Designing Intrinsically Motivating User Interfaces for the Ageing Population

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Abstract. Older people often find it difficult to learn to use new technology. Although they may want to adopt it, they can find the learning process challenging and frustrating and subsequently lose motivation. This paper looks at how psychological theories of intrinsic motivation could be applied to make the ICT learning process more engaging for older users and describes an experiment set up to test the applicability of these theories to user interface (UI) design. The results of the experiment confirmed that intrinsic motivation theory is a valid lens through which to look at current ICT design and also uncovered significant gender differences in reaction to different kinds of learning tasks.

Keywords: UI design, intrinsic motivation, ageing population, gender.

1 Introduction

For many people, it is hard to imagine the world without the Internet. The ability to acquire almost unlimited information and communicate with almost anyone at any time has transformed the way we live our lives. Mobile computing devices have had a similarly drastic effect, removing the barrier of physical location to internet access.

To a significant proportion of the population, however, these technologies create more problems than they solve. Access to information and services is increasingly moving online, and being able to use Information and Communication Technology (ICT) has the ability to improve the quality of life, particularly through preventative healthcare and increased independence, of older people [1]. However, people who do not have experience with modern ICT can face many challenges as they try to learn to use the technology that is becoming increasingly universal [2].

Although there is the common perception that older people immediately fear or reject new technological developments, this is largely not the case [3]. However, research has shown that as people age, their priorities shift more towards the present and away from the future. In other words, they will favour an activity that is immediately enjoyable over one that has a supposed long-term benefit [4, 5]. ICT that presents too many challenges during learning, even if it would have many benefits for the user, will therefore drive away many older users.

This in turn necessitates investigation into how to make the initial phases of learning more enjoyable and engaging to motivate older learners and novice users to adopt

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ICT. Enjoyable and engaging experiences fall under the purview of motivation theory, specifically the subset of this theory that pertains to intrinsic motivation. The focus of this paper is therefore on the application of theories of intrinsic motivation to design of inclusive and motivating ICT for the ageing population.

There are two components to this research: theoretical and experimental. This paper correspondingly discusses the theories of intrinsic motivation that are potentially relevant to inclusive user interface design and analyses the results of an experiment done to test the experimental framework and discusses the design implication of these results. This work ultimately aims to help facilitate improved accessibility to online resources by motivating the adoption of ICT through higher levels of intrinsic motivation in older users.

2 Intrinsic Motivation and Design

Psychological theories of motivation have divided human motivation into two categories: extrinsic and intrinsic motivation. Extrinsic motivation is when a person is motivated by a particular goal, for example running every day to prepare for a marathon. Intrinsic motivation, in contrast, is when a person is motivated by enjoyment of an activity itself – running just for the fun of it instead of to get in shape for an upcoming race. Because older people are more concerned about having enjoyable experiences, intrinsic motivation is a critical construct to harness for designers.

Intrinsic motivation is well-studied in the psychology literature, and there are several prominent theories that are relevant to the current research, specifically Self-Determination Theory (SDT) [6], Flow [7], Theory of Intrinsically Motivating Instruction [8], and 2 x 2 Achievement Motivation Theory [9]. Although these theories are not covered in depth here, a more detailed review can be found in Goldhaber et al. [10]. Figure 1 diagrams the various components of each theory and how they relate to each other.

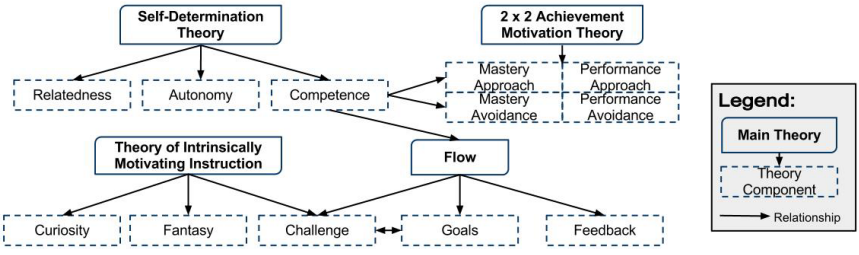

Fig. 1. How the intrinsic motivation theories relate to each other. Adapted from Goldhaber et al. (2012)

The most important concept for the present research is competence, a key focus of both SDT and Flow theory. Both theories explain that if a person does not feel competent – able to cope with the challenges of a situation or task – then that will cause them to feel frustrated or anxious, leading to a decrease in intrinsic motivation.

3 Hypotheses and Methods

The above theories were used in this research to inform a set of hypotheses about what interface modifications could lead to a higher level of intrinsic motivation in users [10]. The first hypothesis was that the methods taken from intrinsic motivation research would be applicable to studying how older people reacted to novel tasks on novel interfaces (in this case a game on a touch-screen device). The second was that generating high feelings of competence or self-efficacy in users would lead to higher levels of overall motivation.

Therefore, the purpose of the experiment described here was two-fold. Firstly, it was done to validate that the methods used in intrinsic motivation research were appropriate in the context of design research for the ageing population. It was expected that there would be strong and significant correlations between constructs in the intrinsic motivation literature, such as autonomy and competence. Second, it was predicted that participants would find the easier Angry Birds condition the most motivating, as it gave sufficient levels of feedback that they could feel competent while being easy enough that playing it posed an appropriate level of challenge.

The experiment itself involved having people over the age of 60 play one of three games: a boring but easy game, a slightly more complex but engaging game, and an interesting but highly complex and challenging game. The boring and very challenging games were meant to be less motivating, whereas the engaging game was meant to be more motivating. Push Button, the boring game, involved having participants push buttons on a screen in a particular order, and the screen regenerated a different set of random numbers when they had finished. There was no feedback or variation in the level of challenge, nor was there a way to correct errors. The engaging and overly challenging games were versions of the popular touch-screen game Angry Birds. In the easier condition, participants played from Level 1, but in the harder condition ("Angry Birds Advanced"), participants began playing on a very advanced and complicated level. The three conditions are shown in Figure 2.

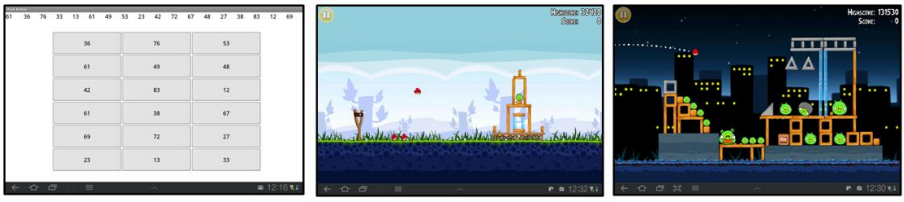

Fig. 2. The three experimental conditions. From left to right: Push Button (an easy but boring game), Angry Birds (a popular game for touch-screen devices), and Angry Birds Advanced, the same game started from a very hard level.

Participants were taught how to play the game and then asked to play for 15 minutes. After 15 minutes, the experimenter left the room to get a questionnaire for the participant, but the participant was told that he or she could keep playing the game if desired. As study sessions were video recorded, it was possible to see if participants

enjoyed the game enough to keep playing. This is a common method to determine levels of participant engagement in intrinsic motivation research [11, 12]. Participants then completed a questionnaire based on several inventories previously used in the intrinsic motivation literature to measure their levels of anxiety, perceived competence, autonomy, and interest/enjoyment. The questionnaire included items from the Intrinsic Motivation Inventory and Perceived Competence inventory [13], the Player Experience of Need Satisfaction (PENS) inventory [14], and new questions measuring levels of confidence in and desire for future game play or use of the technology that were developed and included based on similar questions from inventories in the literature [15, 16].

4 Results

Thirty participants (18 female) over the age of 60 were recruited from educational centres in Cambridge and London (mean age 72). In order to check the validity of the theoretical constructs underpinning the research, a table of correlations was drawn up looking at the variables measured: Interest/Enjoyment, Autonomy, Perceived Competence, Pressure/Tension, and Free Choice Behaviour. Interest/Enjoyment ($\alpha = 0.958$), Autonomy ($\alpha = 0.957$), Pressure/Tension ($\alpha = 0.838$), and Perceived Competence ($\alpha = 0.831$) scores were computed using an average of all responses in that category on the questionnaire (i.e. the total Interest/Enjoyment score would be the average of all responses from the IMI and PENS). Free Choice Behaviour was measured as the number of minutes a participant kept playing the game after the experimenter left the room. Correlations (Pearson, n = 30) between scores are shown in Table 1.

Table 1. Pearson correlations between different measures of motivation. Significant correlations are shown in italics.

	Free Choice Behaviour	**Autonomy Score**	**Perceived Competence Score**	**Interest/ Enjoyment Score**	**Pressure/ Tension Score**
Free Choice Behaviour		*r = .401 (p = .028)*	r = .288 (p = .123)	*r = .423 (p = .028)*	r = -.217 (p = .250)
Autonomy Score	*r = .401 (p = .028)*		*r = .722 (p = .000)*	*r = .817 (p = .000)*	r = -.309 (p = .097)
Perceived Competence Score	r = .288 (p = .123)	r = .722 (p = .000)		*r = .645 (p = .000)*	r = -.299 (p = .109)
Interest/ Enjoyment Score	*r = .423 (p = .028)*	*r = .817 (p = .000)*	*r = .645 (p = .000)*		r = -.317 (p = .088)
Pressure/ Tension Score	r = -.217 (p = .250)	r = -.309 (p = .097)	r = -.299 (p = .109)	r = -.317 (p = .088)	

The correlations in Table 1 conform to the theories used in the experimental design – namely SDT. In particular, strong correlations are seen between the constructs of Autonomy, Interest/Enjoyment, and Perceived Competence, which are predicted by SDT and have been replicated numerous times in other studies. In addition, Free

Choice Behaviour is significantly correlated with both Autonomy and Interest/Enjoyment, indicating its strong potential to act as a more implicit measure of intrinsic motivation. Because the Pressure/Tension score did not appear to correlate with any of the other constructs and was not significantly different across conditions, it is excluded in further analysis.

A one-way ANOVA was conducted and revealed no significant differences between conditions. In addition, post-hoc tests also revealed no significant differences. However, in order to understand if variables like gender or computer experience affected the results at all, independent 2-way ANOVAs were conducted with computer experience and gender as categorical variables (in addition to condition). Although most categories showed no significant differences, the data split by condition and gender returned the graphs shown in Figure 3.

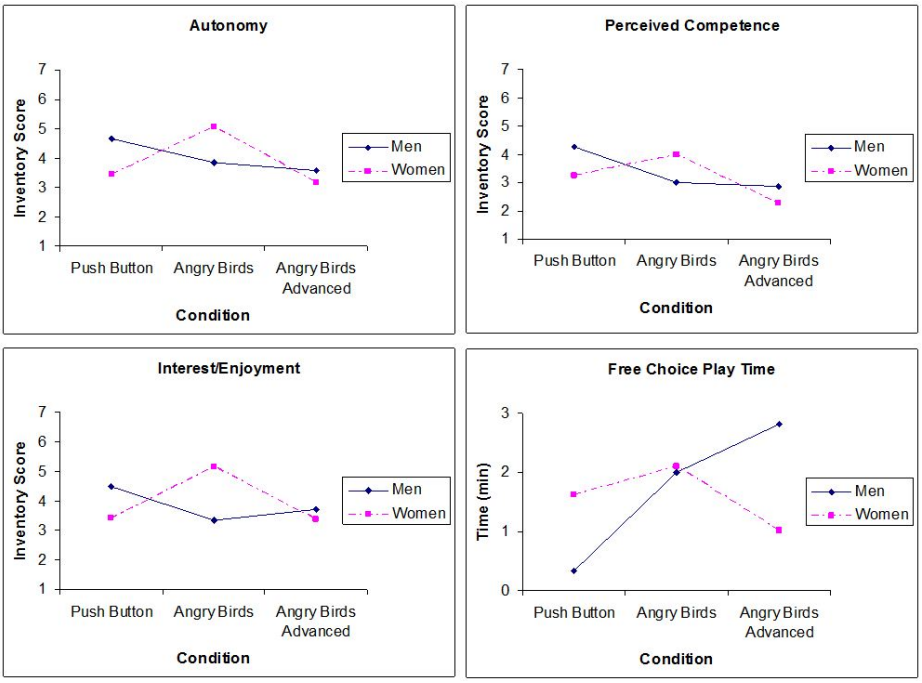

Fig. 3. Graphs of participant scores on Autonomy, Perceived Competence, Interest/Enjoyment, and Free Choice Behaviour split by gender

For most of the inventory responses, the difference between genders is not significant (the differences in free choice behaviour were significant). However, the p values are low enough to merit further investigation, particularly as the pattern of responses for men and women tends to be opposite and at times seemingly contradictory.

Women appear to have the highest levels of autonomy, perceived competence, and interest/enjoyment in condition 2 (Angry Birds), whereas men have the highest levels for condition 1 (Push Button). While the pattern of free choice behaviour follows

predictions for women – higher levels of interest/enjoyment, perceived competence, etc. should theoretically positively affect free choice preference – men have exactly the opposite reaction. Although they report higher levels of interest/enjoyment, perceived competence, and autonomy for Push Button, their free choice preferences levels are highest for condition 3 (Angry Birds Advanced) for which they had the lowest scores on the inventories. Furthermore, the gender differences in free choice behaviour are significant ($p = 0.042$). These counterintuitive results therefore merit further investigation, especially considering their presence even in a small and uneven sample.

The results of this study necessitate a closer look at the existing literature examining gender differences in constructs like self-efficacy and achievement orientation. Although not often referenced in the design literature, there is a rich history of gender research with a particular focus on learning and learning differences. Examined in the context of the current study, it can help explain some of the gender differences found and potentially indicate how they could be rectified through improved design. Some of this literature is summarised in the following section.

5 Gender Differences in Learning

Self-efficacy is the belief a person has that he or she can successfully carry out a task. For learning, it is an incredibly important construct as feelings of capability are related to how well someone learns and what tasks they pursue [17]. There is a plethora of literature demonstrating that women tend to have lower self-efficacy and achievement expectancies compared to men and rate their performance as worse than men even when their abilities are equal [18]. The differences seem to be more severe in certain situations. For example, women have lower self-efficacy for tasks or occupations seen as traditionally male or masculine, such as complex computer tasks [19, 20].

In addition, and likely related to, women's lower self-efficacy, women also tend to be less competitive, more risk-averse, and more averse to high levels of challenge [21-23]. Niederle and Yestrumskas [23] found that, given a choice between an easy or hard task, women sought out challenge less than men. Related to this is women's increased risk-aversion. Byrnes et al. [22] found that men take too many risks, whereas women decline to take risks even in safe, consequence-free environments and situations. This may also affect how men and women respond to different kinds of rewards and feedback [24].

Women seem to have a somewhat more averse reaction to challenge or confusion. For example, in a group of high-achieving men and women of equal ability, men improve their effort and performance after a period of confusion or challenge, whereas women's performance gets worse [25, 26]. This is very relevant to learning new technological skills, because these results indicate that women are particularly susceptible to failure early-on during learning, a situation that has yet to be rectified in the majority of ICT designs.

How men and women view their own skills is also important. Dweck [25] writes about the tendency of girls to view ability as innate and unchangeable, whereas boys view ability as flexible and as changing with increased effort. A rigid view of ability is detrimental to overcoming challenges or pursuing an activity past an initial failure since an innate and unchangeable ability is unlikely to respond to increased efforts. Someone with a rigid perception of their ability is therefore likely to see failure as an indication that they are not suited to the task at hand, not that they should try harder.

It is worth noting that a rigid view of ability for women and a flexible one for men helps to explain one of the most confusing aspects of the data of the current experiment: why men would spend the most time playing Angry Birds Advanced, a game on which they did not do well and which they did not report enjoying. Men chose to redouble their efforts in response to failure whereas women spent more time playing the games at which they felt most competent. Dweck states that: "We had found in our past research that viewing intellectual ability as a gift (a fixed entity) led students to question that ability and lose motivation when they encountered setbacks. In contrast, viewing intellectual ability as a quality that could be developed led them to seek active and effective remedies in the face of difficulty" [25]. When comparing the scores for Confidence in Future Use and Free Choice Play Time between men and women, the trend appears to exactly follow Dweck's findings.

The work of Dweck and others indicates that if there were a way to encourage a more flexible self-view in users, it could have huge implications for ICT learning. What is clear is that design must take into consideration the need to emphasis flexible learning and rewarding effort. An interface with low levels of transparency or feedback in particular has the potential to de-motivate individuals with a rigid achievement orientation.

In an alternate perspective, Koszegi [27] introduces the concept of "Ego Utility": the importance of self-image to an individual and how that motivates their actions. "Overconfidence in beliefs can be coupled with underconfidence in observed actions. In fact, among people who are identical other than in the importance they attach to ego utility, there is a negative relationship between confidence and participation in the ambitious task," Koszegi explains. In other words, an individual might not choose a task that he or she feels confident about precisely because he or she does not want to be proven wrong or shown that the task is in fact beyond his or her ability. Similarly but counter-intuitively, someone with high ego-utility might continue with a very hard task (at which they are not doing well) to attempt to prove their ability in the hopes of maintaining their ego.

This theory actually explains the data of the current study fairly well. Men generally have high ego-utility (since Koszegi asserts that overconfidence is associated with high ego-utility) and therefore don't keep playing a game such as Push Button in which they already have high confidence. This also explains why Interest/Enjoyment was higher for the games the men didn't keep playing - they enjoyed having their positive self-image reinforced, but didn't want to keep "collecting data" about themselves that might harm that image.

Conversely, women have a lower confidence/ego-utility. Therefore, for women, there is a positive relationship between Perceived Competence/Enjoyment and Free

Choice Behaviour. However, women played the least for the game at which they felt the least competent (Advanced Angry Birds). This likely is related to avoiding the reinforcement of an already negative self-image with more negative information, meaning that perceived competence is critical to free choice behaviour for low ego-utility individuals.

6 Conclusions and Recommendations

The purpose of this research was to see if intrinsic motivation theory could be applied to user interface design, and an experiment was conducted to investigate how methods from the intrinsic motivation literature helped to explain older people's interaction with an unfamiliar task on a new user interface. The results of this experiment demonstrate first of all that the theoretical constructs and methods are applicable to the research question. Correlations between various inventory items occurred where predicted by the theories mentioned previously, validating the use of these theories for further research in this area. However, it appears that the theoretical predictions of intrinsic motivation theories are most applicable to women, whereas men have a pattern of behaviour that is not necessarily consistent with traditional theories of intrinsic motivation. The literature on gender differences during learning provides some plausible explanations for why men continued to play games that they did not enjoy while they stopped playing games that they did enjoy and that made them feel competent, whereas women kept playing games that they liked and rated highly on inventory measures. Women's lower self-efficacy, rigid view of their own ability, and low ego-utility help to explain why they are reluctant to keep playing very challenging games while explaining the opposite pattern of behaviour for men.

Gender differences research has shown that early experience with an activity can help shape how someone perceives their ability related to that activity, and that this is particularly important for women, who might see themselves as unsuited for the task if they fail in the first instance. Therefore, the quality of a user's initial experience with a new product or interface is of crucial importance for determining their future relationship with that product or interface, and it is important that designers take this into account. Future work will focus on determining in more detail how initial experience affects longer-term motivation for men and women and how initial experiences can be improved to increase intrinsic motivation in users.

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