, and the TAM, which deals with technology acceptance, is suitable for examining health applications. Accordingly, we argue that this combination gives more insight into why people participate in health-specific behavior changes, for example, the introduction of mobile health applications. Ultimately, this knowledge should be used to develop an improved range of therapies.

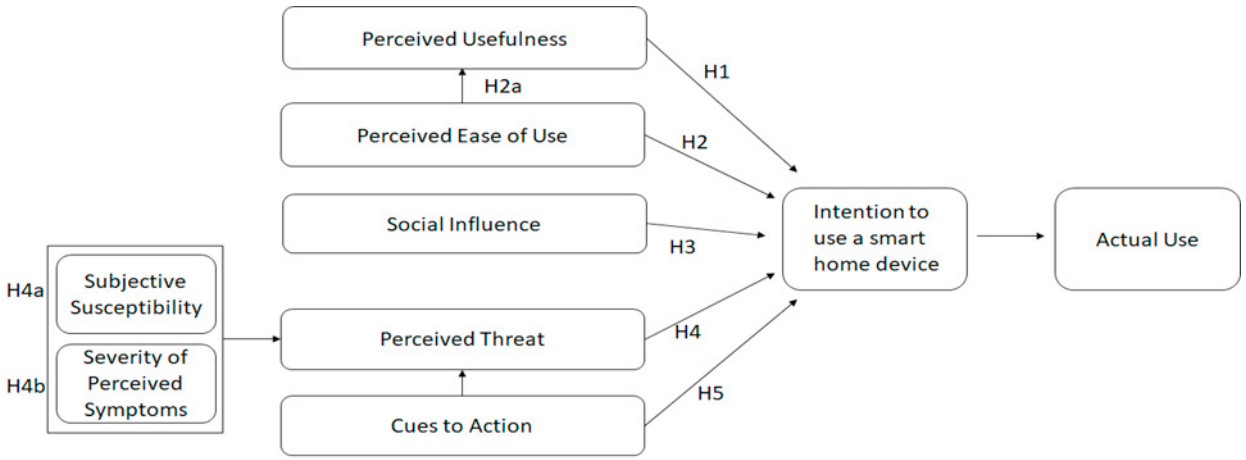

Fig. 1. Proposed research model.

2.1. Perceived Usefulness (PU)

Davis [16] defined Perceived Usefulness as "the degree to which a person believes that using a particular system would enhance his or her job performance". Usefulness and performance play a key role in using any new technology. Mainly when older people use technology, it should offer clear added value and support both in everyday life and in other areas, such as health. So, if older people think that using smart homes to support health will enable them to manage their health better, provide better access to health facilities and improve their overall quality of life, this can lead to a positive perception of Lead use of these systems [31]. Thus, for our context, it is essential to define PU as the extent to which using smart speaker applications will provide direct benefits to older people concerning their overall health. The corresponding hypothesis is:

H1: *The perceived usefulness affects the behavioral intention of elderly users to use the smart speaker for healthcare purposes in a positive way.*

2.2. Perceived ease of use (PEOU)

In contrast, Perceived ease of use considers "the degree to which a person believes that using a particular system would be free of effort" [16]. This follows from the definition of "ease": "freedom from difficulty or great effort" [16]. An effort is a physical or mental activity needed to achieve something. All else being equal, we claim, an application perceived to be easier to use than another is more likely to be accepted by users. Perceived ease of use in this context is defined as the perception of the user whether the mobile health application is believed to be used free of effort following the definition of Davis [16]. Furthermore, if older people hold the belief to be able to operate the application with relative ease, they show a positive perception of the overall usefulness of the application, since they can use all functionalities and are not restricted by the design of the technology. If all other influences were equal, we hypothesize:

H2: *Perceived ease of use affects the behavioral intention of older users to use the smart speaker for healthcare purposes in a positive way*.

H2a: *Perceived ease of use positively influences PU*.

2.3. Social Influences

Following the definition of Venkatesh, Morris [31], Social Influence is defined by the degree on which the individual thinks significant others believe he or she should use mobile health applications. In the early stages of a newly developed technology, users of such a system lack sufficient information regarding its usability, and the user can then be influenced by the opinions or suggestions of their social environment, such as relatives, friends and/or in the case of doctors, therapists, and nurses. The positive relationship between SI and usage intensity has been confirmed in several previous studies [32, 33]. We therefore assume:

H3: *Social influence affects the behavioral intention of older users to use the smart speaker for healthcare purposes in a positive way.*

2.4. Perceived Threat

The perceived threat, in this case, is defined as the potential threat of Aphasie after stroke towards the individual. The perceived threat is a construct influenced by the subjective susceptibility (the perceived likelihood to get to a stroke) and severity of perceived symptoms (the severity of the perceived symptoms after a stroke, e.g., speech diseases like Aphasie) of the illness or the disease [17]. Thus, as more severe, the symptoms of a disease, as more distinguished, would be a perceived threat associated. At the same time, however, the frequency of cases increases a threat, i.e., an illness that occurs only rarely, is also associated with a moderate threat. Consequently, it is not sufficient to only observe the severity of a disease but also the perceived probability of getting a Stroke. Data shows that older adults have a higher potential to get a Stroke, and because of this, the consequences of these strokes are more serious [34]. Thus:

H4: P*erceived threat of getting a stroke positively influences the intention to use a smart speaker.*

H4a: *Perceived susceptibility positively influences the perceived threat.*

H4b: *Perceived severity positively influences the perceived threat.*

2.5. Cues to action

The HBM suggests that a notice is required to promote commitment to health-promoting behaviors. Incentives for action can be internal or external [17, 18]. Physiological indications (e.g., pain, symptoms) are an example of internal signs of measures. External notices include events or information from related parties, the media, or healthcare providers that encourage engagement in health-related behaviors. The intensity of the notices required to take action varies between individuals based on perceived vulnerability, seriousness, benefits, and obstacles. In the case of aphasia, the incentive of the therapist to digitally record a daily training session can convince the patient and thus lead to an improved chance of recovery. We hypothesize:

H5: *Stronger cues to action positively influence the intention to use a smart speaker.*

3. Research Method

Our research aims to unravel why and how using a smart speaker for speech therapy can produce positive and negative effects. Methodologically, semi-structured interviews will be used to examine the factors that influence the acceptance of a mobile health application. TAM and HBM will serve as a baseline for potential factors that might influence the adoption behavior. However, we are open to add on factors that might emerge in the qualitative study. Besides, these results will also be validated on a broader scale, for which quantitative research also appears to be necessary. The target group consists of people from the age of 60.

Objects of observation will be IoT devices such as smart speakers, which show an increasing trend in use. From a clinical point of view, it seems interesting to connect corresponding application which can be used for therapy via internet-based technology. At the core of the development is the voice-controlled element. Voice-controlled devices have the benefit that they are easy to use, especially for older adults, who may have motoric difficulties to use devices such as smartphones. To improve the treatment of patients, data about the physical parameters of the user can be made accessible to the individual's therapeutic, so that a more thorough treatment can be applied.

4. Expected Contributions

Speech therapy has much importance for the well-being and a better quality of living for an elderly aphasia patient. One integral constituent of any patient regime is the home-based training that a patient works on in a much comfortable environment. Although the benefits are well known, there is a significant lag between the exercises prescribed by the therapists and the ones done by older patients.

From this research, we expect to uncover more profound insights into the acceptance and use behavior of older people to understand how IT needs to be designed and constructed to be better utilized by older people. With this knowledge, digital applications can be improved and, in the long term, the extent to which IT can support innovative medicine and simplify and replace various measures can be enhanced. Previous studies showed that perceived usefulness in terms of the Technology Acceptance Model [16] plays a significant role in whether seniors want to use the application or not [35]. Nevertheless, we are convinced that this model shows weaknesses and needs to be revised in the implementation of geriatrics. We first want to elaborate on how this research could contribute to the body of technology acceptance literature, but also research in the context of seniors in the digital age. Here, we are persuaded that also other influences should be mentioned in addition to PU and PEOU.

First of all, the target group should be considered more. People today, aged 60 and older, have not grown up with technology and the associated understanding of digital technologies, which is why use often requires overcoming. Besides, learning new and unknown is much more difficult in older age than in young age [36]. This finding has already been explained in a study by Chen and Chan [24]. Furthermore, some studies show that perceived threats can play a huge role when it comes to the acceptance and use of technologies in the health sector [37]. The more the given technology can prevent or cure a disease, the more people will accept and use it. The perceived usefulness influences the actual use and can thus have a significant impact on people's health, prevention behavior, and well-being. However, if, as in this case, there is a severe illness and this can be cured quickly and more effectively with the help of technology, patients are more likely to agree to the use and to work actively with it. Similarly, we expect positive influences from the social environment and internal and/or external incentives. Notably, the role of the physician and therapeutic can play an essential part in enabling seniors to use the application. With these explanations, the adaptation of the model seems sensible and undoubtedly necessary in the field of gerontechnology.

In order to motivate seniors to use health applications, we think that the basic functionality, but also the overall intention in gathering user health data should be communicated. Besides, we think that when designing a health application, one should mainly focus on the core function, since the additional features were seen as redundant. Moreover, privacy concerns should be addressed, so that people feel confident by disclosing their health data to the application. If users have the feeling that their data is in good hands and not abused for monetary gain, they will engage in a more usual manner with the application.

Finally, we conclude that the perceived usefulness will have the most substantial impact on the adoption. However, privacy concerns, social influences, facilitating conditions as a barrier, and health-specific influences such as the

perceived threat should not be neglected when trying to understand the technology acceptance of health applications for seniors.

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