Virtual Cycling:

Effects of Immersion and a Virtual Coach on Motivation and Presence in a Home Fitness Application

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Abstract

The current paper describes an experiment into the effects of immersion and coaching by a virtual agent on motivation and the sense of presence of participants cycling on a stationary home exercise bike. A basic two-by-two within-subjects experimental design was employed whereby participants were presented with a virtual racetrack with two levels of immersion (high vs. low) and two levels of a virtual coach (with vs. without). Results indicate a clear positive effect of immersion on both motivation and presence, and an effect of the virtual coach on the perceived control and pressure/tension dimensions of intrinsic motivation. Also, the presence of the virtual coach reduced negative effects associated with VEs.

Keywords

Motivation, presence, virtual coach, biofeedback, home fitness exercise

1. Introduction

An object frequently encountered at yard sales, or gathering dust in the attic is the stationary exercise bike. This is most likely due to the fact that exercising on a stationary bike at home is just plain boring. On the other hand, cycling outside can be time-intensive, uncomfortable (e.g. bad weather, smog), or even dangerous around places not well adapted to bikers. Thus, there appears to be a clear need for exercise equipment in the home that is more stimulating and more gratifying to use so that people's motivational levels will not plummet after the initial enthusiasm that led to the purchase of the exercise equipment has faded away.

The current study deals with the question whether virtual environments (VEs) and biofeedback presented via a virtual coach can help raise motivation for engaging in physical exercise. We hypothesized that offering a more immersive environment in which the user feels present would heighten the fun the user is having, and would thus have a beneficial effect on the user's motivation. Additionally, we expected that a virtual coach providing biofeedback information on training intensity, specifically heart rate, would increase the motivation as well, as it helps goal-setting and raises perceived control and competency, both of which help boost motivation.

1.1. Motivation

Motivation is the concept we use when we describe the forces acting on or within an organism to initiate and direct behavior (e.g. Petri, 1981). We usually discern between intrinsic and extrinsic motivation, where intrinsic motivation refers to engaging in an activity purely for the pleasure and satisfaction derived from doing the activity, whereas extrinsic motivation refers to engaging in a variety of behaviors as a means to an end and not for their own sake (Deci, 1975). Intrinsic motivation is often considered more powerful and leading to more stable behaviour than extrinsic motivation and is highly relevant for sports. Below we will discuss how immersion and feedback are thought to influence intrinsic motivation.

1.2. *Immersion and presence*

Slater & Wilbur (1997) refer to immersion as the objectively measurable properties of a VE. According to them it is the “extent to which computer displays are capable of delivering an inclusive, extensive, surrounding, and vivid illusion of reality to the senses of the VE participant” (p. 604). Thus immersion refers to the system’s ability to shut out sensations from the real world, accommodating many sensory modalities with a rich representational capability, and a panoramic field of view and sound.

Presence can be conceptualised as the experiential counterpart of immersion. It has been defined as the sense of ‘being there’ in a mediated environment (e.g. Heeter, 1992; Steuer, 1992) and more recently as the “perceptual illusion of non-mediation” (Lombard & Ditton, 1997), which broadens the definitional scope somewhat, also including social factors.

Various empirical studies have demonstrated a positive effect of immersion factors on presence, including field of view, stereoscopic imagery, interactivity, pictorial realism, spatial audio, and haptic feedback (e.g. Hendrix & Barfield, 1996a,b; Welch et al., 1996; IJsselsteijn et al., 2001).

Presence is generally considered a positive outcome of immersive environments, leading to engagement and more intense enjoyment. If presence could make fitness a more engaging and fun experience, this is likely to boost intrinsic motivation to train.

1.3. *Biofeedback*

The term biofeedback was originally used to describe laboratory procedures (developed in the 1940’s) where trained research subjects were provided with information about their own brain activity, blood pressure, muscle tension, heart rate and other bodily functions that are normally not under our voluntarily control, with the purpose of exerting conscious control over them. Today, biofeedback is often used as a training technique in which people are taught to improve their health and performance by using signals from their own bodies.

In the current experiment, heart rate was measured and, based on this information, feedback was provided to the participant using a social agent, who could either encourage participants to do better, tell them they were doing great, or tell them to slow down a little, if the heart rate became too high. In this way, the coach could both be an extrinsic motivator and at the same time provide feedback on the impact of the exercise. This information is likely to enhance the person’s perceived control and competence and stimulates goal-setting and adherence: the information underlines the person’s efforts and progress.

2. Method

2.1. *Design*

A basic two-by-two within-subjects experimental design was employed whereby participants were presented with two levels of Immersion (high vs. low) and two levels of Virtual coach (with vs. without).

2.2. *Respondents*

Twenty-four employees of Philips participated in the study, none of who engaged in frequent physical exercise. Male/female distribution was even; their average age was 41.3 years.

2.3. *Equipment and Setting*

The experiment was conducted in the HomeLab, at the Philips Research laboratories in Eindhoven, The Netherlands. HomeLab is a future home-simulation, a test laboratory that looks like a normal house and thus provides us with a relatively natural context in which to test the behaviour of the participants using the home fitness application.

The experiment was conducted in a room, which was darkened for the purpose of the experiment to avoid bright sunlight unpredictably influencing the visibility of the screen. Participants were asked to seat themselves on a racing bicycle placed on a training system with variable resistance. The bicycle was placed in front of a wall-mounted screen on which the environment and the coach were projected with a beamer.

2.4. Stimuli

The high immersion condition showed a fairly detailed interactive computer-generated visualization of a person cycling on a racing bicycle through a landscape. Interaction with the environment took place via the handlebars (for direction) and biking velocity. The low immersion condition showed an abstract picture of a racetrack in bird's eye view, with a dot indicating the position of the biker. Interaction with the environment was less rich since participants did not have to use the steer to stay on track, nor could they influence the velocity of the dot on the track (although most participants were not aware of this).

In the condition with virtual coach, an avatar-like female appeared every minute. She gave feedback to the participant, based on heart-rate information measured with a special chest belt. In the second condition this image did not appear.

2.5. Dependent variables

The main dependent measures were intrinsic motivation and presence. Motivation was measured using an existing, well-validated questionnaire, the Intrinsic Motivation Inventory (IMI), consisting of six subscales (interest/enjoyment – which is the most central one to motivation – perceived competence, value/usefulness, perceived control/choice, felt pressure and tension, and effort). For measuring presence various methods have been used or proposed to date (for a review, see IJsselsteijn et al., 2000). The ITC Sense of Presence Inventory (Lessiter et al., 2001) provided sufficient sensitivity, while having proven reliability and validity. It consists of four subscales: spatial presence, engagement, ecological validity, and negative effects. Besides this, heart rate and velocity of the participant were also measured and recorded. The heart rate was used as input for the coach's directions; average speed was considered as a corroborative behavioural measure of motivation, since one would expect participants to work harder during their exercise when motivation is higher.

2.6. Procedure

Participants – in sports clothing – received a short introduction upon entering the exercise room. After putting on the chest belt for easy heart rate measurement, they mounted the bicycle for the first session. The total procedure consisted of four sessions, the order of which was fully counterbalanced. After every session participants filled out the IMI and ITC-SOPI, which also gave them 10 minutes to recover from their exercise. The total experiment took about 1.5 hours to complete.

3. Results

For both the ITC-SOPI presence questionnaire and the Intrinsic Motivation Inventory (IMI), components were computed based on the factor structures that were validated in earlier studies. Subsequently, repeated measures analyses of variance (REMANOVA) were performed on these components according to the full model, with Immersion (high vs. low) and Coach (with vs. without) as independent within factors. Results will be reported for intrinsic motivation components first, then for presence. Lastly we will report bivariate correlations between the various components.

3.1. Intrinsic Motivation

The six IMI components were all subjected to full model REMANOVAs. Four scales (interest/enjoyment, perceived competence, value/usefulness, and perceived control) showed significant effects of Immersion: all scores were higher for high immersion. These last two scales also showed a significant effect of the virtual coach, as did the pressure/tension scale: value/usefulness was higher, perceived control and pressure were lower with the coach present. Finally, the effort/importance scale did not show any significant results. Means of the most important scales are visualized in Figure 1 and reported in Table 2; statistics are reported in Table 1.

Average velocity was used as a corroborative behavioural measure of motivation. Indeed velocity scores showed the same pattern of results as the questionnaire data did. There was a main effect of Immersion $F(1,23)=65.73$, $p<.001$, with average speed higher in the high (v=23.8 km/h) vs. low (v=20.6 km/h) immersion condition. The virtual coach had no significant effects.

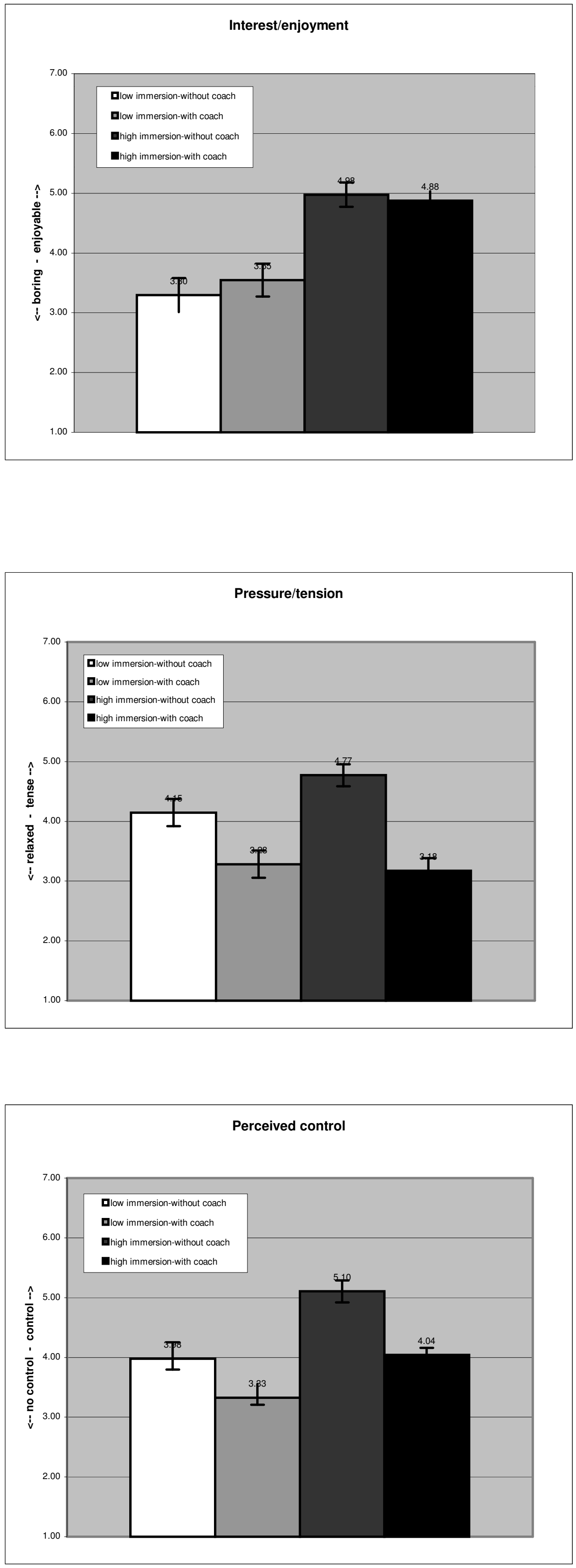

Figure 1. Effects of Immersion and Coach on Motivation as measured by the IMI.

Table 1: REMANOVAs of motivation components

	Immersion		Coach		Imm xCoach	
	F	p	F	p	F	p
interest/enjoyment	29.14	**.00**	0.30	.59	1.49	.23
perceived competence	7.69	**.01**	0.68	.42	0.09	.77
value/usefulness	9.01	**.01**	6.61	**.02**	0.09	.77
perceived control	22.07	**.00**	37.41	**.00**	1.70	.21
pressure/tension	3.89	.06	21.78	**.00**	2.93	.10
effort/importance	1.17	.29	3.85	.06	0.09	.77

Note: all F(1, 23), p values printed in bold < .05

Table 2: Means of motivation components

	Immersion low		Immersion High	
	without coach	with coach	without coach	with coach
interest/enjoyment	3.30	4.17	4.98	4.88
perceived competence	3.95	4.14	4.40	4.35
value/usefulness	4.29	4.75	4.92	5.23
perceived control	3.98	4.11	5.10	4.04
pressure/tension	4.15	3.84	4.77	3.18
effort/importance	4.01	4.23	4.19	4.42

3.2. Presence

Secondly, four separate REMANOVAs were performed with the components of presence (spatial presence, engagement, ecological validity, and negative effects) as dependent variables. Three components showed strong and highly significant effects of Immersion, indicating that spatial presence, engagement, and ecological validity were higher for high Immersion. The effect on the 'negative effects' subscale was smaller, but also significant. This component also showed a significant effect of Coach, as did spatial presence; participants reported more presence and less negative effects in the condition with the virtual coach present. No significant interactions were found. Means are visualized in Figure 2, results of the ANOVAs are reported in Table 3.

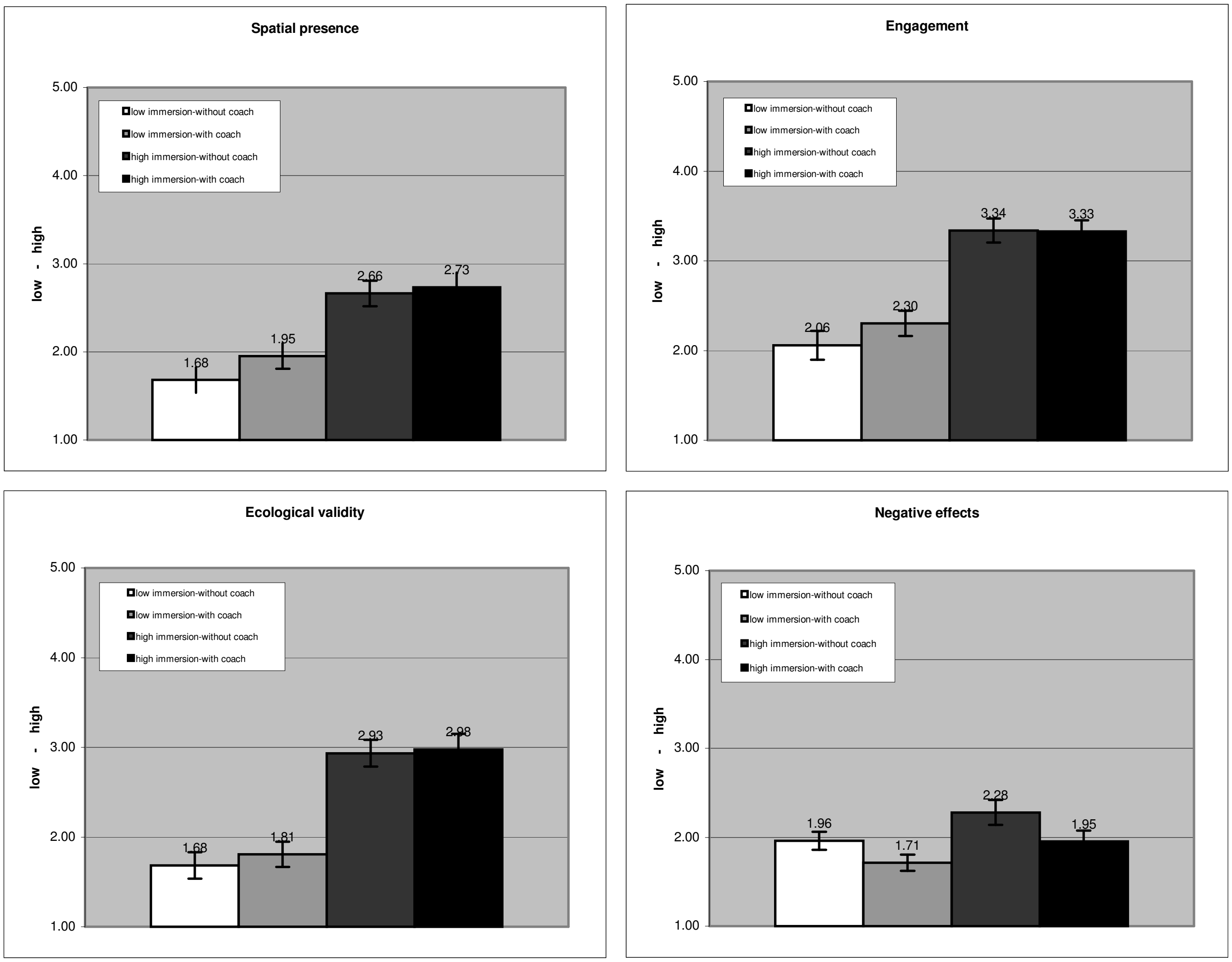

Figure 2. Effects of Immersion and Coach on Presence as measured by the ITC-SOPI.

Table 3: REMANOVAs of presence components

	Immersion		Coach		Imm x Coach	
	F	p	F	p	F	p
spatial presence	72.22	**.00**	9.45	**.01**	1.66	.21
engagement	90.20	**.00**	2.62	.12	2.85	.11
ecological validity	68.08	**.00**	1.53	.23	0.45	.51
negative effects	4.16	**.05**	13.49	**.00**	0.38	.54

Note: all F(1, 23), p values printed in bold < .05

3.3. Correlations between motivation and presence

We were also interested in testing relationships between the various components of motivation and presence. For this reason, bivariate correlations were computed. Space does not allow full coverage of all results. In summary we found considerable correlations between the motivation scales interest/enjoyment, perceived competence, value/usefulness, and perceived control (.44-.67, p<.01), high correlations between presence scales – spatial presence, engagement, and ecological validity (.85-.89, p<.001), and some moderate but significant correlations between presence components (spatial presence, engagement and ecological validity) on one hand and motivation components (interest/enjoyment, perceived control, pressure/tension) on the other (.22-.40, p<.05).

4. Discussion

The results of this study show that offering a more immersive environment in which the user feels present heightens the fun the user is having, and thus has a beneficial effect on the user's motivation. In the highly immersive environment, where the presence experience was stronger, participants reported more interest and enjoyment, more perceived competence and control and – perhaps even more importantly – they cycled faster! Additionally, we found some effects of the virtual coach providing biofeedback information, but not quite what we expected. Training intensity was not influenced and intrinsic motivation was not higher with the coach. However, her presence did lower perceived pressure and tension, which is good, and perceived control. This last finding is somewhat striking since one would expect control to increase with feedback. Perhaps receiving directions regarding the intensity of your workout counteracted this effect. In future studies we hope to disentangle these effects further and continue our efforts to make virtual cycling even better than the real thing.

5. Acknowledgements

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