

# How Younger Elderly Realize Usefulness of Cognitive Training Video Games to Maintain their Independent Living

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## Abstract

The objective of this paper is to understand the perception that younger elderly persons have towards the usefulness of playing Xbox Kinect video games as an assistive technology that is designed to maintain their cognitive abilities. Available literature highlights two kinds of assistive technologies; the first being *Supportive Technologies* that provide aid for already-declined functional abilities (such as hearing aids), and the second being *Empowering Technologies* that maintain functional abilities which have not yet declined (such as Xbox Kinect cognitive games). The difference in the nature between supportive and empowering technologies plays an important role in perceiving their benefits. For instance, while hearing aids as a supportive technology are perceived as useful through the improvement of hearing abilities, cognitive training games as an empowering technology have a long-term usefulness for cognitive abilities. This study conducts twenty-one qualitative interviews (range 65 - 87 years; mean = 71; SD = 3.81) and introduces *perceived transfer effect*. This effect allows the elderly to perceive the usefulness of playing cognitive training video games, which are designed to cultivate the cognitive abilities. In addition, this study found that the elderly value their independent living, and through cognitive video games, the elderly may remain capable of living independently.

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**Keywords:** Assistive Technology; Cognitive Training Video Games; Elderly; Adoption; Usefulness.

## 1. Introduction

As the world's population continues to age, the quantity of elderly persons is estimated to increase dramatically to 20% by 2050 (OECD, 2012). Unfortunately, cognitive ability impairments related to the Alzheimer disease are highly prevalent amongst older people. It has been reported that more than 60% of seniors in first world countries are suffering from some degree of the Alzheimer disease (Ervin et al., 2012). Although adverse side effects such as disorientation and increased falls have been reported from the use of expensive, anti-psychotic medications (Kanagaratnam et al., 2016), those medications are still being largely prescribed (Axmon et al., 2017). However, there is a body of research on the positive impact of intellectual exercise and learning that helps maintain cognitive abilities in the elderly (Fleiner et al., 2017; Öhman et al., 2016; Shen and Li, 2016). In recent years, video games and motion-based technology that are designed to implement intellectual exercises - such as Xbox Kinect - have gained attention in both commercial (Shah et al., 2017) and research communities (Dove and Astell, 2017). Unlike traditional exercise therapies that must

be conducted in clinics, video games are appealing, inexpensive and easy to access (Hamari and Keronen, 2017). In addition, video games involve entertainments and social contexts.

Video games have shown positive impacts on elderly cognitive abilities (Ballesteros et al., 2014; Basak et al., 2008; Charness, 2015; Maillot et al., 2012; McDougall and House, 2012; Zelinski and Reyes, 2009). This is demonstrated through literature that focuses on how untrained capabilities required for independent living - such as driving (Damian Sue et al., 2014; Vichitvanichphong et al., 2016), reading and writing (Maillot et al., 2012) - are improved by playing cognitive training video games. This is designated as a *Transfer Effect* (Mayas et al., 2014): an effect in which the impact of an intervention (e.g. *cognitive training video games*) on a condition (e.g. *cognitive abilities*) can be extended or has a synchronous impact on a capability (e.g. *driving or reading capability*) (Woo et al., 2011). In this paper, the improvement of elderly cognitive abilities transferring to their daily capabilities - such as reading and writing - is considered a *transferred effect*.

Despite extensive research in the *transfer effect* of cognitive training video games, acceptance among seniors is a challenging task (Laver et al., 2011) for not only the effectiveness of the intervention, but also the socio-technical issues involved in the perception of these games as useful by the elderly (McKay and Maki, 2010). There is a topic of literature for adoption of assistive technologies among seniors (Panopoulos and Sarri, 2013), and while there have been several definitions of assistive technologies, the approach of this paper defines assistive technologies as “a product, equipment or device, usually electronic or mechanical in nature, which helps older people to maintain their independence or improve their quality of life” (DOHA, 2008). The determination of technology as supportive or empowering is central towards assisting elderly in perceiving the usefulness of playing cognitive training video games (Venkatesh et al., 2007).

Systematic literature review (Vichitvanichphong et al., 2014a) has classified assistive technologies into two kinds; the first being Supportive Technologies, and the second being Empowering Technologies. There has been a body of literature (Broekens et al., 2009; Leist, 2013; Magnusson et al., 2004) for the adoption of technologies that aim to support the elderly whose functional abilities have already declined (e.g. *hearing aids that help the elderly in their poor hearing*). These technologies are called *Supportive Technologies*. The literature in this area broadly presents perceived usefulness as one of the main constructs of adoption (Mostaghel, 2016; Yusif et al., 2016). However, the *transfer effect* between the driving done by the elderly and Xbox Kinect video games has demonstrated long-term impacts that are difficult for seniors to perceive as useful (Khosravi and Ghapanchi, 2016; Lee and Coughlin, 2015).

Vichitvanichphong et al. (2017) believe that the existing adoption theories do not pay sufficient attention to the context of such empowering technologies. *Empowering Technologies* - as opposed to *Supportive Technologies* - aim to assist the elderly in maintaining their functional abilities that have not yet declined. Perceiving the usefulness of empowering technologies is different than supportive technologies. This is because of the long-term effect of empowering technologies in comparison to the short-term effect of supportive technologies (Vichitvanichphong et al., 2014b). For example, there is a difference between realizing the effectiveness and usefulness of hearing aids (e.g. *supportive technology*) versus Xbox Kinect cognitive training games (e.g. *empowering technology*). The usefulness of hearing aids allows for the maintenance of already lost or weakened hearing while Xbox Kinect cognitive training games allow for the maintenance of daily life capabilities that have not yet been lost.

The concept of *transfer effect* for cognitive training video games requires a different theoretical approach in explaining *usefulness*. The main objective of the present study is to investigate the perception of the elderly regarding the *transfer effect* (e.g. *Perceived Transfer Effect*) of playing cognitive training video games for maintaining their daily life capabilities (e.g. *driving, reading, housework etc.*) that they need in order to continue living independently. As such, this paper is an attempt to answer the following research question:

- *Research Question:* How do the elderly perceive the effect of playing cognitive training video games as a tool for maintaining their daily life capabilities, which are required in order for them to remain living independently?

From the theoretical perspective, adoption theories for empowering technologies that offer positive, long-term effects highlight the role of perceived usefulness but fail to explain the development of perceived usefulness. However, the current study develops *perceived transfer effect* wherein an individual perceives the usefulness of an empowering technology by understanding its *transfer effect* that allows her/him to remain capable of living independently in a standard of living that she/he values. The *perceived transfer effect* of cognitive training video games for maintaining daily-life capabilities - such as driving and reading - has been investigated in this study. Therefore, from a practical perspective, studying the *perceived transfer effect* of Xbox Kinect cognitive training video games on the daily life of the elderly has assisted nursing professionals to better understand how to help the elderly realize the usefulness of empowering technology. Having comprehended the elderly's *perceived transfer effect*, nurses can then help the elderly to realize the usefulness Xbox Kinect cognitive training video games offer towards maintaining their daily life capabilities, thereby improving the use of this intervention.

The remainder of this paper is organized in the following way: Section 2 presents a literature review that includes Table 1 regarding definitions and literature support which closes the gap being addressed in this paper. Section 3 presents the research method used in data collection and analysis of this study. Section 4 presents the results. Section 5 summarizes the findings and discusses the academic and practical implications of this paper. Section 6 concludes the paper, recognizes the limitations of the study, and suggests future work.

## **2. Literature Support for Perceived Transfer Effect of Cognitive Training Video Games for seniors' Independent Living**

Literature suggests that the elderly value their independent living (Huang and Dong, 2014; Leeson et al., 2004; Moulton et al., 2016; Porteous and Brownsell, 2000; Vichitvanichphong et al., 2017). In this study, we define independent living as a choice that seniors have over their lives. However, one of the issues facing elderly's independent living is age-related cognitive decline (Ervin et al., 2012). This study was based on the support of literature for positive impact of intellectual exercise and training on the maintenance of cognitive abilities in elderly people (Fleiner et al., 2017; Öhman et al., 2016; Shen and Li, 2016). However, Vichitvanichphong et al. (2017) believe that the existing adoption theories lack sufficient attention towards the context of empowering technologies such as cognitive training Xbox Kinects games, due in large part to the difficulty of the elderly for understanding the effectiveness or *transfer effect* of empowering technologies. Therefore, this study supports that the elderly perceive cognitive training video games as a useful intervention if they believe that (1) playing training video games helps their cognitive abilities and that (2) those abilities can then be transferred to their daily life capabilities, required for independent living. This will be further elaborated on in Section 2.2. *Perceived Transfer Effect*.

Table 1 presents the definitions and literature support for this study. Table 1 also demonstrates the logical rationale in developing the objective of this study for investigating the *perceived transfer effect* of cognitive training video games to help with the independent living of the elderly.

Table 1 Definitions and Literature Support

Concept	Definition	Literature Support
Elderly, Seniors, Older Elderly, Younger Elderly	<p>A chronological age of 65 years old or greater.</p> <p>For the purpose of this study, the elderly and younger elderly both refer to people between 65 to 85 years old that have not yet shown significant decline in their memory performance and that similarly are treated as seniors.</p>	<p>Orimo et al (Orimo et al., 2006) have discussed the differences between those from 65 through 85 years old, referred to as “younger elderly” and those over 85 years old as “late elderly” or “oldest old”.</p> <p>Votruba et al. (2016) differentiate between younger and older elderlies and believe that cognitive training exercises are more successful in younger adults when they have not yet developed memory performance decline.</p>
Independent Living	<p>From seniors’ perspectives, independent living is defined as having a choice over what they want to do and being independent from others’ help in doing their daily activities (Bedaf et al., 2013).</p>	<p>Seniors value their independent living. (Huang and Dong, 2014; Leeson et al., 2004; Moulton et al., 2016; Porteous and Brownsell, 2000; Vichitvanichphong et al., 2017)</p>
Cognitive Ability	<p>Age-related cognitive declines have been highly prevalent in the elderly (Ervin et al., 2012).</p>	<p>There is a body of research on the positive impact of intellectual exercise and training on the maintenance of cognitive abilities in older age (Fleiner et al., 2017; Öhman et al., 2016; Shen and Li, 2016).</p>
Empowering Technology	<p>As opposed to supportive technology that targets already-declined functional abilities among elderly persons, an empowering technology is a technology - such as cognitive training video games - that aims to help elderly persons maintain their functional abilities - such as cognition - which have not yet declined substantially. (Vichitvanichphong et al., 2014a)</p>	<p>As it takes longer to see the effectiveness of empowering technologies in maintaining functional abilities, it has been shown that it is more difficult for seniors to perceive usefulness in these technologies (Khosravi and Ghapanchi, 2016; Lee and Coughlin, 2015)</p> <p>Vichitvanichphong et al. (2017) believe that the existing adoption theories lack of sufficient attention to the context of empowering technologies.</p>

Transfer Effect	When the impact of an intervention on a condition can be extended or has a synchronous impact on another condition or capability (Woo et al., 2011).	<p><i>Transfer effect</i> of cognitive training video games on daily life capabilities:</p> <ul style="list-style-type: none"> <li>• Video games trainings have shown positive impacts on elderly's cognitive ability tests. (Ballesteros et al., 2014; Basak et al., 2008; Charness, 2015; Maillot et al., 2012; McDougall and House, 2012; Zelinski and Reyes, 2009)</li> <li>• The effect of video game trainings on the cognitive ability of elderly persons can be transferred to the capabilities required for the daily life activities of elderly, making their independent life possible. (Maillot et al., 2012; Damian Sue et al., 2014; Vichitvanichphong et al., 2016)</li> </ul>
Perceived Transfer Effect	When an individual perceives the usefulness of an intervention through understanding its <i>transfer effect</i> that allows her/him to remain capable of living independently in a standard of living that she/he values.	<p>Older adults perceive cognitive training video games as a useful intervention if:</p> <ol style="list-style-type: none"> <li>1. They believe playing training video games helps their cognitive abilities.</li> <li>2. The positive effect of training video games on cognitive abilities can be transferred to their daily capabilities - such as reading and driving, etc. - that are required for their independent living.</li> </ol> <p><b>The objective of this study.</b></p>

Conventionally, “elderly” has been defined as a chronological age of 65 years old or greater. Orimo et al (Orimo et al., 2006) have discussed the differences between those from 65 through 85 years old who are referred to as “younger elderly” and those over 85 years old who are referred to as “older old”. Votruba et al. (2016) differentiate between younger and older elderlies and believe that cognitive training exercises are more successful in younger adults when they have not yet developed memory performance decline. However, for the purpose of this study, “elderly” refers to people between 65 to 85 years old that have not yet shown significant decline in their memory performance and that are similarly treated as seniors (Votruba et al., 2016). This definition connects elderly to the empowering technology definition, which helps the elderly to maintain their functional abilities (*e.g. memory performance*).

### ***2.1. Independent Living as a type of life that seniors value.***

Bedaf et al. (Bedaf et al., 2013) define seniors’ independent living as not doing everything oneself or independently, but as having a choice over what they do and being independent of others’ help. Seniors highly value their independent living (Leeson et al., 2004; Moulton et al., 2016; Porteous and Brownsell, 2000; Vichitvanichphong et al., 2017). Huang and Dong (Huang and Dong, 2014) studied 51 seniors, and they believe that later in life, continuing to live independently is important for most elderly people.

## 2.2. Perceived transfer effect

*Transfer effect* is defined when the impact of an intervention on a condition can be extended or has a synchronous impact on another condition or capability (Woo et al., 2011). In the context of cognitive training video games, *transfer effect* is defined as the ability to extend cognitive ability improvement among the elderly in order to maintain their daily capabilities which they require for independent living. There is a large body of literature that supports video games by showing the positive impacts on elderly's cognitive ability tests; tests such as Wisconsin Card Sorting (Ballesteros et al., 2014), Stroop task (Zelinski and Reyes, 2009), Operation Span (Basak et al., 2008) and Letter–Number Sequence (Charness, 2015), Digit Span (McDougall and House, 2012), and Simple Reaction Time (Maillot et al., 2012). It was also shown that the effect of video game trainings on the cognitive abilities of the elderly can be transferred to the capabilities required for daily activities that make their independent life possible (Maillot et al., 2012; Damian Sue et al., 2014; Vichitvanichphong et al., 2016).

To reiterate: the *perceived transfer effect* occurs when an individual perceives the usefulness of an intervention through understanding its *transfer effect* that allows her/him to continue living the type of life that she/he values. And as stated earlier, there is supporting literature for the *transfer effect* of playing Xbox Kinect video games in maintaining elderly capabilities; however, it is unknown whether or not elderly persons would have a similar perspective to the above-described transformation or not. In effect, this study reveals whether or not seniors believe that cognitive training video games enhance their independent living.

Older adults perceive cognitive training video games as a useful intervention if (1) they believe playing training video games helps for their cognitive abilities, and (2) the positive effect of training video games on cognitive abilities can be transferred to their everyday capabilities - such as reading and driving, etc. - that are required for their independent living for a type of life that they value. While adoption theories highlight the role of perceived usefulness, they fail to explain how perceived usefulness can be developed and recognized by individuals when adopting empowering technologies that require long-term effects in maintaining elderly functional abilities (Vichitvanichphong et al., 2017).

This study introduces the concept of *perceived transfer effect* as a mechanism in which seniors perceive usefulness of an empowering technology. The present work investigates the *perceived transfer effect* in the context of playing cognitive training video games in order to maintain the daily capabilities that elders need in order to continue living independently.

## 3. Research Method

We aim to investigate the transfer effect of video games in cognitive training of the elderly by exploration in seniors' perceptions and words. We seek to understand the underlying concerns about how seniors perceive the effectiveness of video games in empowering their cognitive abilities and adopt accordingly the intervention. In order to achieve this, we required that the seniors participating in this study were aware of and had experienced the intervention. Therefore, we opted to conduct contextual interviews in which the elderly played a cognitive training video game prior to the interview.

The seniors were invited to participate in two steps; step one provides context to participants by giving the opportunity to experience the intervention, and step two involves individual interviews.

### 3.1. Experiencing the Intervention

In this study, Dr. Kawashima's Xbox Kinect video game set has been chosen to provide cognitive training to the elderly.

### *3.1.1. Rationale for the choice of video game and the console: Dr. Kawashima memory performance game on Xbox Kinect*

Dr. Kawashima's cognitive training game is a full set of reading and mathematics exercises that stimulate the memory. Dr. Kawashima's games are a collection of puzzle-type games which ask cognitive questions. The use of this game set has shown some evidence that memory performance can improve in elderly people (De Giglio et al., 2015; Nouchi et al., 2013; Takeuchi et al., 2016). This is shown through the previous research on the playing of this game over Xbox Kinect platform (Damian Sue et al., 2014; D. Sue et al., 2014; Vichitvanichphong et al., 2016), which suggests that because exercises on this platform require that answers be performed through physical actions, the elderly were active and engaged. In addition, Xbox Kinect does not require that any equipment be attached to the player's body, which allows for better engagement.

### *3.1.2. Playing game*

The participants played Xbox Kinect Dr. Kawashima cognitive training game individually over five separate sessions wherein each exercise that the participant requested provided a practice exercise and demo prior to the commencement of the session. The playing process is as follows: (1) the participant is introduced to the game; (2) the participant is asked to practice the game until he/she is comfortable with the game; (3) the participant is given five minutes of rest after the practice session; (4) the participant is assigned a username and profile that contains her/his scores; (5) at the end of each session, the game provides a score to the participant called "memory age," which is not necessarily the same as their actual age. The goal for the participants was to decrease their "memory age" by the end of the five sessions. Finally, the first sessions started.

### *3.1.3. Creating context for interviews*

In order to compare the actual versus memory age of each senior, each participant was given their memory age and then asked to reflect on the results. The objective of this exercise was to engage them in uncovering unarticulated aspects of work, a technique proposed by Holtzblatt et al. (2004). This process allowed seniors to realize the objective of the present intervention; however, no input or opinion was provided to the seniors by the research team. On the select occasions that the participants asked for the opinion of the research team, it was refused.

## **3.2. Interviews**

The seniors who participated in the above step were interviewed individually by the interviewer who asked pre-made, semi-structured questions for the perception of participants about the transfer effect of playing Dr. Kawashima's Xbox Kinect cognitive training video games in their daily lives. The interview process summary included the following: (1) the average duration of each interview was 67 minutes; (2) the interview began with the demographic details of the interviewee – such as occupation, gender, and independent living status; (3) the interview contained open-ended descriptive questions; (4) the interview was conducted in a discussion manner in order to investigate the underlying thoughts of each participant.

### **3.3. Rationale for the use of contextual interviews**

A contextual interview is a semi-structured interview method that obtains information about the context of using an intervention wherein users are first given an opportunity to try the intervention. In the case of this study, while we lacked participants with intervention experience, we were aware that rich, descriptive thoughts could be gained from individual participants who had sufficient intervention experience (Moustakas,

1994). Therefore, we designed a pre-step wherein participants were asked to play Dr. Kawashima's Xbox Kinect cognitive training video game, and then reflect on their results.

While most studies for the adoption of assistive technologies among seniors have followed the traditional quantitative approach, the complexity of the problem and dynamics of the context have created a gap between providing insights into the setting of a problem and generating thoughts (Suchada Vichitvanichphong et al., 2013). On the other hand, the objective of this study is to uncover the seniors' perception extracted from their descriptive perspective, which implies that it is necessary to have a qualitative approach in place in order to understand the underlying point described by seniors.

### 3.4. Sampling method

The recruitment of participants was achieved through an email sent to 224 seniors who had registered themselves in a community that organizes events for seniors. Among those who responded and showed their interest to participate in this study, we selected a pool of possible participants based on the following conditions: (1) between 65 years old and 85 years old, (2) were not diagnosed as a severe Alzheimer patient, and (3) were physically able to stand up, move their hands and their shoulders. We continued the selection of participants from the pool and conducted first and second steps until duplication of data in interviews was apparent. In our selection process, we carefully chose the participants in a way that ensured sufficient demographical differences and similarities. From demographics, we target a population that reflected the diversity among seniors; namely gender, occupation (*having a technical or non-technical background*), retirement status (*not retired, less than five years, five years or more*), and independent living status (*living with someone at home, living alone at home, living with someone at aged care setting, living alone at age care setting*).

Finally, we asked twenty-one individuals (*range 65- 87 years; mean = 71; SD = 3.81*) to participate in our study, including twelve males - ten of which had worked in a technical environment. Eight participants were living with their partners at homes, five were living alone at home, four were living in aged-care settings and the remaining participants were living with their child(ren). The associated demographics of each individual participant are given in Table 2.

Table 2 Participants' Demographics

<b>Total Number of Participants</b>	21
<b>Gender</b>	Female: 9, Male: 12
<b>Age</b>	<=85: 19, >85: 2
<b>Occupation</b>	Non-Technical: 13, Technical: 8
<b>Independent Living Status</b>	At Home Alone: 7, At Home with Partner: 8, With Child: 2, At Aged Care Setting: 4

### 3.5. Analysis

#### 3.5.1. Qualitative Analysis

The qualitative analysis aiming at coding the relevant categories of sentences has two steps; (1) Automated Detection of Categories, and (2) Manual Refinement of Results. The approach taken in this study to code the categories is similar to what was used in (Deng et al., 2016); however, we used a different software package.

**Step 1: Automated Detection of Categories of Sentences:** The analysis of the interviews was conducted using Alceste software (Zafar, 2015). First, Alceste identified contextual units - equivalent to sentences - in

the transcripts. Then, the software computed the data matrix by including words that were recognized by the Alceste already-implemented ontology. The data matrix displayed which words were present in each sentence, words repeated less than four times were excluded (Zafar, 2015). The final part of step 1 was to generate categories of sentences. Alceste uses the Divisive Hierarchical Clustering (DHC) algorithm (Everitt et al., 2011). This algorithm attempts to maximize the significant difference of each two categories by iteratively trying different sentences in different categories. The significant difference presented by  $X^2$  was calculated in Alceste using the Chi Square Test. Only the categories that have ( $X^2 > 10.8$ , significant at the 0.1% level) were included. The percentage of contextual units in the interviews was 68.9% which means that 68.9% of the sentences in the interviews were related in some way to the other sentences. This was a significant result for qualitative discussions and demonstrates that the interviewees were not overly distracted (Reinert, 1998).

**Step 2: Manual Refinement of Results:** This step included human intervention in order to refine the automatically generated categories. First, the coders merged the categories into one category if their sentences were similar. Second, the coders split the categories if the sentences were different. The relevant categories were grouped to make up a hierarchical structure including categories and sub-categories. This was iteratively repeated until changes were no longer necessary. Finally, a title was provided for each category (see Table 3 to Table 7).

In order to ensure the external reliability of results, there were two coders who independently coded the interviews. These coders were different than authors.

### 3.5.2. Demographic Analysis

The demographic analysis was conducted as to whether or not there existed any differences among the sample group, namely from the perspectives of gender, the technical/non-technical occupation history, independent living status (*At home alone, At home with the partner, At the aged care setting, or with the child*) and the retirement status (*working, retired for less than 5 years, retired for more than 5 years*). This analysis was calculated through factor mapping via Alceste.

### 3.6. Research approach

Yin (2013) says that “inductive research is an empirical inquiry that investigates a contemporary phenomenon within its real-life context.” The current research investigates the *perceived transfer effect* of the elderly to use Xbox Kinect cognitive training video games for maintaining their daily life capabilities. While the phenomenon under the study in this paper is *Perceived Transfer Effect*, Xbox Kinect cognitive training games play the role of *context*. Therefore, the research presented in this paper is an inductive effort.

Although Alceste software automatically coded the transcripts of the interviews, the categories coded for the final results have been extracted through the manual refinement of the researchers. The results of the objective coding based on significance of difference ( $X^2$ ) was used as an input only, and the final refinement and titling of the coded categories was made using the subjective background constructed by the interaction between the researcher and the participants. According to the guidelines of Walsham (1995), the subjective involvement in the analysis process refers to the interpretive approach.

## 4. Results

The following results have come out of the analysis of the descriptive questions (see Table 3 through Table 7). In these tables, the column for the sample statement is one of the sentences that Alceste has identified as relevant contextual unit (*sentence*) to the findings in the first column. The last numerical column presents  $x^2$  criterion (Reinert, 1998) expresses the significance level ( $x^2 > 10.8$ , significant at the 0.1% level).

We have only reported the significant findings.

#### 4.1. Qualitative Results

##### 4.1.1. Seniors value their independent living

Our study shows that the elderly prefer living independently because they believe that doing so improves their competence. In additions, the elderly value their current lifestyle despite it not being the same as when they were younger. The elderly also mentioned that they feel lonely at times, but that they still prefer being independent. In summary, we found seniors value their independent lives, even though doing so presents some difficulties. See Table 3.

**Table 3** Seniors value their independent living

Finding	Gender	Occupation	Age	Independent Living Status	$x^2$	
Home as a significance of being competent.	Participant 7					
	Female	Non-Technical	<= 85	At home alone	12.4	
	Participant 20					
	Male	Technical	<=85	At home alone		
Participant 16						
Owning own life	Participant 2					
	Male	Non-Technical	<=85	At home alone	13.1	
	Participant 20					
Male	Technical	<=85	At home alone			
Loneliness	Participant 6					
	Male	Technical	<=85	At home alone	14.8	
	Participant 4					
Female	Non-Technical	<=85	At home with the partner			

##### 4.1.2. Perceived transfer effect and independent life

Seniors believe playing Dr. Kwashima's video game can improve their cognitive abilities such as speed processing, attention and memory. They also believe this game's ability to improve their cognitive abilities and their capabilities, which they need for their daily independent living - such as housework, driving, conversation, reading, planning and taking medicines - See Table 4.

Table 4 : Perceived transfer effect and their independent living: Seniors believe that Dr Kawashima’s video game improves their cognitive abilities which positively impacts their daily life capabilities. This helps them to live independently.

Finding			Gender	Occupation	Age	Independent Living Status	$x^2$	
Conversion Factor	Capability	Independent Living						
Processing Speed	Housework	Independent to the others’ help	Participant 5				At aged care setting	15.1
			Female	Technical	<=85			
	Participant 10				At home alone			
	Male	Non-Technical	<=85					
Driving	Independent to the others’ help	Participant 16				At home with the partner	12.1	
		Male	Non-Technical	<=85				
Attention	Conversation	Control of what to do	Participant 12				At home alone	13.3
			Male	Technical	<=85			
	Reading	Control of what to do	Participant 18				At home with the partner	11.7
Male			Technical	<=85				
Memory	Planning	Control of what to do	Participant 9				At home with the partner	16.8
			Male	Technical	<=85			
	Taking medicine	Independent to the others’ help	Participant 10				At home alone	13.1
			Male	Non-Technical	<=85			
	Housework	Independent to the others’ help	Participant 6				At home alone	13.7
Male			Technical	<=85				

#### 4.1.3. Seniors’ characteristics influence the perceived transfer effect of playing cognitive training video games in their daily life capabilities.

Seniors believe that having technical expertise would help them to receive more benefits from the games. In addition, they believe that the amount of interest that they have in technology is a key factor for whether or not they can understand the games and thereby improve their daily life capabilities. They also indicated that lack of sufficient levels of physical, visual and cognitive abilities may act as a barrier. However, this was only applicable when we run the Dr. Kawashima games on Xbox Kinect. In summary, Seniors’ characteristics influence their perception of the *transfer effect* of cognitive training video games for their driving performance.

*Table 5 Seniors' characteristics influence the perceived transfer effect of playing cognitive training video games in their daily life capabilities.*

Finding		Gender	Occupation	Age	Independent Living Status	$\chi^2$
Technical Expertise		Participant 15				13.1
		Female	Non-Technical	<=85	With the child	
Innovativeness		Participant 7				10.9
		Female	Non-Technical	<=85	At home alone	
Functional Conditions		Participant 19				14.6
		Male	Technical	>85	At aged care setting	
		Participant 4				17.1
		Cognitive Conditions	Female	Non-Technical	<=85	
Visual Conditions		Participant 7				14.3
		Female	Non-Technical	<=85	At home alone	

*4.1.4. Seniors' opinions about cognitive training video games influence the perceived transfer effect of playing video games in their daily life capabilities.*

Seniors indicated that the cognitive training video games were confusing, particularly at the beginning. However, they also indicated that the games were fun. They liked the challenge implied by the memory age score in the Dr. Kawashima games that motivated them to continue.

*Table 6 Seniors' opinions about cognitive training video games influence the perceived transfer effect of playing these games in their daily life capabilities.*

Finding		Gender	Occupation	Age	Independent Living Status	$\chi^2$
Negative	Confusing	Participant 17				12.3
		Male	Non-Technical	<=85	At the aged care setting	
Positive	Fun	Participant 18				15.8
		Male	Technical	<=85	At home with the partner	
	Challenging	Participant 6				14.1
		Male	Technical	<=85	At home alone	
Participant 4						
		Female	Non-Technical	<=85	At home with the partner	

#### 4.1.5. Social context influences the perceived transfer effect of playing video games in their driving.

Elderly believe that the video games can create a social context in which playing the games would be more fun and more encouraging for improving their daily life capabilities; See Table 7.

Table 7 Social context influences the perceived transfer effect of playing cognitive training video games in their daily life capabilities.

Finding	Gender	Occupation	Age	Independent Living Status	$x^2$
Games for kids	Participant 16				
	Male	Non-Technical	$\leq 85$	At home with the partner	11.2
Games as a means of social interactions	Participant 7				
	Female	Non-Technical	$\leq 85$	At home alone	13.8

#### 4.2. Demographic Analysis Results

Figure 1 presents the results of the demographic analysis conducted by the Alceste software. The demographic analysis, as discussed in Section 3.5.2, was only conducted on the holistic perspective of the constructs in order to confirm that the results of the analysis were valid. Figure 2 shows the significantly different demographic sample groups only. We have not found any significant differences in our results among independent living status sample groups.

We found the following:

- (1) Both females ( $x^2 = 11.6$ ) and males ( $x^2 = 14.4$ ) significantly value their independent living; however, our statistical test demonstrates males place more value on their independent living than females;
- (2) Seniors with a technical job history ( $x^2 = 12.1$ ) realized the *perceived transfer effect* more significantly than those with non-technical occupations ( $x^2 = 9.7$ );
- (3) Participants can be influenced by their retirement status. In comparison with retired seniors, working elderly ( $x^2 = 8.9$ ) do not significantly perceive the *transfer effect* of cognitive training video games. It was also indicated that seniors who have been retired less than five years ( $x^2 = 14.3$ ) have a significantly different opinion regarding the *transfer effect* of cognitive training video games than that of seniors who have been retired more than five years ( $x^2 = 16.7$ ).
- (4) Seniors' opinions about the cognitive training video games generally influence their perception regarding the *transfer effect* of the games on their driving; however, the opinions are significantly different between the elderly with non-technical occupations ( $x^2 = 9.2$ ) and the elderly with technical occupations ( $x^2 = 13.5$ ). Regarding cognitive training video games: the opinions of seniors with technical occupation histories impact their *perceived transfer effect* significantly, whereas the opinions of seniors with non-technical occupations are not as impactful on their *perceived transfer effect*.
- (5) Males and females are significantly different in their opinion about the impact of social context regarding the *perceived transfer effect*. Females believe there is influence from the social context ( $x^2 = 11.3$ ), whereas males do not see a significant concern ( $x^2 = 6.1$ ).
- (6) Seniors with technical job history ( $x^2 = 14.8$ ) perceive the *transfer effect* of cognitive training video games significantly stronger than seniors with non-technical jobs ( $x^2 = 7.5$ ).

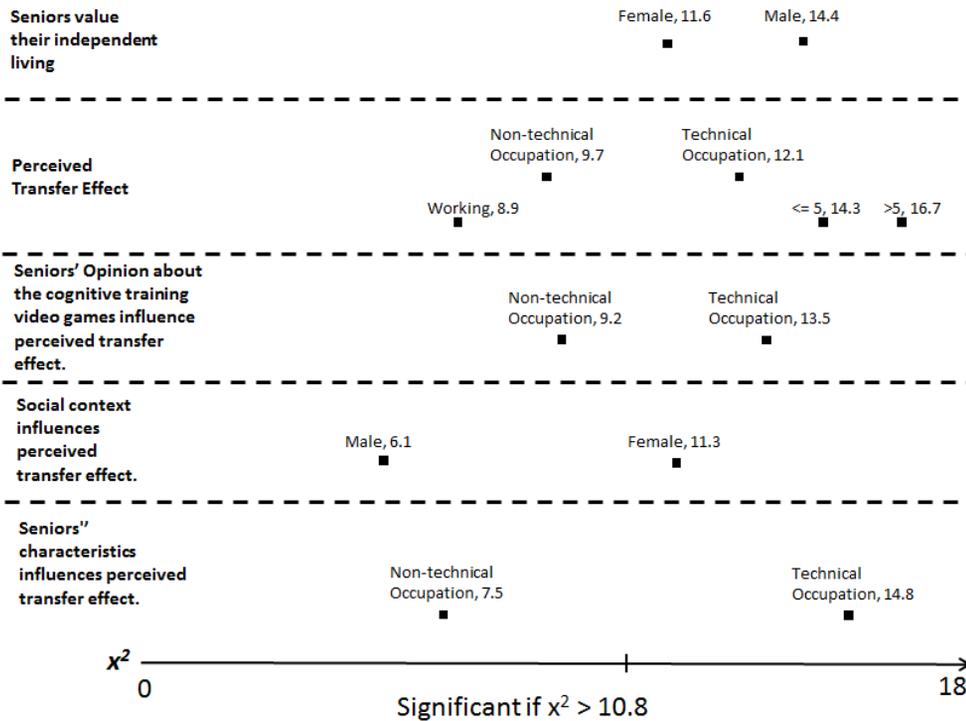


Figure 1 Demographic Analysis Results

#### 4.3. Summary of Results

As we age, our functional abilities decline. There is a great body of research for the adoption of technologies that are designed to help the elderly with maintaining their functional abilities (Broekens et al., 2009; Leist, 2013; Magnusson et al., 2004; Or and Karsh, 2009; Yusif et al., 2016). However, most of these studies focus on the elderly's perception about the usefulness of these technologies in maintaining physical, cognitive or visual abilities that have already declined (Vichitvanichphong et al., 2017). Perceived usefulness in these types of technologies – supportive technologies such as hearing aids – that assist older adults in their declined functional abilities is easier to comprehend (Lee and Coughlin, 2015; Vichitvanichphong et al., 2014b) than the technologies that require a long-term effect to maintain the functional abilities of the elderly – empowering technologies such as cognitive training video games. While most studies that adopt technologies for the elderly have indicated perceived usefulness as one of the determinants of adoption, the study of the process in which elderly perceive the long-term effect of empowering technologies (*i.e. usefulness*) is lacking.

*Transfer effect* of cognitive training video games demonstrating the usefulness has been shown in literature (Broekens et al., 2009; Leist, 2013; Magnusson et al., 2004; Or and Karsh, 2009). However, this study aims to understand the seniors' opinion about the perceived transfer effect of cognitive training video games in their everyday life capabilities such as driving, reading, housework etc. That are required for independent living. This work is an attempt to understand how younger elderlies comprehend usefulness of cognitive training video games. Such research informs on the *perceived transfer effect* of cognitive training video games that allow elderlies to maintain their existing capabilities, required for independent living.

Figure 2 summarizes the findings of this research by depicting the *perceived transfer effect* while simultaneously extracting the concepts indicated by the elderly in their individual interviews.

In order to address the lack of literature explaining how older adults perceive the usefulness of empowering technologies, the *perceived transfer effect* was introduced in this study, defined as an individual who perceives the usefulness of an intervention through understanding its *transfer effect* that allows her/him to remain capable of living independently in a standard of living that she/he values. Therefore, the present study investigated the *perceived transfer effect* of playing cognitive training video games on daily capabilities - such as driving, reading, etc. - that the elderly require for living independently.

The following discusses the findings of this study (see Figure 4), as well as defines the main concepts and compares them to previous literature.

The findings of this study indicate that older adults perceive cognitive training video games as a useful intervention because (1) they believe that playing training video games helps maintain their cognitive abilities, and (2) the positive effect of training video games on cognitive abilities can be transferred to their daily capabilities - such as reading, driving, etc. - that allows her/him to remain capable of living independently in a standard of living that she/he values.

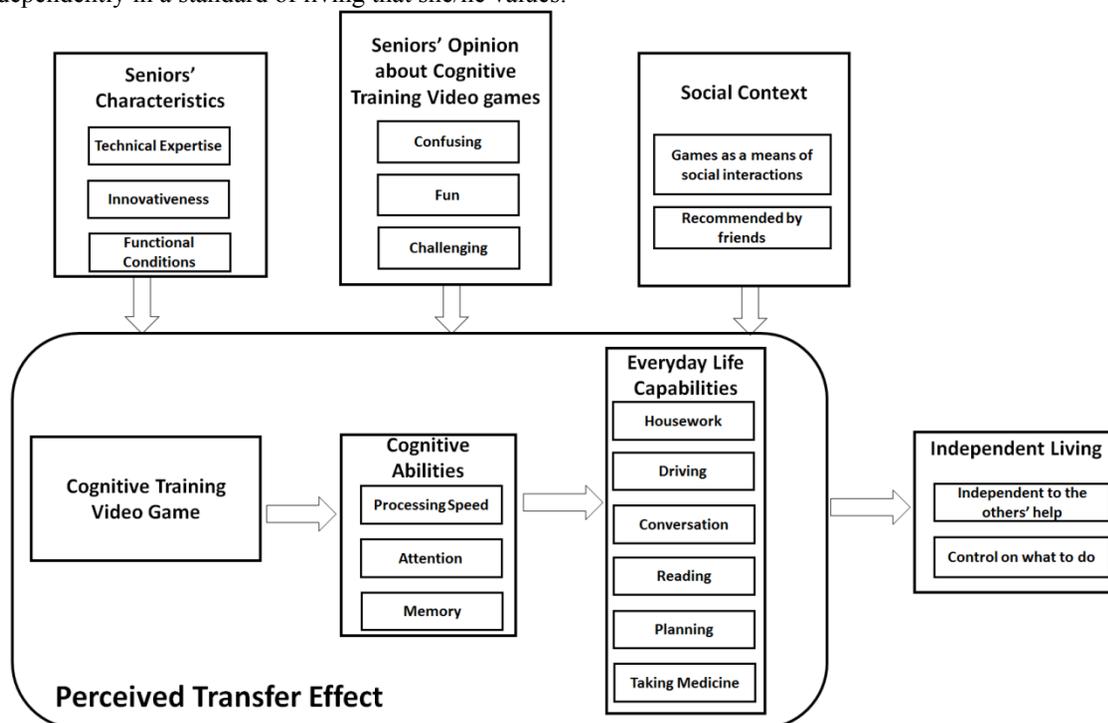


Figure 2 Perceived Transfer Effect of Xbox Kinect Video Games to Help with Driving Performance of Older Adults

*Transfer effect* is defined when an impact of a technology on a condition can be extended or has a synchronous impact on another condition or capability. The research available on video games for the elderly show that Xbox Kinect provides a technological platform that assists seniors with improving the capabilities that are necessary to perform their daily activities independently (Maillot et al., 2012; Damian Sue et al., 2014; Vichitvanichpong et al., 2016). Our study is consistent with the conceptual model presented in

Vichitvanichphong et al. (2014b) which elaborates on how the elderly benefit from the use of technology when they are able to perceive the *transfer effect* of said technology on their capabilities. The empirical results presented in our paper indicate that seniors perceive the usefulness of cognitive training video games when they see how these games improve their cognitive abilities, which consequently improves their daily capabilities that allows her/him to remain capable of living independently in a standard of living that she/he values (*i.e. perceived transfer effect*).

It is important to note that the seniors' opinions regarding the *transfer effect* were similar to the experts' opinions, which were presented in supporting literature (Ballesteros et al., 2014; Basak et al., 2008; Charness, 2015; Maillot et al., 2012; McDougall and House, 2012; Zelinski and Reyes, 2009). There was no conflict, but it was determined that seniors did not recognize the connection of the intervention to their driving skills. For example, they did not realize that playing video games can improve the physical abilities of the elderly, which can have a positive impact on their skills in awareness, response time, and their ability to turn and/or park a vehicle. This disconnection might be due to the medical complexity associated with these relationships that can only be observed by experts. Another possibility might be due to the limitations associated with our research method wherein we were incapable of extracting every detail of a seniors' mind. Therefore, a more quantitative approach that tests the experts' opinions from a seniors' perspective could be encouraged for future research. Unfortunately, there has not been an empirical investigation on the *perceived transfer effect* of playing Xbox Kinect video games in relation to a senior's driving ability. The empirical results presented in our paper indicate that from a senior's perspective, Xbox Kinect cognitive training video games can improve their cognitive abilities which can then be transferred to maintain their capabilities required for independent living as they value.

Our study acknowledges the results of the study by Talaei-Khoei et al. (2015) which focused on the adoption of humanoid robotic technologies among seniors. That study in combination with this paper have connected perceived usefulness by seniors to the *transfer effect* of empowering technologies, resulting in their ability to live independently. However, a few differences related to the nature of these two technologies were observed. The main difference being that the level of technology learnability, defined as the ability to learn new techniques (Häikiö et al., 2007), was a significant characteristic of individual seniors in the robotics study. While we did not find learnability to be a significant characteristic of individual seniors as to influencing their *perceived transfer effect* for the adoption of cognitive training video games, we did determine that innovativeness was a significant characteristic, which was not the case for the robotics study. This contrast may be due to the fact that in the robotics study, elders needed to be trained on how to use the robots. Regardless, in this study, the highly interactive interface of the cognitive training video games and the possibility for different scenarios required more intuition.

The literature of both supportive and empowering technologies have generally demonstrated the role of elderly characteristics in technology (Vichitvanichphong et al., 2017). For instance, self-confidence (Ahn et al., 2008; Chou and Wang, 2000) can improve a senior's perspective towards internet usage. Our study did not focus on the self-confidence of the elderly, but we found that technical expertise was a significant factor for the *perceived transfer effect* and can result in self-confidence (Ahn et al., 2008). Another example of elderly characteristics in regards to technology would be technology preference (Laver et al., 2011) wherein the act of choosing an empowering technology - such as Wii Fit - significantly influenced the elderly's opinion on the effectiveness of a technology. However, during interviews, technology preference was not included as a potential factor.

Literature has shown that seniors' opinion about a technology impacts their perception about the effectiveness of the technology. For example, in the context of supportive technologies, this perception has been shown as an effective element (Ahn et al., 2008; Umemuro, 2004). Our study also acknowledges the results of adopting

humanoid robots for everyday lives of elderly (Talaie-Khoei et al., 2015). Current research highlights social implications (Kim et al., 2016) such as social context, which has been shown to be a significant factor for the elderly's perceptions of technological effectiveness. In our study, the social implication occurs in the elderly's perception of video games: they are meant for kids. However, a more common example would be that some seniors with medical conditions won't wear neck or wrist monitors because they feel ashamed about wearing a medical device (Steele et al., 2009). Our study is in disagreement with Smith et al. (2002) which demonstrates that seniors were less likely to use self-reporting devices for monitoring health conditions because their family, friends, or neighbors implied that the technology would not work accurately or be useful. One could say that our study is in disagreement with Smith et al. because ours was done in the context of empowering technologies; however, in the earlier referenced adoption of humanoid robotic technology study which also used empowering technologies, it was found that when seniors were advised not to use the proposed intervention by family, friends, or neighbors, they were more likely to quit and avoid using the technology. Again, this was not found in our study. It is possible that this is due to the innate difference between robots and video games, the latter being more technologically complicated. Another possibility could be related to the fact that video games can be used as a means of social interaction - as pointed out by seniors during the study. Seniors were able to interact in social circles which resulted in social context transferring as a motivator rather than a demotivator for the use of the technology. Researchers in the area are encouraged to investigate further reasons between the differences of these two studies.

Finally, we conclude that: (1) the demographic analysis of our results shows that both females and males value their independent living. This is consistent with the findings of (Huang and Dong, 2014); (2) The *transfer effect* of cognitive training video games can be perceived easier by elderly people with technical backgrounds. This is most likely due to the fact that they may better understand the technicalities behind the application of the video games to their daily capabilities; (3) Seniors' opinions about cognitive training video games can influence their perception about the *transfer effect*; (4) Seniors' characteristics can influence their opinion about the *transfer effect* in the application of cognitive training video games (e.g. *a senior with a technical occupation may have developed more innovativeness and technical expertise*); (5) Retired elderly are able to perceive the *transfer effect* more significantly than working elderly who believe that they experience a sufficient level of cognitive exercises each day; (6) The influence of social context can be seen among female seniors more significantly than males. This is consistent with the findings of Braun (2013), which states that women are more influenced by the social context than men.

## 5. Discussion

Various literature (Broekens et al., 2009; Leist, 2013; Magnusson et al., 2004; Or and Karsh, 2009) place value in *perceived usefulness* as a main construct for the adoption of technologies among the elderly; however, this literature fails to recognize the difference between the nature of *perceived usefulness* in supportive technologies versus empowering technologies (Vichitvanichphong et al., 2014a); supportive technologies - such as hearing aids that help older adults in their already declined functional abilities - are easier to recognize as useful than those of empowering technologies - such as Xbox Kinect cognitive training video games - due to the difficulty associated with recognizing long-term effects (Khosravi and Ghapanchi, 2016; Lee and Coughlin, 2015).

The present study investigated the *perceived transfer effect* for the playing of cognitive training video games in order to maintain the basic capabilities that the elderly need in their daily life in order to remain independent. The findings of this paper offer a proof of concept for the notation of the *perceived transfer effect* (see Figure 3) wherein an elderly person can perceive the usefulness of an empowering technology if

she/he believes that the use of the technology improves her/his functional abilities in a way that strengthens or maintains her/his capacity to performing a daily activities, resulting in independent living. Our findings demonstrate that for the elderly to perceive the *transfer effect* of empowering technologies, their characteristics, their opinions about the technology, and social context need to be considered as important factors.

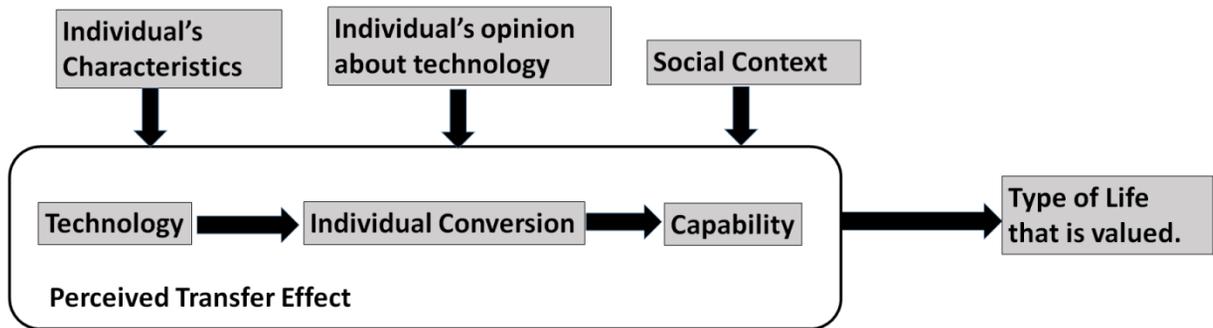


Figure 3 Perceived Transfer Effect: A process to understand the usefulness of empowering technologies

The definition of *dynamic capability* (Winter, 2003) is “the firm’s ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments”. In that regard, we may be able to transfer rapidly changing environments to elderlies beginning to experience decline in their functional abilities which will ultimately result in an inability to live independently. Researchers are encouraged to conduct quantitative research in order to prove the link between *perceived transfer effect* and *dynamic capability*. However, the author recognizes that insufficient evidence exists to generalize the *perceived transfer effect*. This study must serve as a proof of concept for researchers of this field to conduct future studies that can examine this process in other interventions for the elderly.

The current study provides support for the seniors perspective on the potential use of innovative interventions as an inexpensive, motivational, and enjoyable method for providing a *transfer effect* to specific daily capabilities that could help them to remain living independently. The present work looks at possible influences on the elderly’s perception of the *transfer effect* and the adoption of video games. From a practice perspective, this framework provides an empirical reference to aged care and nursing professionals for the issues influencing the elderly’s perception of such an intervention being useful. In addition, the demographic analysis available from this study paper can be used by practitioners to better understand different demographic populations in their adoption of video games for the purpose of improving or maintaining daily capabilities.

## 6. Conclusion

The literature fails to explain how elderly can comprehend the *perceived usefulness* of empowering technologies (Vichitvanichphong et al., 2017). The main objective of this study was to investigate the perception of the elderly through the *transfer effect* of playing cognitive training video games in order to maintain their capabilities that are required to remain living independently. The study introduces the *perceived transfer effect* as a process in which elderlies realized the usefulness of cognitive training video games as to their driving. The study conducted 21 contextual interviews. The seniors who participated in this

study tried Dr. Kawashima's cognitive training video game. The visualization of the *perceived transfer effect* process is available in Figure 2.

## 6.1. Limitations and Future Research

### 6.1.1. Need for Further Quantitative Research

While most of studies in the adoption of assistive technologies among seniors have followed the tradition of quantitative approaches, the complexity of the problem and the dynamics of context have hindered insights into the depth of the problem and the generation of hypotheses to test further (Suchada Vichitvanichphong et al., 2013). Due to this, the objective of this study was to uncover the seniors' perceptions as extracted from contextual interviews; however, the authors acknowledge the need for further qualitative research.

### 6.1.2. Limited Number of Participants

The authors acknowledge the limited number of participants, particularly when analyzing the  $x^2$  metric, and plan to re-run the experiment with an increased quantity of participants, which would increase the reliability of these results.

### 6.1.3. Limited Findings on socio-economic issues

The present study could not provide a sufficient level of depth in socio-economic issues such as cost or technical support. The findings are also limited in terms of emotional aspects. This limitation may motivate researchers in this area to incorporate targeted questions as to these insufficiencies in future interviews that may involve larger data collections.

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