Acceptance and Flow Experience in Virtual-reality-based Exergaming

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Abstract. The aim of the study was to establish if the acceptance and experience of exergaming match or exceed those of conventional exercise and to identify predictors of acceptance in both forms of exercise in a healthy sedentary population. Participants were randomised into either an Exergaming group (n = 19, IREX™) or Control (n = 16, gym-based exercise) three times over a two-week period. Outcome measures of technology acceptance and flow experience were used. Only in the technology acceptance sub-domain Performance Expectancy (PE) did significant within-group change occur, increasing from baseline in the exergaming group.

PE was also significant predictor of Behavioural Intention in both groups before and after exercise and Facilitating Conditions was an additional significant predictor of Behavioural Intention (only after exercise). There were no significant differences in flow between the groups, but flow increased over time with exercise for Autotelic Experience, Clear Goals and Transformation of Time.

Key words: Exergaming, Virtual Reality, Technology acceptance, Flow state, Behavioural Intention.

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INTRODUCTION

Exergaming involves the use of computer-generated environment with which users interact to undertake physical exercise. A number of systems are available commercially and have been highly popular with the general public. Exergaming is also being viewed as an option to promote physical activity for health and to assist in rehabilitative exercise for people with clinical conditions (Betkler, Szturm, Moussavi, & Nett, 2006; Bryanton, et al., 2006; Weiss, Bialik, & Kizony, 2003; Rand, Kizony, & Weiss, 2004; Van Schaik, Blake, Pernet, Spears, & Fencott, 2008).

In exercise/physical activity for rehabilitation, the person's concordance with the programme is as important as the physical effects of the exercise/activity. A positive experience is important to enhance concordance. Exergaming systems are designed to be engaging and enjoyable and some studies have confirmed that people can have a positive experience with various systems in specific clinical and non-clinical settings (Kizony, Katz, & Weiss 2004; Thornton, et al., 2005; Plante, Aldridge, Bogden, & Hanelin, 2003). The experience of the user has tended to be explored relatively superficially, however. Two key concepts that can provide greater theoretical depth are the usability/acceptance of the technology and Flow experience.

Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris, Davis, & Davis, 2003) provides a conceptual model for analysing usability/acceptance. The UTAUT was designed in order to develop a unified model acceptable for analysing technology acceptance and use in the information technology field by incorporating 8 previous models of performance such as theory or planned behaviour (Ajzen 1991), technology acceptance model (Davis 1989), and theory of reasoned action (Fishbein and Ajzen 1975).

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In particular, the theory assesses the behavioral intention to use a particular technology for a particular purpose and links this with four main factors; performance expectancy, effort expectancy and facilitating conditions and social influences (Venkatesh et al., 2003). Performance expectancy is the degree in which an individual believes the system will help them to achieve their goals; effort expectancy is the degree of ease of the system; and facilitating conditions is the degree in which an individual believes that technical and organizational infrastructure exists to support the use of the system (Venkatesh et al., 2003).

Flow is a state in which an individual feels totally immersed in an activity both physically and mentally and nothing else at the time seems to matter (Csiksentmihalyi 1990). It has been linked to improvement in exercise performance (Bakker, Oerlemans, Demerouti, Slot, & Ali, 2011; Pates, Karageorghis, Fryer, Maynard, 2003).

Therefore, the study had two aims: to compare an exergaming system (IREX™) with a conventional exercise programmer on (i) usability/acceptance and (ii) flow experience.

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METHODS

Research design and participants

An experimental two-group pre-test post-test design was used. Ethics clearance was granted by the Teesside University (TU) School of Health and Social Care Research Governance and Ethics Committee. Participants were randomized (blind card) to one of two groups: exergaming or conventional (gym based) exercise. 38 sedentary adults were recruited from staff and students at TU; three did not complete final outcome measures due to failure to re-attend the final testing. Analysis is presented from: n=19 in the exergaming group, (age mean 30.9; 1SD 10.12; minimum- maximum 21-54; 9 men and 10 women) and n= 16 participants (age mean 37.5; 1SD 15.51; minimum-maximum 22-60; 7 men and 9 women) in the standard group.

Materials and equipment

The exergaming system was the Interactive Rehabilitation and Exercise System (IREX™) (GestureTek Health, Toronto, Canada), which has been used in previous research (Brown-Rubin, Rand, Kizony, & Weiss, 2005). The IREX™ system allows participants own body image to be projected in real time on the television screen whilst performing the games.

To asses participants' acceptance of exercise a questionnaire, based on the Unified Theory of Acceptance and Use of Technology (*Venkatesh* et al., 2003) was used with a 1-7 LIkert response scale format. The subscales performance expectancy (PE), effort expectancy (EE), facilitating conditions (FC), and behavioural intention (BI) were analysed. The measurement of all variables was reliable (Cronbach's alpha > 0.70).

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To assess participants' Flow experience the Flow State Scale (Jackson and Marsh 1996) was used; this consists of 36 items grouped in 9 sub-scales using a 5-point Likert format: autotelic experience (AE), clear goals (CG), challenge-skill balance (CB), concentration of task (CT), paradox of control (PC), unambiguous feedback (UF), action-awareness merging (AM), transformation of time (TT), and loss of self-consciousness (LS).

Procedure

Participants reported to the TU rehabilitation laboratory and informed consent and demographic data were documented. Participants were then randomised (picking a sealed opaque envelope) to either exergaming or conventional groups. For both groups GB demonstrated the exercises and both groups completed three individual supervised (GB), 30 minutes exercise sessions each week for two weeks. Participants in the exergaming played four pre-selected games, for one minute each, three times, at an intensity setting of 3/10. The standard group performed exercises designed to induce the same physiological demand in a similar sequence, duration and intensity. All participants were taught, in the first session, a programme of home exercise and asked to perform these on days where they did not have supervised session. At the first and last session participants completed the UTAUT before exercising and the flow state scale questionnaire immediately afterwards.

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Statistical analysis

Between-group comparisons of final scores in each sub domain, of each questionnaire, were undertaken using analysis of covariance (ANCOVA - baseline score as covariate); Within-subject comparisons were undertaken using mixed analysis of variance (ANOVA). To explore predictor variables - regression analysis of behavioural intention (dependent variable) with performance expectancy, facilitating conditions, effort expectancy and exercise intervention (exergaming or conventional exercise) as predictor variables was undertaken. An alpha level of 0.05 was used throughout all analysis was performed using SPSS Version 18 for Windows (SPSS™, Chicago, IL, USA).

RESULTS

Effects of exercise type on technology acceptance (Table I)

Baseline scores were high overall (see Table I). Compared to the conventional exercise group, performance expectancy was significantly higher in the exergaming group, in which it increased significantly from baseline. Even taking into account the baseline differences between the groups, performance expectancy (but none of the other variables) was significantly higher in the exergaming group than in the conventional exercise group (ANCOVA, with baseline as the covariate, F (1, 32)= 4.15, p = 0.05, ε^2= 0.12).

Test of acceptance model

Regression analysis of baseline data demonstrated that the effect of the technology acceptance variable on behavioural intention was statistically significant after the completion of the exercise program (see Table II). The only significant predictor of behavioural intention, was performance expectancy at baseline testing, and performance expectancy and facilitating conditions where significant predictors of behaviour at the end of the exercise intervention. The main effect of intervention and interaction effects with the technology acceptance variables were not significant.

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Effects of exercise intervention on flow experience

Again, baseline scores were high (see Table III). From baseline to completion of programme there were significant increases in both groups in autotelic experience ($F (1, 32) = 4.97$, $p = 0.03$, $\varepsilon^2 = 0.13$), clear goals ($F (1, 32) = 5.14$, $p = 0.03$, $\varepsilon^2 = 0.14$) and transformation of time ($F (1, 32) = 8.29$, $p = 0.01$, $\varepsilon^2 = 0.20$). The interaction effect of time and group was not significant. ANCOVA results demonstrated that these variables were not significantly different between the two groups at the end of the programmes.

DISCUSSION

The aim of the study was twofold: (1) to establish if the acceptance and experience of exergaming match or exceed those of conventional exercise and (2) to identify predictors of acceptance in both forms of exercise in a healthy sedentary population. Performance expectancy was higher in the exergaming group after completion of the course of exercise than in the conventional exercise group. Therefore, participants found exergaming exercise a more useful way to perform exercise. There were no significant differences between the groups on other technology-acceptance variables. Multiple regression analysis shows that performance expectancy was also a significant predictor of behavioral intention after exercise for both groups.

A possible reason as to why PE was significant in the exergaming may be due to exergaming being perceived as more enjoyable and a fun activity to do as opposed to conventional gym - based exercise, which may encourage people who are normally sedentary to exercise (Pasch, Bianchi-Berthouze, van Dijk, & Nijholt 2009). Thornton et al (2005) concurs with the fun aspect related to exergaming (VR), when comparing the effects of exergaming (virtual reality) compared to standard exercise in a group of adults with Traumatic Brain Injury. In turn, this could have had an influence of people's performance expectancy and ultimately their behavioural intention to use the exergaming system for exercise, as they may associate exergaming as more enjoyment and play like activity rather than standard exercise or sport and use the exergaming system as a way to motivate them to exercise and ultimately to help them maintain exercise.

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In relation to the effect of enjoyment having on performance expectancy and, ultimately, behaviour intention to use, Sun and Zhang (2008) analysed perceived enjoyment as an aspect or technology acceptance on a group of general internet users. The results showed that perceived enjoyment can have a direct impact on perceived usefulness (PE in our current study). Therefore, a potential reason as to why PE was significantly higher in the exergaming group than the conventional-exercise group could be that exergaming is more enjoyable.

The results from the Flow State Scale showed that there were no statistically significant differences occurring between groups for any of the nine sub-scales for flow state. However, within-subject increases over time were significant for autotelic experience, clear goals, and transformation of time from baseline to completion of the exercise programme. Despite the short intervention, improvements over time could be due to participants become more experienced with the exercises and as a result goals could be perceived as easier to attain and more in balance with their skill level.

The results indicate the potential for the use of exergaming compared to standard-based exercise for a sedentary population, with levels of acceptance of exercise and flow experience as high as or higher than those achieved with conventional exercise. In addition, both performance expectancy and (after completion of the exercise programme) facilitating conditions were predictors of intention to exercise. Therefore, efforts to promote exercise of both types should emphasize its usefulness and address conditions that could facilitate exercise.

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A possible explanation for PE being a significant predictor of BI both at the baseline and at the end of the exercise program is that the participants at baseline had already seen the system in action before conducting any exercise and could see the potential use of the system for exercise. In contrast, the participants would only be able to gain and rate the system in terms of EE and FC after actual experience. This could explain the significant effect of FC on BI at the end, but none at baseline. A possible explanation why EE was not significant could the easy nature of the exercise throughout the testing, as intensity remained the same over the two week duration. In support, Davis and Venkatesh (2004) assessed perceived usefulness (PE in the current study), perceived ease of use (PEOU/ EE) and intention to use the system (BI) in a study analyzing people's initial thoughts (baseline), following a month's training (post) and 3 months follow-up when in a group of customer service representatives using a new IT product. The results suggest and support the current findings that PE can form initial views at baseline without any physical experience of the equipment, whereas EE and FC require hands-on interaction with the system in order for people to develop thoughts regarding the new system and its ease of use.

In conclusion, the application of exergaming as a method of exercise shows some potential application to a healthy sedentary population cohort with respect to acceptance and flow experience. However, further work should look at the effects of a longer- duration exercise programme to analyze the acceptance and flow experience of the gaming environment in a healthy subject population and how flow experience facilitates the actual level of exergaming performance. Larger-scale studies would also be advantageous in further work in order to generate more precise results for a healthy population.

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Author Disclosure Statement

I confirm (on behalf of all co-authors):

- That all named authors were fully involved in the study and preparation of the manuscript and that the material within has not been and will not be submitted for publication elsewhere.
- None of the named authors have any conflict of interest or in relationship to the study, preparation or publication of the manuscript.
- Appropriate acknowledgements have been included in the manuscript uploaded.

Regards

Gillian Barry

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- Ethical standards have been respected in accordance to the Teesside University (TU) School of Health and Social Care Research Governance and Ethics Committee and informed consent was gained prior testing for all participants involved.
- I have presented part of the data from this paper in an oral presentation as part of my PhD at the International Conference for Virtual Rehabilitation (ICVR) in Zurich, 2011.

Table I ***Descriptive statistics (Mean ± SD) for technology acceptance variables***

Variable	Exergaming exercise		Standard exercise	
	Start[a]	End[b]	Start	End
Performance expectancy	4.51 (1.33)	5.24 (1.32)*	4.84 (0.82)	4.66 (0.61)
Effort expectancy	5.99 (1.00)	6.20 (1.11)	5.64 (1.05)	5.55 (1.14)
Facilitating conditions	5.41 (1.32)	4.93 (1.41)	5.89 (0.76)	5.46 (1.27)
Behavioural intention	4.11 (2.15)	4.67 (2.22)	4.13 (1.32)	4.15 (1.36)

[a]Start of exercise programme. [b]End of exercise programme.

*$p < 0.05$. **$p < 0.01$.

Table II
Multiple Regression Analysis for technology acceptance variables

Independent Variable	Start[a]	Start	End[b]	End
β				
PE	**0.55	**0.60	**0.71	**0.59
EE	-0.32	-0.06	-0.14	-0.08
FC	-0.44	0.01	**0.44	*0.32
Intervention	-	-0.07	-	0.09
PE×intervention	-	0.15	-	-0.21
EE×intervention	-	-0.11	-	-0.21
FC×intervention	-	0.10	-	0.04
R^2	0.29	0.33	0.59	0.66
Adjusted R^2	0.23	0.17	0.55	0.57

[a]Start of exercise programme. [b]End of exercise programme.
*$p < 0.05$. **$p < 0.01$.

Table III. ***Descriptive Statistics (Mean ± SD) for flow experience subscales***

Variable	Exergaming exercise		Standard exercise	
	Start[a]	End[b]	Start	End
Autotelic Experience AE	3.96 (0.70)	4.09 (0.75)*	3.50 (0.61)	3.85 (0.48)
Clear Goals CG	4.17 (0.90)	4.33 (0.61)*	3.51 (0.52)	4.20 (0.45)
Challenge- Skill Balance CB	4.05 (0.74)	4.03 (0.75)	3.78 (0.60)	4.02 (0.59)
Concentration of Task CT	4.43 (0.64)	4.17 (0.95)	3.70 (0.76)	3.84 (0.61)
Paradox of Control PC	4.20 (0.71)	4.05 (0.77)	3.64 (0.57)	4.03 (0.46)
Unambiguous Feedback UF	4.00 (0.69)	4.12 (0.66)	3.72 (0.53)	4.41 (0.21)
Action- Awareness Merging AM	3.53 (0.87)	3.59 (1.00)	3.56 (0.49)	3.78 (0.66)
Transformation of Time TT	3.22 (1.16)	3.67 (0.86)**	3.06 (0.60)	3.39 (0.69)
Loss of Self- Consciousness LS	4.47 (0.62)	4.46 (0.59)	3.84 (0.56)	4.03 (0.36)

[a]Start of exercise programme. [b]End of exercise programme.
*$p < 0.05$. **$p < 0.01$.