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Abstract

Purpose – As the information society further develops, electronic services are created and physical distribution networks become sparse, it is important to analyse the determinants that inhibit or facilitate the ability to use these services. By focusing on the perceived behavioural control of computers, the purpose of this paper is to analyse how perceived physical restrictions, computer anxiety and ease of use influence the perceptions of control.

Design/methodology/approach – The authors examined older consumers (aged 60-79) in two cross-sectional studies conducted through mail surveys in 2004 and 2012. Randomized samples ($n = 1{,}000$ in 2004 and $n = 3{,}000$ in 2012) were drawn from the Finnish Population Register. The empirical research utilized structural equation modelling through multi-group analysis to explore the differences in the interrelationships between physical restrictions, computer anxiety, perceived ease of use and perceived behavioural control.

Findings – The results indicate that perceived behavioural control is directly influenced by ease of use and indirectly influenced by physical restrictions and computer anxiety. The eight-year time gap moderated only the relationship between physical restrictions and ease of use. Development seems to have been favourable, and device-related restrictions do not decrease ease of use as much as previously reported.

Originality/value – The present study starts a new discussion on how time moderates the relationship of technology perceptions in behavioural models that have been used to predict behavioural intent.

Keywords Behaviour change, Technology adoption,
Consumer behaviour/choice/demand/empowerment/reviews/consumerism,
Technology acceptance model (TAM)

Paper type Research paper

1. Introduction

As the information society develops, differences emerge in the purposes of technology use and perceptions among users because learned behavioural models are dependent on the cultural contexts of living (Wallace *et al.*, 2013; Shin, 2012). Mobile applications, online services, e-government and social media have gained ground as contact interfaces for daily-use services, meaning that all citizens must have a minimum ability to use computer-related devices. To maintain this ability, users must keep up to date, highlighting the importance of continuous learning at the individual level, which has become necessary for survival in this modern information society (Gripenberg, 2011). For instance, older people may use the internet to communicate with family and friends, perform routine tasks, such as banking or shopping, and to access information on health, community resources and a variety of other topics (Kilpeläinen and Seppänen, 2014). However, aging user may experience reduced abilities to use and accept today's technology due to experimental, habitual, functional and cognitive hurdles common in older age (Hanson, 2011; Lin and Hsieh, 2012). To make technology useful and accessible to older adults, the research and design community must "get to know the user" by seeking to understand the needs, preferences and abilities of older people (Vroman *et al.*, 2015). This makes time an important factor, as technological

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development in recent years has been rapid. Users currently aged 65 have different computer-related technology and application ability levels, and there is evidence for the reverse U-shaped behaviour of a person's self-rated ability to use new technology over their lifetime (e.g. Varma and Marler, 2013). In practice, the people adopting today's technologies will experience improved performance and continue using these technologies until further developments erode their capabilities, causing feelings of uncertainty during use.

Because of constantly evolving technologies and development of new ways to use them in daily life, it is important to explore how trait-like attitudes and perceptions towards technology change in populations over time. It is also important to study the stability of relationships between factors associated with technology use (Meuter *et al.*, 2003; Sun and Jeyaraj, 2013). In this paper, we analyse changes in the attitudes of aging people towards technology in a population between two periods. The general attitudes and skills related to basic computer use were selected as the focus of the research due to the greater reliability of measuring technology perceptions as trait-like phenomena instead of task-specific attitudes (Kher *et al.*, 2013). The general assessment of computer skills is not tied to a particular context of technology use, which is useful when studying changes over long periods. Multiple studies have focused on the external influences of an individual's technology use, such as society, effects of training and platform-design-based factors (Kim and Glassman, 2013; Lee and Xia, 2011; Lau and Woods, 2009; Wild *et al.*, 2012; Chang *et al.*, 2015a, b). However, minimal amounts of research in the accepted technology literature include elapsed time as a moderating element (Brown *et al.*, 2010). Recent studies have also assessed professional users in business contexts, still leaving the need to research behaviour in more diverse sets of users unmet (Lau and Woods, 2009). Finally, confirmatory approaches focusing on behavioural dynamics are also called on to explain the changes in population levels (Carpenter and Buday, 2007; Lau and Woods, 2009; Lin and Hsieh, 2012; Wild *et al.*, 2012). We address the recognized research gap, providing a comparative study on technology perceptions in a population over an eight-year period.

The paper provides empirical evidence from two cross-sectional mail surveys that included equal measurements for independent samples in the same population. The surveys were conducted in 2004 and 2012 in southeast Finland. Structural equation modelling was applied to test the proposed hypotheses, which consider the relationships among physical restrictions, anxiety, perceived ease of use and behavioural control of technology. Furthermore, multi-group analysis was done to test whether time influences the interrelations between different perceptions of technology in a population. We discuss the potential influences of technology change on aging technology adopters at the end of the paper.

2. Literature review and hypotheses

2.1 Behavioural and cognitive learning models

The literature on behavioural intentions can be divided into behavioural and cognitive learning models. Behavioural learning models are based on the premise that observable behaviour takes place as a response to specific external stimuli; alternatively, cognitive learning models are important in a situation that requires problem solving or attitude formation before responding to external stimuli (Schiffman and Kanuk, 1983). Research related to innovation adoption uses these models and the theoretical grounds arising from the theory of reasoned action (Fishbein and Ajzen, 1975), the theory of planned behaviour (TPB) (Ajzen, 1985), the technology acceptance

model (TAM) (Davis, 1985) and the diffusion of innovations theory (Rogers, 1983). Attitudes and perceptions towards computer use are related to prior experiences, and the perceived benefits of the technology depend on the user's knowledge and abilities (Martínez-Torres *et al.*, 2015). Depending on research questions and context, as well as the bases for the theories, the literature discusses perceived behavioural control or perceived ease of use to describe the appropriateness of the functional requirements to a user's abilities. Originating from the TPB, perceived behavioural control refers to people's perceptions of the ease or difficulty of performing the behaviour of interest (Ajzen, 1991), which is a higher order construct for commonly used self-efficacy measures (e.g. Kim and Glassman, 2013; Compeau and Higgins, 1995; Pavlou and Fygenson, 2006). In the original model, behavioural control influences both the intention to perform the target behaviour and the actual behaviour. The greater the perceived behavioural control the more likely the behaviour will occur. A person with a pessimistic view of his or her control over the behaviour may never try and may therefore fail to learn whether the behaviour was the most beneficial or effective (Ajzen, 1985; Chien *et al.*, 2014). Behavioural control is based on beliefs that determine the presence or absence of requisite resources and opportunities (Ajzen and Madden, 1986).

The TAM explains user behaviour across a broad range of end-user computing technologies and user populations (Davis *et al.*, 1989). In TAM, the perceived ease of use is defined as an individual's belief that usage experiences are free from significant physical and mental effort, which affects behavioural intentions directly and indirectly (Davis *et al.*, 1989; Davis, 1985). The decomposed TAM combines elements from TPB and TAM within the same model. The decomposed model measures both behavioural control and ease of use but does not provide any evidence of the existence or absence of a bilateral relationship between these concepts; instead, the model assumes that no relationship exists (Taylor and Todd, 1995). This extended model has been modified and applied to consumer acceptance of electronic services (Bhattacherjee, 2000; Hung *et al.*, 2003). Furthermore, Hsieh *et al.* (2008) found that perceived ease of use has a direct positive influence on perceived behavioural control, which drives the continuance of computer use. If connecting ease of use to a lack of physical and mental effort, and connecting behavioural control to the existence of required skills and knowledge, the first hypothesis is:

H1. Perceived ease of use has a positive influence on perceived behavioural control.

At present, the aging part of the population grew up in a world without computers and the internet, which inevitably has an impact on willingness to use computers in daily life. Many elderly consumers were not acquainted with the use of technologies during their careers, and learning to use novel technologies is a voluntary decision. The fear of technology (i.e. technology anxiety) is a common issue being researched among elderly users, and it is typically driven by uncertainty as to whether the innovations will perform as desired (Lunsford and Burnett, 1992). According to Meuter *et al.* (2003), technology anxiety focuses on a user's state of mind regarding his or her ability and willingness to use technology-related tools. Computer anxiety manifests as a fear, apprehension or phobia felt by individuals towards interactions with computers (Chua *et al.*, 1999). At a general level, attitudes towards computers are good predictors of an individual's understanding of computers and experience with them (Potosky and Bobko, 1998), and they decrease or increase the subject's expectations and confidence regarding their ability to performance computer-related tasks (Glass and Knight, 1988).

Therefore, computer anxiety is an essential factor when an individual user judges his or her abilities to perform different tasks using a computer. Thus, we hypothesize:

H2. Computer anxiety has a negative influence on perceived behavioural control.

According to Igbaria and Iivari (1995), computer anxiety has a negative influence on perceived ease of use and a negative total effect on computer use. Computer anxiety has also been linked to the adoption model as having an indirect effect on technology acceptance through perceived ease of use (Phang *et al.*, 2006). Higher levels of computer anxiety indicate that computers are considered complex and difficult to use. Considering current, ongoing trends in the information society, computers and mobile devices should be easy to use, and the general attitudes towards new technologies should be favourable (Haluza and Jungwirth, 2015). Considering the link between anxiety and ease of use, we hypothesize:

H3. Computer anxiety has a negative influence on perceived ease of use.

Technology acceptance and usage models dealing with new technologies and electronic services have added an element that facilitates conditions (e.g. Bhattacherjee, 2000; Hung *et al.*, 2003; Taylor and Todd, 1995), referring to the availability of necessary resources (time and money) and technology compatibilities (Taylor and Todd, 1995). These conditions are related to behavioural control (e.g. Bhattacherjee, 2000). Karahanna and Straub (1999) used the concept of perceived accessibility to cover physical access to information systems, a necessity for system usage. In today's society, connections are readily available and money is not necessarily a limiting resource; instead, devices should be accessible and commensurate with a user's physical abilities. A lack of these abilities may arise, for example, from physical impairment or poor eyesight, thus forming physical restrictions that decrease willingness to use computers or make using them impossible. Shih and Fang (2004) found that self-confidence and the overall feeling of efficacy have significant positive relationships with perceived behavioural control. Persons with disabilities have a proven unwillingness to use computers because of a lower perceived behavioural control due to physical restrictions (Heart and Kalderon, 2013). Thus, we hypothesize that:

H4. Perceived physical restrictions have a negative influence on perceived behavioural control.

Some effort has been made to connect aging-related attributes to computer usage. Phang *et al.* (2006) included a declining physiological condition (i.e. reductions in functioning, such as hearing, speech, locomotion and memory) as a determinant of perceived ease of use in the analysis of e-government service acceptance among senior citizens, but they found no support for predicting perceived ease of use of the services. Opposite to previous, the age and the presence of chronic has shown to negatively influence on the experiences with computers, because the person with disabilities may feel lacking capabilities for effective use (Agree, 2014). In our study, an aging-related decline was measured on a general level, which was not tied to actual use of the appliances. If including the physical characteristics of a device, it is hypothesized that:

H5. Perceived physical restrictions have a negative influence on perceived ease of use.

2.2 Time influence on technology perceptions

Time influence is commonly studied with regard to planned interventions focused on limited groups of professional users where the influence of actual experience,

task-specific attitudes, performance expectancy of use and social influences on acceptance are observed (e.g. Varma and Marler, 2013; Pontiggia and Virili, 2010; Kher *et al.*, 2013; Sun and Jeyaraj, 2013). The reported longitudinal researches demonstrate changes in technology perceptions in a timeframe of a few months to less than two years, which does not directly support the assessment of influences over a long period in a population.

As per the literature, individual beliefs, contextual factors (e.g. social influences), culture and features of technology (e.g. complexity and compatibility) influence computer use over time (Hu *et al.*, 2003; Sun and Jeyaraj, 2013; Peek *et al.*, 2014). Ease of use is influential on perceived behavioural control, which indicates that overall fluency of use is an important factor for the performance of use. However, evidence of the influence of time on the relationship between ease of use and behavioural control is unequivocal. The studies emphasizing social behaviour suggest that users tend to be pragmatic during the initial stages emphasizing ease of use, whereas context-related factors and other benefits have greater influence later (Hu *et al.*, 2003a). In other words, the behavioural control is influenced by the observed social status benefits resulting from use, for instance, when usage has continued over time (Venkatesh and Davis, 2000). The studies targeting cognition models of technology use have provided different evidence for the influence of time on the relationship between ease of use and behavioural control where the influence can be expected to remain stable over time (e.g. Sayago *et al.*, 2013). Perceived ease of use is related to familiarity and attitudes in this case, which results from the accumulation of expertise and the routines of using technology (Sun and Jeyaraj, 2013). The prior experiences of computer use also create mental models, which foster habits to utilize new technologies and develop performance during usage (Ko and Dennis, 2011; Giger *et al.*, 2015). However, the established habits may have detrimental effects on perceived benefits among experienced users, which can override the time influence on other context-related factors shaping behavioural control (Varma and Marler, 2013). Attitudes and habits also have longstanding effects on behavioural control because attitudes created during using experiences tend to change slowly (Barnard *et al.*, 2013; Wang *et al.*, 2013; Sun and Jeyaraj, 2013). Similarly, critical attitudes caused by anxiety may not diminish over time, thereby reducing perceived ease of use with regard to new technologies (Courtois *et al.*, 2014; Carpenter and Buday, 2007; Hanson, 2011; Forquer *et al.*, 2014). Thus, we hypothesize the following at a general level:

H6a. The relationships between computer anxiety, perceived ease of use and perceived behavioural control are the same across the two time points.

Personal characteristics, such as functional ability, influence perceived behavioural control and ease of use, which define an individual's ability to adapt new technology to the routines of daily life (Hu *et al.*, 2003; Kher *et al.*, 2013; Kim and Glassman, 2013; Sintonen and Immonen, 2013; Chang *et al.*, 2015a, b). The studies focusing on long-term use of computers have found that the evolution of technology causes similar outcomes as the rate of natural age-related physical and cognitive impairments increase, regardless of an individual's prior experiences, skills or abilities (Hanson, 2011; Harper *et al.*, 2011). This finding is significant because it reveals that time erodes the effects of some positive drivers for computer use because of natural aging and continuously expressed new technologies. In practise, even a mild natural functional decline may decrease motoric, hearing or vision capabilities, resulting in an inability to adapt information from changed user environments (Harper *et al.*, 2011). Thus, if the effect

of natural functional decline in older age and the evolution of technology are assessed over the long term, a general hypothesis for the time effect at the population level is as follows:

H6b. Perceived physical restrictions will have a similar influence on perceived ease of use and on perceived behavioural control at two time points.

The research from the literature review is presented in Figure 1, which captures the key concepts and summarizes the research hypotheses. The research model is twofold, where anxiety measures, general attitudes towards computer usage and physical restrictions describe the influence of general functional limitations on usability factors. Age is used as a control variable in the model.

3. Methods

3.1 Sample and demographics

The empirical evidence was gathered from two cross-sectional mail surveys distributed in southeast Finland and conducted in the last quarters of 2004 and 2012. The selected approach produces an eight-year timeframe to test the differences in technology perceptions. The first study targeted a sample of 1,000 individuals aged 55-79, of whom 556 provided responses. The second study targeted individuals aged 60-90 years using a random sample of 3,000, resulting in 1,121 valid responses. The samples for the first and second studies were drawn from the Finnish Population Register and divided into five-year categories with the sample frames based on population age distribution. The age and gender distribution was in line with the true population in both surveys.

Given the differences in age ranges between the studies, the present study was limited to individuals aged 60-79 to ensure equal age distribution. Additionally, because the present research focused on personal attitudes and perceptions related to computer usage, it was necessary to filter out elderly individuals who had neither experience nor the possibility of computer usage. Consequently, the first data set included 143 and the second included 435 respondents.

The descriptive demographics are presented in Table I, with a focus on the respondents included in the analyses. A comparison of the data sets showed no significant differences in

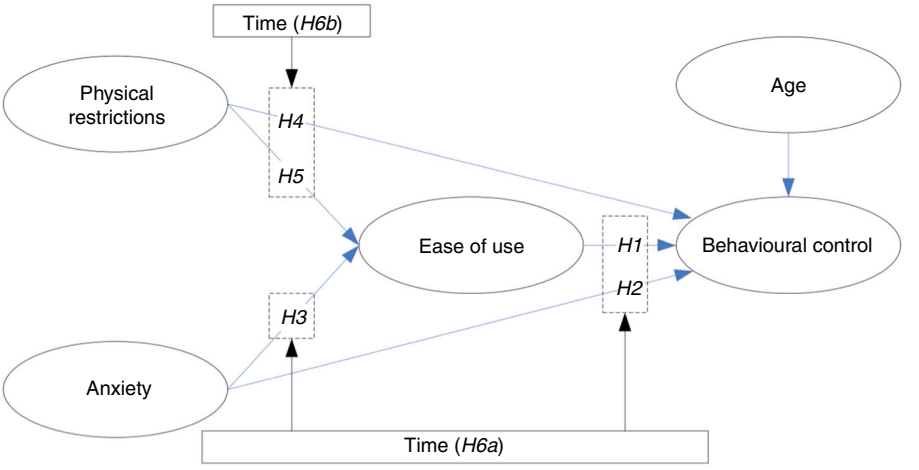

Figure 1.
Research model

	Study 2004 ($n = 143$)	Study 2012 ($n = 435$)
Age		
Mean	65.97	66.18
SD	4.82	4.08
Gender (%)		
Female	52.2	50.7
Male	47.8	49.3
Marital status (%)		
Living with a spouse	72.3	82.0
Single	4.9	3.4
Divorced	12.0	6.8
Widowed	10.9	7.7

Table I. Descriptive information of the studies

age distribution; moreover, the gender distribution was statistically the same. There were slight differences in marital status because the first study had a greater share of divorced or widowed individuals. Both studies comprised respondents living independently in the community.

3.2 Analysis method

The empirical analysis comprised structural equation modelling using LISREL to test the proposed hypotheses. For the structural model, polychoric correlations with asymptotic covariances were used as input data, given the ordinal nature of the variables (Olsson, 1979). The unweighted least squares estimation method was used and had no assumption about the distribution of observed variables (Long, 1983). The modelling used a multi-group analysis approach to compare the two data sets. Before testing the hypotheses, the measurement invariance was verified, meaning that the confirmatory factor analysis was conducted simultaneously for both study points. The procedure included phases of structural invariance (the composition of the measurement model is the same in both groups); metric invariance (equal factor loadings exist in both groups); and factor variance invariance (Byrne and Miller, 2009; Steenkamp and Baumgartner, 1998).

4. Research model, key concepts and measurements

The computer-related concepts illustrated in Figure 1 were each measured using two items. Considering the target population and the data collection method, it was necessary to keep the measurement scales as short as possible to avoid frustrating and exhausting the respondents. All items were statements measured using a five-point Likert scale that ranged from complete disagreement to complete agreement.

The two items selected for measuring perceived behavioural control were based on studies by Morris and Venkatesh (2000) and Taylor and Todd (1995). Revisions were made to match the present context. The measurement of perceived ease of use was obtained and modified from O'Cass and Fenech (2003). Two items were selected to measure ease of use, referring to ease and comfort in using computers. Item selection was based on the study's goal to make a clear distinction between two highly related concepts.

Prior literature used numerous measurement scales to gauge computer anxiety (e.g. Cohen and Waugh, 1989; Loyd and Loyd, 1985; Selwyn, 1997). Each study discovered elements such as fear, discomfort, insecurity and embarrassment tied to computers and their usage. The short two-item measures of anxiety consisted of feelings of fear and embarrassment. Perceived physical restrictions in using computers were reflected through two items addressing usage difficulties related to the keyboard and the screen size.

The measurement model was verified using confirmatory factor analysis, and it was estimated for both groups at the same time to confirm the measurement invariance. The measurement invariance was achieved, indicating that the factor loadings, intercepts and residual variances across the groups were the same. Because the numbers from observation were somewhat inadequate for use with the full latent factor structure in the path analysis, summated scales were applied through computing indicator error variances from the summated scale variance and the composite reliability (CR) (see Fisher and Price, 1992).

Table II summarizes the measurements of the key concepts based on a latent factor structure. The measurement reliabilities were assessed using CR and level of average variance extracted (AVE), both based on factor loadings and error variances (e.g. Diamantopoulos and Siguaw, 2000; Fornell and Larcker, 1981). The CR coefficient should exceed 0.50, which approximately corresponds to a standardized loading of 0.70 (Hair *et al.*, 1998). If the AVE is less than 0.50, the variance attributable to measurement error is larger than the variance captured by the construct (Fornell and Larcker, 1981). CR and AVE were computed separately for both studies after assessing configural invariance. Slight differences between the groups occurred in the coefficients concerning ease of use, computer anxiety and physical restrictions. The level of measurement reliability was higher in the latter study. This is related to the differences in error variances and is considered typical when the sample sizes are different.

For descriptive purposes, Table III summarizes the means and standard deviations of the measured concepts using summated scales. Comparing the means between the study points with a *t*-test revealed that the levels of perceived behavioural control

	Study 2004 ($n = 143$)	Study 2012 ($n = 435$)	Both samples after measurement invariance
Behavioural control			
CR	0.947	0.946	0.946
AVE	0.900	0.897	0.898
Ease of use			
CR	0.808	0.895	0.847
AVE	0.679	0.811	0.736
Computer anxiety			
CR	0.756	0.825	0.808
AVE	0.610	0.702	0.677
Physical restrictions			
CR	0.861	0.812	0.823
AVE	0.760	0.686	0.702

Table II. Measurement reliabilities

and ease of use increased over the years. Additionally, the level of perceived physical restrictions decreased. Only computer anxiety remained statistically the same.

5. Results of the multi-group modelling

Table IV summarizes the modelling results. The model produced an excellent fit for the data, as indicated by the χ^2 test, the normed fit index (NFI), the non-normed fit index (NNFI) and the root mean square error of approximation (RMSEA) (e.g. Hair *et al.*, 1998; Kelloway, 1998). For each path, the standardized path coefficient was reported, including its level of significance. The first part of the table (the unrestricted model) gathers the results of the basic model estimated separately for both groups. The second part of the table (the restricted model) includes the results of the comparison of the path coefficients across the groups.

H1 suggested that perceived ease of use has a positive relationship with perceived behavioural control, and this is supported by the results in both groups. A relatively high and positive path coefficient indicates that behavioural control strongly depends on ease of use. *H2* proposed that computer anxiety has a negative influence on behavioural control, but this hypothesis was not supported by the analysis. Accordingly, *H2* is rejected. *H3* concerned the relationship between anxiety and ease of use. For both groups, the path coefficient was statistically significant and negative, as expected; therefore, *H3* is accepted. *H4* and *H5* discussed the effect of perceived physical restrictions on behavioural control and ease of use. Concerning behavioural control, only a weak but significant coefficient appeared in the group of the latter study, thus partly supporting *H4*. In this group, higher physical restrictions produced lower perceptions of behavioural

	Study 2004 ($n = 143$)		Study 2012 ($n = 435$)	
Technology perceptions	Mean	SD	Mean	SD
Behavioural control*	2.78	1.320	3.42	1.252
Ease of use*	3.49	1.034	3.77	1.076
Physical restrictions*	2.62	1.295	2.14	1.037
Computer anxiety	2.04	1.040	2.10	1.079

Note: *t-test for mean difference, significant at $p < 0.001$

Table III. Descriptive analysis of technology perceptions between the samples

Unrestricted model				Restricted model	
Hypothesis	Path	Study 2004	Study 2012	Hypothesis	$d\chi^2$ (ddf = 1)[a]
H1	Ease of use→behavioural control	0.927****	0.745**	*H6a*	−1.70
H2	Anxiety→behavioural control	−0.044	−0.163	*H6a*	−0.90
H3	Anxiety→ease of use	−0.655****	−0.724****	*H6a*	1.55
H4	Physical restrictions→behavioural control	0.025	−0.092*	*H6b*	0.36
H5	Physical restrictions→ease of use	−0.359****	−0.165***	*H6b*	3.94**
Control	Age→behavioural control	0.035*	0.020**	Control	0.14

Notes: Unrestricted model statistics: $\chi^2 = 19.87$ ($p = 0.010$); df = 7; NFI = 0.975; NNFI = 0.952; RMSEA = 0.079. [a]$d\chi^2$ is the change in the model's χ^2 when the degrees of freedom in the model changed by one unit (ddf = 1). *$p < 0.100$; **$p < 0.050$; ***$p < 0.010$; ****$p < 0.001$

Table IV. Modelling results

control. From this unrestricted model, the analysis supported *H5*, indicating that physical restrictions negatively influence perceived ease of use.

The next step in the analysis was to examine whether the path coefficients estimated in the unrestricted model were statistically the same across the groups (*H6a* and *H6b*). To test the assumptions, each of the paths was forced to be the same across the groups. That is, when estimating the model, each path (e.g. ease of use to behavioural control) was estimated for the first study and assumed the same for the second study, rather than freely estimated. The change in the model's χ^2 ($d\chi^2$ in Table IV) was used as an indicator of model deterioration if the paths of the groups differed significantly from one another.

H6a focused on exploring the group-wise differences in the relationships between anxiety, ease of use and behavioural control. No deterioration was found in the model when the following paths were fixed to be the same across both studies: ease of use to control; anxiety to control; and anxiety to ease of use. This result clearly supports *H6a* in that the relationships are statistically the same across the two groups. The final *H6b* was tested by forcing the paths from physical restriction to behavioural control and ease of use to be the same across the studies. A significant difference was found in the effect of physical restriction on perceived ease of use, which led to the conclusion that *H6b* is only partially supported. This result suggests that the negative influence was stronger in the previous study and that the higher perceptions related to physical restriction had less of an effect on perceived ease of use in the latter study.

Age was used as a control variable to predict behavioural control. In both data sets, age was a significant but rather weak predictor of behavioural control. Interestingly, the coefficient was positive, thus indicating that older respondents perceived higher behavioural control. The group-wise differences concerning age were insignificant.

To understand the complete effects of physical restrictions and anxiety, indirect effects in addition to direct effects were estimated for the model. The standardized indirect effects are presented in Table V. As shown, the indirect effect of computer anxiety through ease of use is quite high and statistically significant during both periods. Anxiety had no direct effect on behavioural control, and it seems to contribute to control only through ease of use. Physical restrictions had a relatively weak direct effect and only in the latter study. Based on the estimated indirect effect, the results suggest that physical restrictions primarily influence behavioural control indirectly through ease of use.

6. Discussion and conclusions

The present study starts a new discussion on how time moderates the relationships of technology perceptions in behavioural models that have been used to predict behavioural intention. The purpose of this study was to analyse how an eight-year time gap changed users' perceptions of technology and the interrelations of factors influencing technology usage at the population level. Time was attached to the model

Table V. Standardized indirect effects

Indirect effects	Study 2004	Study 2012
Anxiety→behavioural control	−0.619***	−0.536***
Physical restrictions→behavioural control	−0.339**	−0.122*

Notes: *$p < 0.100$; **$p < 0.050$; ***$p < 0.001$

developed to moderate the perceived behavioural control of computers. The empirical evidence of the study was gathered from two cross-sectional mail surveys conducted in 2004 and 2012 in southeast Finland, which included equal measurements for independent samples.

The hypotheses in this study were partially confirmed. Table VI summarizes the findings from the study in contrast to the set hypotheses. The perceived ease of use had a strong influence on behavioural control over computers, which was also similar in both years. Attitudes towards computer use had similar influences on technology usage perception in both groups, indicating stability of the attitude factor. Physical restrictions to computer usage had differentiating influences on perceived ease of use and behavioural control. The relationship between perceived functional restrictions and perceived ease of use was also moderated by time.

Considering the research gap in the field of behavioural models, including technology perceptions, the present study shows how technological development over the years has changed the relationships between attitudinal perceptions towards computers while also providing information on what relationships have been stable over the research period. The focus on elderly people is important because they represent a growing market.

The study contributes a conceptual discussion on factors influencing technology acceptance and usage. Although the concepts of ease of use and behavioural control arise from different grounds, the conceptual distinction between these dimensions is clear. The estimation procedure did not suggest any significant modification indices for the measurement model. This result, together with a high level of reliability and invariance, suggests that ease of use and behavioural control can be dealt with as separate concepts. The connection between these concepts has not been widely analysed, and studies using the decomposed TAM (e.g. Taylor and Todd, 1995; Bhattacherjee, 2000) measured these concepts independently despite the similarities between the concepts and their operationalizations.

Hypothesis	Conclusion	
Structural model		
H1	Supported	The influence between effortless use and perceived control of computers is strong in both groups
H2	Not supported	A significant relationship between attitudes towards and perceived control of computers was not found
H3	Supported	Negative attitudes towards technology have a strong negative relationship with user's perceived ease of use
H4	Partially supported	A minor statistically significant relationship between physical restrictions and behavioural control was found in the recent study
H5	Supported	Physical restrictions have a significant moderate influence on user's perceptions of ease of use
Time influence on interrelationships in the model		
H6a	Supported	Ease of use has a constant influence on behaviour control over time. Indeed attitudes cause similar effects to perceptions related to usage
H6b	Partially supported	Physical restrictions to using a computer were found to have a significantly lower influence on perceived ease of use in the recent research

Table VI. Summary of the findings

6.1 Theoretical implications regarding time influence

Before testing the proposed hypotheses, the descriptive analysis revealed several interesting time-related features of technology perceptions across the studies. The ease of use and behavioural control of computers has improved over time where statistically significant differences were found. In the later study, improved computer-use capability is not in line with earlier researches, which expected usage to be a problem in older age due to a higher occurrence of memory disorders (Hanson, 2011). The results could also be explained by the sample, which was gathered mainly from persons living independently. Physical restrictions to computer usage slightly decreased in the population over the study period. Similar changes were expected in the literature in which prior experience with computers and technology acceptance increase because of accumulated skills (Kher *et al.*, 2013; Kim and Glassman, 2013). Interestingly, the research data showed no existing differences in computer anxiety between the studied time points, which confirms the reported findings that the general attitudes are constant trait-like factors that vary slowly (Hanson, 2011; Lin and Hsieh, 2012; Meuter *et al.*, 2003). Through our research findings, it is suggested that a person's self-rated abilities to use new technology may reach an inflection point at some stage (Varma and Marler, 2013).

At the model level, we made several observations. The structural model showed that perceived behavioural control strongly depends on perceived ease of use, and the influence of computer anxiety, as well as physical restrictions, is primarily mediated through ease of use. We suggest that perceived ease of use is a stable and significant determinant of perceived behavioural control, which emphasizes the importance of effortless usage over time. Similarly, prior research has found that effortless usage of technology leads to experiences of usefulness and controllability (Carpenter and Buday, 2007; Hanson, 2011; Sun and Jeyaraj, 2013). In line with the literature, the findings also indicate that both computer anxiety and physical restrictions are sources of uncertainty regarding computer usage, which could inhibit the perceived benefits of using the technology (Glass and Knight, 1988; Igbaria and Iivari, 1995; Heart and Kalderon, 2013). Computer anxiety was also found to have a stable influence on ease of use over time in our data. This finding supports earlier reported observations on the detrimental effects of habits and routines on using new technologies developed over time (Varma and Marler, 2013; Wang *et al.*, 2013). One statistically significant time moderation was found concerning the influence of physical restrictions on perceived ease of use, which decreased over time. The finding is similar to the expectations in the literature, which compare technology acceptance between initial and later stages of use. We assume that the diminishing dependence between functional ability and ease of use is driven by today's elder user who has a greater ability to adapt technology to their daily activities (Hu *et al.*, 2003), as well as the effect of prior computer usage in searching for effective ways to use technology (Ko and Dennis, 2011). Furthermore, we suppose that functional decline is not so influential on technology usage in the future, as was expected in previous studies (Harper *et al.*, 2011).

Overall, considering the literature related to innovation adoption categories, the description of the late majority is very suitable for the elderly: "You do not buy unless comfortable with your ability to use the technology. As a result, you wait until something has become an established standard, and even then you want to see lots of support" (Yi *et al.*, 2006). However, considering computer usage in the present study, the development of an information society has affected how physical restrictions influence the ease of use of appliances. A strong relationship exists between computer

anxiety and ease of use, suggesting that sources of insecurity using novel technologies cannot be neglected in research focused on aging consumers.

6.2 Practical implications

The share of aging consumers is growing, but the influence of negative attitudes remains the same. Thus, computer use still seems to cause discomfort among older users, which potentially arises from a lack of prior experience with novel technologies. The differences between groups regarding the indirect effect of physical restrictions on behavioural control may indicate that present interface designs are more usable for aging users with different experience levels.

As the selection of self-services on the internet increases and the provision of traditional face-to-face services diminishes, aging consumers face the challenge of learning how to access the sphere of computer-facilitated services. The present study provides several practical outcomes for both the initial and later stages of use. Recent studies stated that appropriately designed interfaces improve elderly access to technologies (Carpenter and Buday, 2007; Harper *et al.*, 2011), which, by our findings, means effortless use and the fit of processes to habits. We propose that cognition of users and learned behavioural models should be better employed in appliance design and service information content.

Computer anxiety in this study appears to have a negative effect on perceptions about the value of technology. However, education has contributed to a decrease in technology anxiety (Wild *et al.*, 2012), and awareness of the usefulness of technology is influential on elderly usage because it promotes the perception of benefits (Carpenter and Buday, 2007). Our findings also support that adequate lifelong training is needed for all groups to support the ability to use technologies later in life (Gripenberg, 2011; Hanson, 2011; Lin and Hsieh, 2012; Sintonen and Immonen, 2013).

6.3 Research limitations and future research directions

Cross-sectional research is always limited because measurements are based on subjective opinions, but no other method exists to obtain these measurements. Additionally, the present research focused on a limited target group in terms of age. Future work should address other user demographics in the population to gather a deeper understanding of the mechanisms of how the development of electronic devices and services has changed behaviours and attitudes over time. In contrast, a limited scope provides implications from a practical point of view rather than only theoretical generalizations. The present study also concentrated on computers, and replicating the study particularly for electronic services would provide valuable insights into service design in general. Finally, even though the present study provides evidence from an eight-year period by comparative methods, true longitudinal researches are needed to confirm reverse U-shaped patterns of technology usage at individual ability levels over long periods.

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Appendix. Measurement items

Behavioural control

- I have the knowledge necessary to use a computer.
- I have control over using a computer.

Ease of use

- I find computers easy to use.
- Using computers is pleasant.

Physical restrictions

- Size of the computer screen makes computer difficult to use.
- Size of the keyboard buttons makes computer difficult to use.

Anxiety

- Computers frighten me.
- Using a computer makes me feel nervous.

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