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Body in the interactive game: How interface embodiment affects physical activity and health behavior change

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ABSTRACT

Does the delivery platform for a health behavior game contribute to its effectiveness? With the growing popularity of interactive video games that combine physical exercise with gameplay, known as "exergames," there has been a burgeoning interest in their impact on users' exercise attitudes and behavioral outcomes. This study examines how the level of user interface embodiment, the degree to which the user's body interacts with the game, affects the user's experience, game behavior, and intention for behavior change. We conducted a between-participants experiment in which participants ($N = 119$) played an exergame under one of the three levels of user interface embodiment (low, medium, and high). Our results revealed a significant positive main effect of user interface embodiment on user experience (i.e., the sense of being in the game, "presence," and enjoyment); level of energy expenditure (change in heart rate); and intention to further engage in exergame-play exercise but not necessarily to increase exercise in the physical world. A further analysis revealed the mediating roles of user experience in the association between user interface embodiment and intention to repeat exergaming and a potential link between heart rate change and level of presence in the game. We conclude that type of interface is a key variable in this health communication environment, affecting user experience, behavior, and some intention for behavior change.

1. Introduction

Playing certain computer games can affect our behavior (Anderson & Dill, 2000; Lieberman, 2006; Squire, 2003). Taking advantage of this, within the class of serious games there are several games that attempt to change health behavior during the game or in real life after the game is played (Garn, Baker, Beasley, & Solmon, 2012; Lieberman, 2012; van Schaik, Blake, Pernet, Spears, & Fencott, 2008). One single behavior, level of exercise, is associated with many different disease outcomes. Not only is exercise good for general health and fitness, but also, in recent years, research has shown that exercise can increase neurogenesis (Rhodes et al., 2003). Despite this knowledge and despite recommendations by health professionals to increase physical activity, many people do not exercise. With recent advances in video game technology, however, we now have access to a variety of interactive video games that combine physical exercise with gameplay, called "exergames."

Exergames virtually guide players through various exercise regimens based on a player's level of ability and interest in various types of exercise. In most exergames, a virtual coach teaches and leads players as they perform exercises. Performance feedback is provided to the players to help them understand how well they are exercising. For example, video of player activity may be superimposed onto the game screen or 3D data about player activity may be integrated into the game in the form of a virtual avatar. Sound effects are used in some games to indicate when a player has the correct posture and balance, while in others, a virtual coach provides voice feedback to encourage the players or help them do a better job. Exergames can be deployed on many platforms, from mobile phones to virtual reality systems. Increasingly exergames involve the user's body in the game by using more embodied interfaces, such as augmented virtuality and augmented reality (Azuma et al., 2001; van Schaik et al., 2008).

This study addresses the following guiding research questions: (1) Do exergames and other health-related behavior games become more effective as interaction approximates actual physical activity by involving more of the user's body? (2) Does the interface

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platform itself, specifically the level of user interface embodiment, influence the psychology of the game and users' physical behavior, and does it contribute to greater persuasion and behavioral change?

More specifically, this study explores the following:

(a) Does the level of user interface embodiment associated with a game alter users' experiences in the virtual environment?
(b) Does the level of user interface embodiment significantly affect users' physical activity; in this case, exercise intensity (i.e., energy expenditure)?
(c) Will increased user interface embodiment lead to stronger intentions to engage in the modeled behaviors (i.e., exercise) in the future?
(d) What are the key mediators in a user experience that augment users' intentions to engage in behavioral change after the game?

2. Using computer games to change health behavior

2.1. Media in health behavior interventions

Since the rise in obesity cases over the past few decades (Boughter, 2006), there has been a growing interest in creating effective health communications that increase physical activity, improve diets, and change overall negative health behaviors. Studies have looked at past efforts to bring about change through a variety of media, including print, telephone, television, Internet, and mass media campaigns.

All of these media have had moderate success in the short term with participants who are already motivated, but generally failed to stimulate and affect long-term behavior change (Marshall, Owen, & Bauman, 2004). For example, Marcus, Owen, Forsyth, Cavill, and Fridinger (1998) showed that while recall was high with mass media, there was a lack of significant behavior change. Further studies showed that tailoring messages specifically to an individual's own current behavior was more effective than typical, general health communications (Bock, Marcus, & Pinto, 2001; Kreuter & Strecher, 1996).

Immersive and interactive virtual environments have the ability to influence learning by offering situated learning and applicable lessons (Dede, 2009). Thus, while traditional media often fail to provide effective messages for behavioral change (Schooler, Chaffee, Flora, & Roser, 1998), virtual environments afford interaction with (not just observation of) specific, targeted messages that can reach a massive audience (Fox, 2010). They provide the necessary elements outlined by social cognitive theory (Bandura, 1977) to bring about change.

2.2. Getting the body into the game: user interface embodiment and cognition

Does the interface platform matter in experience? There is a big difference in user experience between a book that describes how to play to tennis and a full body simulator that takes the user's body through the experience, and there is ample evidence in the psychological and neuroscience literature on the role of the body in cognition. Embodied cognition research indicates that the sensory disposition, movement, and extension of the body can affect user's perceptions, experience, decisions, and learning (e.g., Bohil, Alicea, & Biocca, 2011; Klemmer, Hartmann, & Takayama, 2006; Wilson, 2002).

There is a current trend to make gaming interface platforms increase the level of sensory immersion and motor immersion. For example, some games utilize common technologies like picture-in-picture video or sound effects while others use highly sophisticated techniques to record and interpret players' full body motions and nonverbal behaviors (Won, Yu, Janssen, & Bailenson, 2013). Biocca (1997) calls this variability in interface sophistication "progressive embodiment" and defines it as the "steadily advancing immersion of sensorimotor channels to computer interfaces through a tighter and more pervasive coupling of the body to interface sensors and displays" (section 2, para. 3).

User interface embodiment refers to the degree to which the user's body is coupled to the interface. This is influenced by three aspects: sensory immersion, motor immersion, and the representation of the user's body. By sensory immersion we mean the range of sensory modalities (i.e., vision, auditory, touch, etc.) and the sensory richness within each modality (i.e., fidelity and sensory range such as amount of the visual field). Motor immersion is the degree to which the body (motor system) is engaged by the interface. For example, a mouse pointing device only engages one hand within a very limited range of 2D interaction. By contrast, some virtual reality systems can record and respond to the full range of a user's body motions.

2.3. Augmented virtuality in exergames

Within the class of interfaces that enhance user embodiment are so-called "augmented virtuality" (AV) interfaces. These are part of an emerging suite of technologies (including interactive user interfaces, photorealistic 3D graphics, motion input devices, and hands-free input devices) that inject elements of the real world into virtual reality spaces to create mixed reality environments (Milgram, Takemura, Utsumi, & Kishino, 1994; Simsarian & Akesson, 1997). Such environments can produce a strong sense of interactivity, presence, and feedback for the player (Kim, Lee, Gramzow, & Biocca, 2012).

Modern exergames exemplify the idea of AV, and normally consist of a virtual environment that is augmented in various ways by elements of the real world. Exergames often combine real and virtual images by enabling video capture or real-time 3D sensing of whole body motions and nonverbal behaviors (Won et al., 2013). Furthermore, the ability to analyze and interpret body movements in real time allows body motion to be used as player input in many exergames. This can be done with motion input devices like balance boards and accelerometer-based hand controllers, as well as with infrared (IR) camera systems. These input systems introduce real-world events (not just images) into the virtual environment and allow exergame systems to understand and respond to player gestures and exercise movements (Won et al., 2013). Feedback to the player can include visual, auditory, and sometimes even tactile feedback, injecting some aspects of the virtual environment back into real space.

3. Effects of user interface embodiment on gameplay outcomes

3.1. Sense of being in the game: presence

It is widely argued that one goal of immersive technologies like virtual reality and augmented virtual reality is to create the illusion that one is "there" in the virtual environment, a psychological illusion called *presence*. Zeltzer (1992) suggests that presence reflects a match between the human senses and virtual inputs or outputs such as visual displays, sound reproduction, and haptic or tactile input. In this way, presence is "a rough, lumped measure of the number and fidelity of available sensory input and output channels" (Zeltzer, 1992, p. 128).

Presence is a central concept for research on virtual environments and is concerned with both the sense of "being there" (spatial presence) and the sense of "being with someone" (social