Elderly's Perception about The Value of Assistive Technologies for their Daily Living: Impacting Factors and Theoretical Support

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Abstract

This paper presents a review of relevant studies found in a systematic search for research on the elderly's perception about the value of assistive technologies. We found that the majority of papers did not use any theory to frame the research question or explain their results. We suggest that invariably occurs in benefits realization through the use of empowering technologies designed to provide training to help older people maintain their functional capabilities. Maintaining these functional capabilities is important for people to live independently for longer and in order to assess the benefits more quickly; we suggest researchers use the capability approach. The existing theories of adoption appear to be much more suited to supportive technologies that aid elderly in their functional disabilities. This is mainly due to the fact that the immediate benefits i.e. usefulness of these technologies can be seen more easily compared to empowering technologies.

1. Introduction

In this paper, we acknowledge the wealth of literature that refers to problems associated with the use of technology acceptance models. However, we believe that in certain areas, for example the adoption of technologies outside the work place such as technology to improve the functioning of elderly people, requires further context-sensitive studies. Gary Johns [1], [2] suggests that researchers have not paid enough attention to contextual issues in the research they undertake. The evaluation of information systems in relation to assistive technologies for everyday living of seniors is a very much different context than the use of information technology in organisational settings. The individual perception and their daily living may require a different approach. This lack of contextual awareness is evidenced in the research evaluated in an investigation of the literature over a 13-year-period on how effectively adoption theories have been utilized in the context of seniors' perception about assistive technologies.

The literature has taken two approaches to define assistive technologies for aged care related purposes:

- o *Supportive*: The traditional approach such as the Administration of aging in USA [3] define assistive technologies in the context of aged care as "any service or tool that helps the elderly perform their everyday activities that they have always performed, but must now do differently". The above definition focuses on supportive technologies that aid the elderly in their daily activities in an attempt to overcome their functional disabilities, i.e. cognitive, physical, visual or communicational.
- o *Empowering*: Recently research in this area has enhanced the concept of assistive technologies to technological products that train seniors and empower their functional capabilities by the means of means physical or educational training that helps older people to maintain their capabilities with respect to their daily activities and accordingly be able to live independently to maintain their independent living [4], [5].

In this paper, we define assistive technologies as technological products that *support* elderly people in performing their daily activities or *empower* them to maintain their functional capabilities.

Perceived antecedents of adoption are subjective judgments of technology users of what contributes to their decisions to adopt or reject the use of a technology [6]. In contrast to the actual value of antecedents, perceived antecedents are the result of a cognitive process [7].

The current study systematically searches the literature in this area and aims to provide a comprehensive taxonomy of the perceived factors influencing adoption of assistive technologies among seniors. In addition, the study identifies the theories that have been utilized in this context and attempts to see how effectively these theories could explain the psychological factors.

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This study aims to identify deficiencies in current research undertaken in the adoption of assistive technologies from elderly's perception and to provide evidence of the need to redefine research in this area to more fully understand contextual issues. While the review found no overwhelming widespread model for adoption of assistive technologies among seniors, the authors identified major limitations in using existing theories of adoption with respect to seniors' perception about empowering technologies. The paper presents an outlook of future research on the application of new theoretical grounds such as Capability Approach to better analyse the value of assistive technologies from elderly's perspective.

Conventionally, "elderly" has been defined as a chronological age of 65 years old or greater. Orimo et al [8] have discussed the differences between those from 65 through 85 years old, referred to as "early elderly" and those over 85 years old as "late elderly" or "oldest old". For the purpose of this work, we treat the term elderly as people who are over 65 years of age.

The rest of this paper is organized in the following way: Section 2 presents the method of searching and analysing the papers used in this study. Section 3 presents the theoretical perspective and perception factors found in the searched papers. Section 4 discusses the theoretical support for the factors.

2. Method

A systematic literature review was conducted to evaluate the application of existing adoption theories in the context of psychological issues involved in the adoption of assistive technologies. In order to be inclusive and because of differences in terminology and the use of keywords the search needs to be done based on adoption and then later on when extracting the data out of the papers, we can narrow down and filter only the papers relevant to the factors related to elderly's perceptions.

The review customized the guidelines for systematic review laid down by [9] and conducted by [44]. Springer, Wiley, Since Direct, IEEE, ACM, Scirus, PubMed and Google Scholar were searched using the following search keys:

- o Technology AND
- o [aged care" OR "aged" OR "aging" OR "senior" OR "old" OR "elderly" OR "elder" OR "older"] AND
- o ["adoption" OR "acceptance" OR "use" OR "behavioural intention" OR "behavioural intention" OR "attitude" OR "believe" OR "belief" OR "usefulness" OR "diffusion" OR "user"].

Following the Keele 's guidelines [9], the choice of keywords targets a wide range of papers with possible connections with the topic. The objective in this stage is not to narrow down the list, while the relevant papers will be extracted in the filtering process conducted based on titles, abstracts and full texts of the papers.

The search considered titles, keywords, abstracts and full texts of papers published since 2000, inclusive and returned 723,944 articles. The distribution of papers in each database is presented in

Due to the large number of papers, publications after 2000 inclusive have been targeted to ensure timeliness of the results. We also found some of the papers were indexed by multiple databases, see Table 1.

Among 723,944 papers searched in the above mentioned databases, 420 papers were remaining after analysis of their titles and irrelevant articles were excluded. In this filtering procedure, an intuitive process has been employed to keep the papers that the researcher believed they might be relevant or have some connections to the topic. These papers will be excluded in later stages, if they are not relevant. 138 articles were remained after abstract filtering and 104 papers were identified as final list of relevant papers after reading the full texts. Articles that have one of the following exclusion criteria were removed:

- o Did not focus on adoption of assistive technologies for aged care.
- o Did not have any empirical evidence.
- o The definition of elderly does not fall into 65 years old or greater
- o Were in languages other than English.
- o Were not in the relevant fields or could not be applied to relevant fields.
- o Were not peer reviewed.
- o Were not available online.
- o Could not meet the quality metrics of McMaster critical review framework [10], [11].

The final list of the relevant papers can be found in the link below:

https://onedrive.live.com/redir?resid=7D934CF0AC729F11!417&authkey=!ACWap84EbOEhchE&ithint=file%2cdocx.

In the data extraction stage, key details related to perception factors and also theories from the selected papers were obtained. Two types of data were collected from each paper: (1) Utilized adoption theories, if available, and (2) Psychological factors impacting on adoption of assistive technologies.

This paper aims at understanding the underlying factors reported in literature that influence the perception of elderly about the value of assistive technologies in their everyday lives. Therefore, the

insight from the relevant set of papers were read, analyzed and extracted qualitatively by authors.

Name of Database	Initial list of papers	Filtered by titles		Filtered by abstract		Filtered by text	
		Number of found articles	Number of duplicated articles	Number of found articles	Number of duplicated articles	Number of found articles	Number of duplicated articles
Springer	16,539	213	22	31	11	18	6
Wiley InterScience	453,537	99	15	17	8	11	5
ScienceDirect	11,442	49	18	38	16	32	10
IEEEXplor	69,690	30	13	22	12	16	6
ACM Digital Library	560	21	6	14	5	10	3
Scirus	94,487	27	7	18	6	14	4
PubMed	10,989	33	9	25	8	18	6
Google Scholar	66,700	160	122	48	16	39	14
Total	723,944	632	212	213	75	158	54
Relevant papers by deducting the duplicated articles		420		138		104	

Table 1 Distribution of papers in each online database

3. Results

3.1 Theories

The major theories used to research the adoption of assist technologies among seniors as shown in the literature are listed below (note that appropriate referencing to the theory itself is also shown);

Technology Adoption Model (TAM) [12], [13]

Diffusion of Innovation (DoI) [14]

Unified Theory of Acceptance and Use of Technology (UTAUT) [15]

Other theories have attracted less attention and these include; the Theory of Reasoned Action (TRA) [16], Theory of Planned Behavior (TPB) [17], Seniors' Technology Acceptance Model (STAM) [18], Motivation Theory (MT) [19], Learning Theory (LT) [20], Activity Theory (AT) [21], Theory of Disengagement (ToD) [22], Parsimonious Technology Acceptance Model (pTAM) [23], Ubiquitous Computing-service Acceptance Model (UCAM) [24], Attribute of Technology (AoT) [25]; See Figure 1 and Figure *2*.

Learning theory (LT) [20] has been identified as one that is relevant to the context in question, this theory describes how information is absorbed, processed, and retained during learning or trying a new technology. LT introduces three dimensions influencing the adoption of new technology, namely; emotional and cognitive abilities of individuals as well as the social context involved in the use of the technology. TAM is still the predominate theory used and there have been few modification of TAM when applied to technology adoption amongst seniors. Some examples of modifications include, pTAM [23] which suggests that perceived usefulness and perceived ease of use directly impacts on a person's intention to use and as such pTAM has removed the attitude construct from the original version of TAM.

Ubiquitous computing acceptance model (UCAM) [24] indicates that cognitive and affective attitudes are potentially the primary factors of technology acceptance or intention to use. Seniors' Technology Acceptance Model is a modified version of TAM that suggests technology adoption among seniors begins with behavioral intention and that this is influenced by social context and perceived usefulness. The seniors' behavioral intention can be converted to actual use and, if usefulness is confirmed, it can be related directly to adoption, Another theory of adoption that has been specifically developed for seniors is the theory of disengagement, this theory claims that some elderly people will disengage themselves from the intervention due to concerns about their own mortality and whether a long term intervention is worth all the effort.

The review found that there is no overwhelming widespread model for adoption of assistive technologies among seniors but rather it was noted that the adoption theories have not been effective in the context of aged care (62 papers did not mentioned any theory at all). As there is very limited use of theoretical perspectives in the adoption of empowering technologies in the literature (25% used theories while 75% avoided them), we infer that there must be a degree of disillusionment in the theories available and (based on the systematic review undertaken here) this appears to have resulted in a large amount of research (almost 51% in Supportive technologies and 25% in empowering technologies) being conducted devoid of any theory.
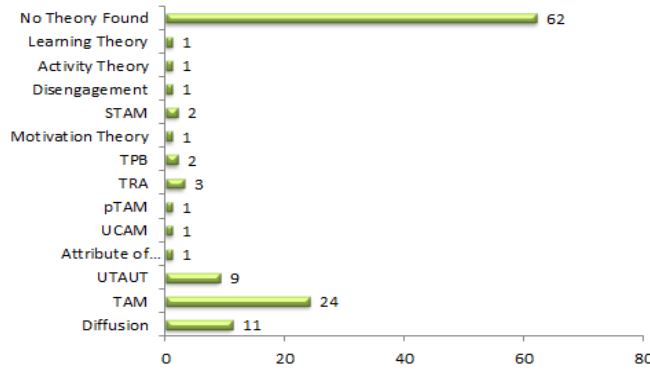
Figure 1 Distribution of the number of papers used adoption theories in the context of assistive technologies among seniors
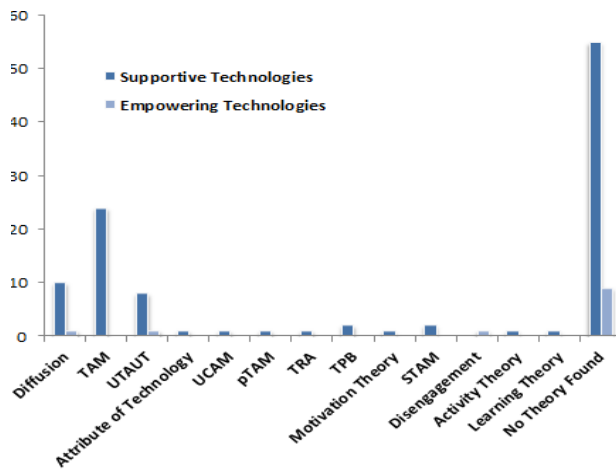

Figure 2 Application of Theories for Adoption of Supportive versus Empowering Technologies

The main title (on the first page) should begin 1-3/8 inches (3.49 cm) from the top edge of the page, centered, and in Times 14-point, boldface type. Capitalize the first letter of nouns, pronouns, verbs, adjectives, and adverbs; do not capitalize articles, coordinate conjunctions, or prepositions (unless the title begins with such a word). Leave two 12-point blank lines after the title.

3.2 Perception Factors

This section discusses the perception antecedents of adoption of technologies by elderly, see *Figure 3*.

Perceived independency refers to seniors' perception of their ability to live alone. Kiel [26] believes that using technologies enhances seniors' Perceived independence as they can now shop, pay bills, bank, learn and engage in chat groups. *Perceived quality of life* has been defined as one's cognitive appraisal of his or her overall satisfaction with life [27]. The research in this area puts a significant emphasize on the life conditions of individuals. Steele et al [28] suggest that monitoring health conditions of the elderly using wireless sensors improves their health conditions and as such seniors feel better about their lives. *Perceived usefulness* refers to a cognition that an elderly person believes that using a given technology will be useful in supporting or empowering their functional abilities. For instance, tele-monitoring technology has been perceived as useful by seniors to support them in the management of their health conditions [29].
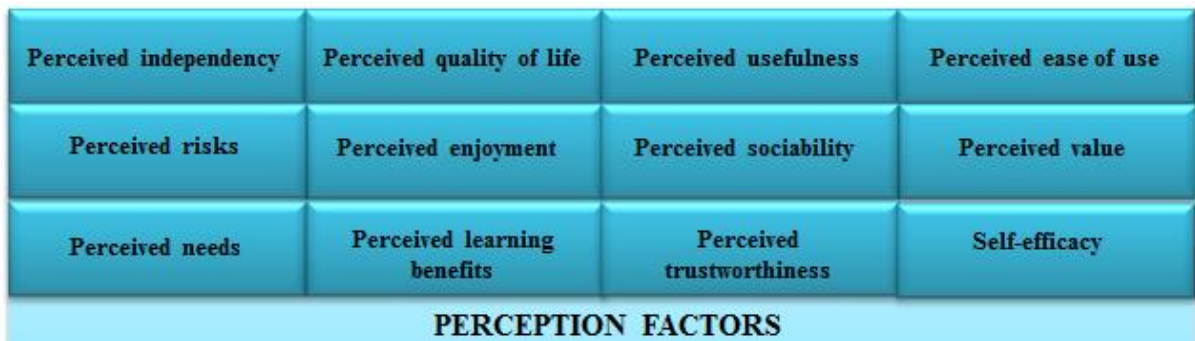

Figure 3 Perception factors impacting the adoption of assistive technologies among seniors

Games have been found to help, for example the shooter game has been found useful by seniors to improve their visual abilities and this may help them to live independently longer [30]. Older people are traditionally resistant to change but may adopt new technological products, if they think they are easy enough to use. This relates to *perceived ease of use*.

For example, McKay and Maki [30] found if seniors at the very early stage of adoption think that shooter game is easy to play, this significantly motivates them to adopt the technology even if later on they realize there are some difficulties in playing the game. McKay and Maki [30] have related this to the primary motivator that attracts seniors to the technology. In

contrast with the perception of perspective to ease of use, Renaud and Biljon [18] proposed STAM and suggested that the impact of actual ease of use of the adoption of technologies among seniors could improve overall adoption. However, this has been disputed in several other studies e.g. [29]. *Perceived risk* occurs when seniors feel in physical danger while they are using a technology. For example, [31] deployed Wii fit as a rehabilitation therapy aid and found that seniors believe that there are potential risks associated with the use of Wii fit and they are very concerned about these risks. Zaad and Allouch [32] suggest that if older people perceive a risk in using a technology sooner or later they might feel reluctant and decide to stop using it. *Perceived enjoyment* refers to the perception of the elderly about a technology and whether it is entertaining. McKay and Maki [30] asked seniors to play the shooter game to improve their visual abilities. They found that those elderly people who, prior to play, believed that the game was going to be entertaining showed more willingness to play the game. *Perceived sociability* refers to the perception of the elderly to believe that the technology is able to display sociable behaviors. Heerink et al [33] ran an experiment and asked elderly people to interact with iCat robot [34]. It was found that the socially expressiveness of the robot lead seniors to believe the social abilities of the robot to be real and accordingly this improved adoption. For instance, if the robot uses the participant's name in its communication and keeps eye-contact or apologizes for its mistakes; older people consider the robot to be appropriately socially expressive and would adopt it more easily. *Perceived value* explains the utility derived from the technology due to a reduction of its perceived short term and longer term costs. It was found that the elderly are concerned about the value return of their money when they spent it on buying smartphones to access mobile healthcare information services [35]. This was identified as a significant factor for their intention to use these services. *Perceived needs* define the seniors' belief that they would require the assistance of a technological intervention now or in the future. Through multiple case studies in aged care settings in Ireland, it was found that the elderly who believe that they need ICT services for better care, are willing to adopt these services [36]. *Perceived learning benefits* refer to the perception of seniors about the benefits that they receive through the efforts they make to learn a new technology. In a survey conducted in U.S. [26], it was found that if seniors think that the effort of learning email is worthy enough to stay connected with family and friends, they would be happy to put this effort and learn how to use emails. *Perceived trustworthiness* explains the elderly's belief that a

technology performs as it is supposed to perform. Zaad and Allouch [32] deployed an intelligent monitoring system consisting motion sensors at the seniors' home, which learns their life style. Any changes in the life style might indicate that the person's abilities have started to degenerate or that some other problems have occurred. If this event occurred, a report would be sent to the care giver. They studied a fully automated version of the system that directly sends the report and a semi-automated system that verifies the report with the elderly before sending the report. It was found that seniors believed that the semi-automated version is more trust worthy and they adopted it more easily. *Self-efficacy* defines an elderly person's self-perceived capability with respect to certain technology-specific tasks. For example, if seniors do not think that they are able to enter URLs, or create bookmarks and folders they would not use computers [37].

4. Discussion and Outlook

4.1 Theoretical Support for Perception Factors

Many of the perception factors such as risk, trustworthiness, and enjoyment can be explained with the Theory of Attribute of Technology. However, we believe in many cases, it is important to clarify the details of those factors with respect to adoption of technology among seniors. This is because it is necessary to define specific features in relation to the context. For example, although perceived independence plays a significant role in defining the context of adoption among seniors, this influencing factor has remained unexplained by adoption theories. It was also found that perceived quality of life needs further attention from a theoretical perspective. The definition given in [27] and applied in [28] relies on overall satisfaction with life. This definition commits the application of the construct to ambiguity as the definition of satisfaction with life may vary from one person to another. The Seniors' Technology Acceptance Model differentiates between perceived and confirmed usefulness and states that confirmed usefulness follows an early exploration of the technology by the elderly person. STAM fails to explain what happens in the exploration stage; that is the conversion from perceived usefulness to confirmed usefulness.

This theory presents the impacts of the successful exploration of the technology, but does not justify how this confirmation of belief can be achieved. In other words, what experience the elderly need to have to convert the initial belief into confirmed usefulness.

This exploration stage should be different when investigating supportive technologies compared to empowering technologies because it would be a different experience when seniors use technology to support or empower themselves. Although STAM attempts to utilize the actual ease of use as an antecedent on the exploration stage, other literature such as [29] and [30] found actual ease of use does not contribute much to adoption if the seniors in the early stage form their opinion about how easy technology is to use. This conflict also requires further study. Although there is a conceptual relationship among perceived usefulness, need, learning benefits and value; this relationship has not been theorized from a seniors' perspective. In order to relate perceived usefulness, need, learning benefits and value constructs to technology, there is a need to differentiate the two different types of assistive technologies. This will assist in the clarification of the different cognitive process for supportive and empowering technologies. This is an example of the lack of context in many of the identified studies. For example, an elderly person will naturally accept technology that provides a direct and tangible benefit to them straight away (for example a wheel chair), however they may not be as accepting of empowering technology that may result in not needing to use a wheel chair at all. A better understanding of these contextual issues will assist in the clarification of the different cognitive process associated with the adoption of supportive and empowering technologies. It is also interesting to observe that not all the perception factors can be explained by the attributes of the technology. Some are also related to an elderly person's perception of him or herself. These perceptions include self-efficacy and/or other conditions such as their perceived need for the technology.

4.2 Outlook: Proposing differentiation between support and empowerment

We found that the theoretical aspects of the adoption of assistive technologies lack a more specific approach to cater for a senior's contextual situation. This is particularly the case when researching the seniors' perception about empowering technologies. For example, the factors mentioned in this paper have been revealed by studies to be influential while in some cases theories are unable to describe how they can be systematically applied. This literature review found that many studies did not use any theory to explain their results and if they did use a theory, they could not justify their empirical findings. This aspect needs further attention by the research community and we

may well ask the question "Why are these theories not being used?" An answer to this question could well be the lack of an ability to adapt to the specific contextual factors of the elderly as outlined in this paper.

The analysis of different antecedents of adoption and their suitability to the theories has led us to develop a process in which the elderly's living situation (whether it is living independently or a range of age-related conditions) can account for to such an extent that it can be converted into perceived or actual usefulness. This would accordingly influence adoption research. The usefulness here is judged in many cases, and of course not all, in terms of facilitating the independent living of the elderly. However, theorizing this process is very much related to whether the technology being adopted is supportive or empowering. Supportive technologies help seniors in their functional difficulties and empowering technologies help seniors to maintain or improve their functional abilities.

For instance, the adoption of supportive technologies requires an assessment of the actual usefulness of the technology for elderly in the context of independent living. This has been theorized in the Seniors' Technology Acceptance Model (STAM). STAM introduces the exploratory stage of adoption where perceived usefulness can be converted to actual usefulness by the senior actually trying to use the technology. In many cases this is applicable to supportive technologies when usefulness can be demonstrated by literally managing the elderly's functional difficulties and conditions. Therefore, this approach would help seniors live independently or as independently as possible.

For empowering technologies, the process of converting seniors' conditions and lifestyle to a useful endpoint is more difficult. Empowering technologies provide training to maintain the functional abilities of seniors. This would allow them to live independently longer. However, the empowerment expected from these technologies occurs over the time and cannot be easily demonstrated as is the case with supportive technologies. This involves garnering the opinions of seniors about empowerment and how they perceive empowerment of a technology as being useful or not.

The Capability Approach argues that the empowerment of capabilities essentially provides freedom for people to choose one type of life over another in order to achieve the functionings that they value. Capability in this approach has been defined as "what people are effectively able to do and be" [38], [39]. Functionings is called by Sen as "what people value" [38], [39]. Therefore, one would try to empower her/his capability to be able to choose his own valuable functionings [38], [39]. The concept of

"empowerment" has been defined as any process whereby people can gain increased capability over the freedom for the choice that they may wish for their lives [40]. Comparing the definition of empowerment in empowering technologies with the Silva's [41] understanding of empowerment allows us to utilise the Capability Approach as a theoretical foundation in which a study on the adoption of an empowering technology among seniors can be grounded. The perceived impact of technology on the quality of life has been measured as an antecedent of adoption among seniors [28]. However, the capability approach suggests that the quality of life is perceived by individuals based on their capability that provides a freedom of choice to the type of life that he/she values i.e. functionings. Since seniors value their independent living [42], [43], seniors would adopt a technology if they believe that using the technology can train or maintain their functional capabilities (abilities) for performing an everyday activity which makes it possible for them to live independently. Robeyns [40] elaborates on the mental process of converting a technology to perceived empowerment and extended the capability approach. He suggests that the individual and technology characteristics as well as the social context influence this conversion.

In this paper we have identified major limitations in using existing theories of adoption with respect to seniors' perception about empowering technologies. This is related to many factors and perhaps the major one is the lag that invariably occurs in benefits realisation through the use of empowering technologies. The existing theories of adoption appear to be much more suited to supportive technologies for aged care, mainly because the technology can be used and an immediate benefit can be seen. We are suggesting that adoption studies in aged care should account for the two different categories of supportive and empowering and that serious consideration should be given to an alternative approach when researching adoption with empowering technologies. It appears that the capability approach can be very helpful in this regard. To this end, we are recommending that the capability approach be considered as an appropriate framework for studies that are looking at the seniors' perception about feasibility or usefulness of empowering technologies.

Authors acknowledge that the work at this stage is research in progress and thus limited in empirical support. However, they have designed qualitative in-depth interviews that would collect evidence on the possible potential of the Capability Approach as a context-aware theoretical perspective in perceived factors that influence the adoption of empowering technologies among seniors. Although qualitative studies provide in-depth understanding of concepts, they are not as strong as quantitative approach in statistical generalization of the results. This study is no exception; however, this work can be considered as a development to raise the awareness in applicability of Capability Approach in explaining seniors' perception about empowering technologies whilst future quantitative studies are required.

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