Paper accepted to Human-Computer Interaction

Understanding the role of body movement in player engagement

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ABSTRACT

The introduction of full-body controllers has made computer games more accessible and promises to provide a more natural and engaging experience to players. However, the relationship between body movement and game engagement is not yet well understood. In this paper, we consider how body movement affects the player's experience during game play. We start by presenting a taxonomy of body movements observed during game play. These are framed in the context of a body of previously published research that is then embedded into a novel model of engagement. This model describes the relationship between the taxonomy of movement and the type of engagement that each class of movement facilitates. We discuss the factors that may inhibit or enhance such relationship. Finally, we conclude by considering how the proposed model could lead to a more systematic and effective use of body movement for enhancing game experience.

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1. INTRODUCTION

The introduction of full-body controllers by the game industry has proved hugely successful. The Nintendo Wii, for example, has been reported to be among the top 4 games sold[1]. Two new recent full-body games include Microsoft Kinect[2] and Sony Move[3]. Unlike the Nintendo Wii, Microsoft Kinect directly detects the player's movement rather than the controller's movement. Presumably, the idea has been to create a more natural and engaging player experience and to make it accessible to a larger population of users.

Whilst one reason why these games are being so successful is the physical activity that they promote (Byrne, Byrne, 1993; Yeung, 1996), we argue that another reason for this success is that body movement also affects cognitive and emotional processes and that the increased involvement of body movement during game plays results in increased enjoyment. Indeed, it has been shown that body movement supports cognitive processes, regulates emotions, and mediates affective and social communication. As such it is a very important means for technology to exploit, to not only facilitate a more positive user experience but also to address issues such as motivations and positive emotions in various sectors such as health and education. Edutainment, for example, stands to benefit from methods aiming to support and facilitate task-related movements in the learner. Recent studies have shown that the use of body motion during cognitive processes supports them (Rambusch, 2006) even if the gestures performed are not necessary to the accomplishment of the task (Clark, 1997; Singer, Goldin-Meadow, 2005). Health and fitness are also areas in which there is a growing interest in making training and rehabilitation more engaging and effective (Papastergiou, 2009; Boyle, Lavery, Elborn, Rendall, 2009; Voida, Greenberg, 2009; Foster, Foster, McCrady, Jensen, Mitre, Levine, 2009). Positive emotions have a strong effect on increasing motivation by increasing self-coping capabilities (Isen, Reeve, 2005).

These considerations make it critical to better understand if and how body movement can be exploited to modulate the quality of a player's experience. To this end, we present and discuss a hypothetical model of the complex relationship between body movement, controller and the components of playing experience.

The paper is organized as follows. Section 2 summarizes the literature related to this study by focusing on the three key terms: engagement, embodiment and affective experience. Section 3 lays the foundation for our engagement model by identifying body

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[1]http://www.independent.co.uk/life-style/gadgets-and-tech/features/the-10-bestselling-games-1784793.html (published on 12 September 2009)[retrieved on 21 September 2009]

[2] http://www.xbox.com/en-GB/kinect [retrieved on 19 May 2011]

[3]http://www.newscientist.com/article/dn18115-sony-demos-game-controller-to-track-motion-and-emotion.html (published on 5 November 2009)[retrieved on 4 January 2010]

movements that are observed during computer game play. A first set of experiments based on a single player setup is described in Section 4. Section 5 discusses how the experiments support and refine our model. In Sections 6 and 7, we describe an experiment aimed to explore the effect of movement in a 2-player setup and which leads us to further refine the model. Finally, we discuss game design issues suggested by the model as well as future directions of investigation.

2. BACKGROUND

2.1. Engagement and body movement

In the context of games, the definition of engagement, and its related terms, is still unclear. Csikszentmihalyi's theory (1990) uses the term "flow" to depict a state of mind in which a person feels so engaged by an activity that his/her actions and awareness merge. Also known as optimal experience, this phenomenon is closely linked with motivation and attention, and is essential in games. An optimal level of challenge is necessary to maintain motivation in game players. When skills improve, a new level of challenge is required for challenge to meet the improved skill level (Berieter, Scardamalia, 1992). Whilst Brown and Cairns (2004) define engagement as the first step in immersion then to engrossment and then to full immersion, Chen et al. (2005) use the terms fidelity, immersion, and engagement. In Brockmyer et al. (2009), the authors take yet again a different position and use the term engagement as a "*generic indicator of game involvement*", regarding the other terms of immersion, presence, flow and psychological absorption as representing a progression to a deeper engagement. Although these studies cannot be directly compared, all introduce the notion of a multi-step progression in the level of engagement and identify possible barriers to this progression, e.g. game control, game structure and aural and visual aspect of the interface.

Rather than getting in a discussion as to the exact definition of each terms used to describe the different levels of engagement, in this paper, we adopt Brockmyer et al.'s use of the term engagement and place our focus on how this experience can be modulated. On these lines, the model proposed by Ermi and Mäyrä (2005), identifies three different types of engaging experience: challenge-based immersion, imaginative immersion, and sensory immersion. Whilst challenge-based immersion and imaginative immersion are also captured by the previously mentioned models in terms of flow and character identification, the sensory experience is the type of experience that most relates to our work. However, in Ermi and Mäyrä's work, sensory experience denotes a visual, aural or tactile sensorial experience without any reference to proprioceptive experience (i.e. sensory input from joints and muscles). This could be due to the fact that at the time the model was proposed, movement-based games were yet to be as popular as they are now and thus only those other senses were exploited in the design of computer games.

With the appearance of the Nintendo Wii, it has now become clear that proprioceptive feedback can also play an important role in engaging the player. Indeed, Nintendo Wii very quickly became successful despite its display having lower graphical performance than the other 7th-generation consoles[4]. Whilst many factors could have contributed to this success, e.g., the naturalness of the interface, the fewer stigma associated with the use of movement-based interfaces, or the beneficial health consequences that physical activity promotes, a key question pertaining to the design of such devices needs to be asked and answered: Is there a form of sensorial engagement experience specifically linked to an increased involvement of the proprioceptive system? And can this form of engagement be more systematically used to enhance game experience?

None of the above mentioned models contain movement-specific items and the measurements used to study engagement do not take into account the role played by physical activity (Mueller, Berthouze, 2010). Yet, body movement has been shown to have an effect on the sense of presence in virtual reality environment (Slater, Steed, McCarthy, Maringelli, 1998). Presence in virtual reality occurs when a person behaves and responds as if s/he was in the place represented by the virtual environment. Slater and colleagues showed that when participants were asked to move within the virtual environment in a way that was related to the task they had to accomplish or to the world they had entered, their sense of virtual reality experience was enhanced.

Further in this direction, we will argue that movement has a strong influence not only on the sense of presence of the player but also on the overall engagement experience and that it provides the means to modulate this experience. In the next subsection, we report on the literature that shows that a link exists between body movement and affective experience and hence that it should be considered in the design of movement-based computer games.

2.2. Embodied cognition

At the beginning of the 20th century, philosophers opposed the dualism of the Cartesian view and proposed instead that mind and body are intertwined in perceiving and experiencing the world (Merleau-Ponty, 2002). The Gibsonian ecological view of perception highlights the fact that "*one sees the environment not with the eyes but with the eyes-in-the-head-on-the-body-resting-on-the-ground*" (Gibson, 1979). Studies in neuroscience have now started to explain the mechanisms underpinning the connection between mind and body; see, for example, the somatic marker hypothesis of Damasio (1994; 1996).

This view of cognition as being embodied (Clark, 1999) had an impact on researchers from various fields. In robotics, for example (Brooks, 1999) it was proposed that intelligent behavior can only be obtained if robots have the ability to sense and the motor skills to perceive and manipulate the world appropriate to the task, thus taking a very distant position from that of traditional artificial intelligence and cognitive science. More recently, HCI and ubiquitous computing have seen the emergence of embodied interfaces. Dourish (2001) uses the term "embodied interaction" to stress the importance

[4] Sanchanta, M.: Nintendo's Wii takes console lead. Financial Times, 12.07.2007. Retrieved from www.ft.com.

of considering our physical and social relationships with the world when designing interactive systems. According to these lines of thought, technology affordances affect experience. In a computer game context, this means that constraints imposed on body movement by the controller, by the affective state or by the cognitive load, impinge on how the player (actively) perceives and engages with the gaming environment.

Concepts such as affordance (Gibson, 1979) and image-schema (Lakoff, Johnson, 1980; Johnson, 1987) are becoming central to the design of interactive technology. Lakoff and Johnson theorized that linguistic expressions correspond to image-schemata that are dynamic patterns of recurrent bodily experience or using Johnson's words "*recurring, dynamic pattern of our perceptual interactions and motor programs that gives coherence and structure to our experience*". They hypothesised that, given the frequency and depth of these body experiences, image schemata must be instantiated in our nervous system. Johnson extended the concept to cognitive processes other than language. Through the use of imaging technology, studies in neurosciences have recently started to identify the mechanisms underlying these concepts, i.e., a "*distributed model of semantic comprehension*" that show that brain areas previously thought dedicated only to sensori-motor experience have also an important role in higher cognitive processes such as language (Rohrer, 2006).

An example of use of image-schemata in the design of interactive technology is presented in (Antle, Corness, Droumeva, 2009). The study explores the benefits and limitations of exploiting embodied metaphors (i.e., body movements) to design the interaction layer of an augmented audio environment. Its results show that people found it easier to learn an interaction model based on an embodied metaphor, than with a standard form of interaction. However, the authors argue that the interaction model needs to be carefully designed by considering factors such as the body movements more likely to be performed by the users, the discoverability of the mapping between body movements and commands and the perceivability of the feedback to support such mapping. Hence a principled designed approach is necessary to fully exploit this approach.

Adding to this suggestion, we argue that affective experience derived from body movement should also be carefully considered when designing the interaction between human and technology as image-schemata may go beyond purely cognitive processes and also include affective processes. From a phenomenological perspective, we are interested in how the player's cognitive and emotional experience is affected by the perception of his/her own body movement during game play, either alone or with other players. Niedenthal et al. (2005) present a comprehensive review of the studies done in this area and discuss how theories of embodied cognition such as the Perceptual Symbol System by Barsalou (1999) can explain the findings of these studies. In particular, the authors provide a comprehensive analysis of how the literature on attitude, social perception and emotion shows that social information processing is embodied. They follow Wilson's definition of online and offline embodiment (Wilson, 2002) to distinguish between embodied reactions that are due to stimuli that are actually present and the reactions that are due to stimuli that are not present: e.g., stepping back when seeing a large animal vs. recalling a scary experience. They point out that this distinction is important to understand how the creation of knowledge and the use of knowledge can in fact exploit the same underlying neural mechanism of somatic responses (Damasio, 1989, 1996). In the next subsection, we report on this literature to highlight the relationship between body movement, affective experience and well-being.

2.3. Well-being, affective experience and body movement

The works of Malone (1981) and Lazzaro (2004) have identified emotional and social factors as two important motivations other than hard-fun (challenge), easy-fun (fantasy factors) bringing people to play games. Full-body games appear to open new possibilities for supporting these types of experience. In fact, studies from various disciplines have investigated the relation between physical activity and well-being. Physical activity in general has been shown to have anti-anxiety and anti-depressive effects (Byrne, Byrne, 1993; Yeung, 1996) with a most immediate effect in the case of a minimum of 2 hours of acute exercise of any intensity (Landers, Petruzzello, 1994). Beneficial effects on food intake and self-image have also been reported with participants displaying higher self-evaluated performance in movement-based game than in non-movement based games (Bloom, Hunker, McCombs, Raudenbush, Wright, 2008).

Computer games that require intense physical effort from their players (Mueller et al. 2003) have also been shown to have a strong effect on the establishment of social bonds. The experiments run by Mueller et al. (Mueller, Agamanolis, 2003; Muller, Gibbs, 2007) suggest that the arousal associated with physical movement might support social interaction. Participants who played sports through movement-based distance technology reported a significantly greater social bond than players who used a keyboard interface. A survey on the effect of playing Dance-Dance Revolution[5] on its players has also highlighted the social benefits of physical activity (Hoysniemi, 2009).

Another thread of studies investigated the effect of body expression on mood (Laird, J.D. 1974). These studies suggested that changes in posture can induce changes in affective states or have a feedback role affecting motivation and emotion. For example, Riskind and Gotay (1982) showed that "*subjects who had been temporarily placed in a slumped, depressed physical posture later appeared to develop helplessness more readily, […], than did subjects who had been placed in an expansive, upright posture*." A similar result was reported by Stepper and Strack (1993) when assessing the role of affective posture in the evaluation of self-performance.

Further evidence of the interaction between proprioceptive cues and mood is provided by Wells and Petty (1980) whose study showed an effect of overt head movements (nodding vs. shaking) on attitudes toward a product. Similarly, Cacioppo et al. (1993) showed that people flexing their arms evaluated neutral Chinese ideographs more positively than when extending their arms. Neumann et al. (2000) further investigated and confirmed the relation between movement and information processing. They stated that "*perceived movements toward a person trigger the approach system and thereby*

[5] http://www.ddrgame.com/ [downloaded on 29 January 2010].

facilitate the processing of positive affective concepts, whereas perceived movements away from a person trigger the avoidance system and thereby facilitate the processing of negative affective concepts […]" (Neumann, Strack, 2000).

From a slightly different perspective, Riskind (1984) studied the relationship between the affective state really felt by a person and the body expression shown. His studies showed that when a postural expression does not reflect the felt affective state, there is loss of control and motivation in managing the situation. He put forth the *appropriateness hypothesis* that postural expressions congruous to emotional states (e.g. a slumped posture) can support information-processing and facilitate responses to such mood-relevant situations (e.g. a negative mood situation). This naturally raises implications regarding self-regulatory processes of emotions (Riskind, 1984). Finally, Richards and Gross (2005) demonstrated that simply keeping a stiff upper lip during an emotional event affected memory of the event, and exacted a cognitive toll as great as intentional cognitive avoidance.

Given the compelling evidence for a relationship between body movement and well-being (including affective and social experience), various studies have aimed to identify the mechanisms and factors at the basis of this relationship. Biological and neurological explanations have been offered and evidence has been found that could explain post-exercise phenomena like the "runner high phenomena" (Dishman, O'Connor, 2009). Beliefs about the value of exercise for health have also been shown to have a strong effect on well-being, i.e., they increase the positive effect of the exercise (Plante, 1999). More recently, Cole et al. (2007) proposed the term affective proprioception. They discussed the possible neurological basis and evolutionary origin for the existence of a dedicated connection between proprioceptive system and brain area involved in the affective processing of stimuli akin to that of the tactile system. Exercise would produce an affective experience on the basis of the quality of the movement performed, and not just on the physiological changes it induces in the body. The authors argue that "*pleasure in movement may depend not on feedback but also on harmony between intention and action."*

3. MOVEMENT TAXONOMY IN COMPUTER GAMES

Whilst the above studies showed that movement-based games have the potential to elicit a positive effect on self-image, by promoting positive emotion, increasing motivation, and favouring social interaction, the question remains of how full-body movement games should be designed to maximize this potential. To begin to address this question, we now refer to a set of experiments described in detail in (Bianchi-Berthouze, Cairns, Cox, Jennett, Kim, 2006) and in (Pasch, Bianchi-Berhouze, Van Dyck, Nijiholt, 2009). The aim is to examine the type of movement patterns players adopt in desktop and full-body movement games and propose a body movement taxonomy which will be at the basis of a novel model of the relationship between movement patterns and player engagement.

3.1. Engagement and body movement in desktop games

A first observational study reported in (Bianchi-Berthouze, Cairns, Cox, Jennett, Kim, 2006) involved two different types of desktop computer games. The first game was a very low-engagement game in which the user simply had to mouse-click on a target appearing randomly on a display. The second game was a very engaging first person shooter game, Half-Life[6]. The primary modality of input was the keyboard with some additional commands involving the mouse.

Twenty participants were randomly assigned to one or the other game, and were interrupted after 10 minutes of play to fill an engagement questionnaire (Cairns, Cox, Berthouze, Dhoparee, 2006). The sessions were videotaped to provide a view of the subject in the saggital plane where most of the motion was expected to take place. The body movement was then analyzed in relation to the questionnaire score. The original aim of this study was to explore body movement as a measure of engagement as it took place in contrast to the use of questionnaires that correspond to a post-experience appraisal of the experience.

Through the analysis of the videos it was observed that the “clicking” group, who returned very low scores, was characterized by many shifts in the sitting position, alternating between a very disengaged position (e.g., arm stretched behind the head and body leaned back) and boredom (e.g., yawning) showing a strong awareness of their physiological needs. Some of the participants showed more attentive/focused behaviour with a forward still leaning body and still head.

The “shooting” group, which returned significantly higher engagement scores, revealed a different pattern of changes in body posture. Participants showed very few changes in posture, with those that showed more game-unrelated posture changes (i.e., fidgeting) scoring lower in the engagement questionnaire. Stillness was at time broken by muscle relaxation arm movement, especially in the more engaged player. Interestingly, some players also displayed head motion that were related to the game, e.g., moving the head as if following the main character in its digital environment. Such movements may be seen as a sign of presence in the game, but also as a way to facilitate control of the game, i.e., navigating in the complex environment.

In summary, both game conditions required little involvement of the body for controlling the game. However, we observed the emergence of other body movements that were not necessary to play the game: fidgeting movements representing affective expressions of discomfort/boredom/disengagement/relaxation; stillness to facilitate attention and focus on the game; and task-facilitating movements supporting the control of the game.

[6] http://en.wikipedia.org/wiki/Half-Life_%28video_game%29 [Retrieved on 30 June 2011]

3.2. Engagement and body movement in full-body games

A full-body movement game scenario was studied in (Pasch, Bianchi-Berthouze, van Dijk, Nijholt, 2009). Through a triangulation of qualitative and quantitative methods, movement patterns adopted by players when playing Nintendo Wii sports games were explored.

The Wii gaming console was chosen because of its very loose control of the gamer movement. This loose control makes it possible for gamers to adopt the game in various ways. The Wii Sports game is a collection of five sport simulations: tennis, baseball, bowling, golf and boxing. By using the Wii Remote (also called Wiimote), the gamer can mimic actions performed in real life sports, such as swinging a tennis racket. The rules of each game are simplified to be more accessible to a larger population. The Wiimote is embedded with motion sensing capabilities: it senses the acceleration along three axes and, through an optical sensor, senses where it is pointing. Rather than capturing the movement of the body of the gamer, it senses its own movement and as such some movement quality of the gamer. In addition, rather than recognizing the simulated sport's movement, it detects the timing of the movement, and the direction in which the Wiimote is moved. For example, a gamer in the Wii Boxing game can simulate a punch movement either by extending his/her arm forward or by simply flicking his/her wrist forward. Both movements will be considered identical by the game interface because the Wiimote is moved in an identical manner with respect to the sensors of the interface. This lack of a strict control on the gamer's body movement enables us to look at different strategies gamers adopt and what factors may explain such strategies.

14 players were either interviewed and/or observed and their movement measured while playing. Grounded theory (Glaser, Strauss, 1967) was used to analyse the interviews whereas quantitative analysis of body movement was performed through a full-body motion capture system.

The results highlighted three important issues related to body movement: motivation, level of sport realism of the simulation, movement feedback. The interviews showed that expert players intentionally chose movement patterns according to the experience they wanted to achieve. When the motivation was to win, expert players used tiny and carefully controlled movements that bore little resemblance to the sport being simulated. Instead, when the motivation was relaxation, these patterns changed to sport simulation patterns. In such case, the player produced movements that clearly pertained to the sport being simulated even if at the expense of the game score. A quantitative analysis performed through observation and motion capture data confirmed the existence of these two main clusters of movement along with an intermediate cluster of players. The movement patterns in this intermediate cluster were less defined showing either explorative behaviour that could reflect poorer game control skills or poorer knowledge of the simulated sport, or low level fitness and poor body movement skills (e.g., poor coordination),

The interviews also highlighted that a different level of realism of the type of movements necessary to play the game was considered important by the players to facilitate engagement. Less skilful players commented that in the tennis game control was sufficiently complex and that requiring more movement realism (e.g, running to catch the ball) would have made the game too challenging. The opposite view was brought forth by experienced tennis players. Particularly relevant to this discussion was the observation that there was a gap between the proprioceptive feedback players were receiving from their own movement and movement feedback provided by the game interface through the computer character. This gap was often considered a possible barrier to fully engage with the body in the game.

In summary, two different patterns of movements were observed: the first was a very controlled type of movement aimed to focus and perform well in the game. Amount and type of movements were completely dictated by the game controller. The second pattern reflected a desire to simulate a role, in this case that of an athlete, with less attention to game score. The level of control over the movement strategies the players could adopt was dictated by factors that ranged from personal motivation and knowledge of the game to personal movement skills.

3.3. Body movement taxonomy and a novel engagement model

Following on these studies, we propose five different classes of body movements that can be displayed during game play and describe their relation with the four types of engagement component reported in Section 2.3, i.e., hard-fun or challenge, easy-fun or fantasy, altered state and social component. Whilst we do not argue that this taxonomy is complete, we argue that these movements do play a role in player engagement on the basis of the literature presented in Section 2.

Five Classes of Body Movement

Task-control body movements. These movements are defined by the game controller or by the game interface. They are necessary to control the game and/or to score points. As shown by Brown and Cairns (2004) for desktop-type games, a good mastering of the control commands (e.g., keyboard and mouse control) is necessary to facilitate the involvement in the game and let the player engage in winning the game. Analogously, a good command of body movements controlling the game (i.e. timing and direction of the wrist or arm movement controlling the Wiimote) is essential to enable the player to perform well in the game, i.e. to play the game to win: what Lazzaro defines as hard-fun.

Task-facilitating body movements. These movements are not defined by the game interface in the sense that the game interface does not recognize or react to them. They are consciously or unconsciously selected by the player to facilitate game control. As shown by Kirsh and Maglio (1984), when game complexity is high, a player may distribute the control of the game over the resources available (i.e. a form of distributed cognition). They showed that in the Tetris computer game[7], players continuously rotate

[7] http://www.tetris.com/ [downloaded on 6 January 2010].

an element to facilitate decisions on how to position it. They suggested that this occurs more frequently as players become more skilled but only when there is a gain with respect to the cost of performing the action (Maglio et al., 2008). In the highly engaged group of the desktop study reported earlier, skilled players were showing head navigation movements to facilitate navigation within the environment. In full-body movement games, a new type of resource is made available: the body. Hence, within the limits of the game interface's affordance and the player's skills, body movement becomes a resource to explore new strategies to facilitate game control towards winning the game (i.e., hard fun).

Role-related body movements. These movements are typical of the role adopted by the player in the game scenario. As in the previous case, the game interface does not recognize or react to them. Some of the role-related movements can be also seen as task-facilitating movements as they may facilitate the control of the game as well as indicate a higher sense of presence in the game world. An example is provided by the head movements observed in the half-life game experiment described earlier. However, role-related movements do not necessarily facilitate the control of the game. Instead, they can sometimes interfere with game play. They are acted by the player who endorses the role and enters the fantasy world. For example, in the Wii scenario, expert players reported to consciously select sport-like movements over the more efficient tiny arm movements when they wanted to relax even if they were conscious that the score of the game could be negatively affected. Hence, this type of movement seems to favor an easy fun type of engagement where the player explores a new reality and a new way of being. Note that such decision can only be made when the player' skills allow it. As reported earlier, more explorative behaviours are observed when the controller affordance is not yet known to the player. We suggest that even in this case, body movements have a strong influence on the player experience through sensori-motor feedback.

Affective expressions. This class of gesturing expresses the affective state of the player during game play. They are spontaneously expressed or acted and generally not recognized by the current game interface. They are a window on the player's experience but, as discussed in Section 2, they are also a means to change the player's state of mind (the third factor of Lazzaro). In the desktop scenario, the affective state of the player was clearly evident from the presence (boredom) or not (focus) of fidgeting. In the sport game scenario, the style of play was chosen by players to change their state of mind, with a more active/sport-like style of play being seen as a relaxing one. In a hard-fun type of game, typical expressions observed are frustration, a sense of defeat or triumph. A larger set of emotions is experienced in other genres of games (Lazzaro, 2004). Furthermore, as reported in Section 2, an increase in positive emotions and self-esteem has been observed in body-movement games.

Expressions of social behaviour. Expressions of social behavior are expressions that facilitate and support interaction between players (e.g., attracting attention, showing empathy, etc.). They are spontaneously expressed and are not currently recognized by the game controller. They indicate the level of awareness of other players in the game, i.e., the person factor of Lazzaro. By sending social signals, these movements enable the social experience to gain a more important role in the game experience as a whole. These are movements used to interact with the co-player but not required by the game. This type of body movements was not observed in the two studies reported earlier as the conditions considered only involved one player at a time. However, we feel it is important to include them here as the social factor is one of the motivations bringing people to play games. For example, in the previously cited Dance-Dance Revolution study, an increase of social engagement was reported by players (Hoysniemi, 2009).

Engagement model

Here, we would like to argue that these five classes of movements are not just a window on the player's experience, they also represent an important means of steering the player's engagement towards a certain type of experience. Our aim is to start building a framework to address our question and finally offer the basis for a more systematic approach to the design of full-body computer games that take into account, and exploit, body movement as a means for modulating player experience. Hence, it is important to understand if and how the game controllers themselves influence players in exploiting such movement. In Figure 1, we illustrate our proposed model relating the five types of body movements to the four components of engagement identified by Lazzaro (thick white arrows). The grey arrows indicate the possibility of shift of the player in his/her physical engagement with the game: from a simple command control type of involvement to a strategy that exploits the body as a resource to distribute the cognitive load imposed by the game. Factors such as controller affordance and player expertise are indicated as some of the possible inhibitors or facilitators of this shift.

FIGURE 1 ABOUT HERE

With this model, we suggest that: 1) the design of the game controller in relation to the type of movements that it requires or affords affects the way the player physically engages with the game; and 2) each class of movements can facilitate or inhibit the emergence of another class of movements and hence affects the type of engagement. In particular, we suggest that task-controlling/facilitating body movements that are also role-related can facilitate a shift from hard-fun to easy-fun and affective and social engagement. In the following section, we report a set of controlled experiments investigating these two questions in the context of single player's games.

4. HARD-FUN AND EASY FUN: THE ROLE OF BODY MOVEMENT

The question we specifically address here is whether games that require task-control body movements and favor task-facilitating body movements that relate to the role-play of the game will: 1) result in an increase in player engagement; 2) induce more role-related body movements; and 3) involve a broader set of emotions in the players. To address this question, we conducted two separate experiments (Bianchi-Berthouze, Kim, Patel, 2007) that we report here for completeness. In the first experiment (Section 4.1), the participants played a same computer game using two different controllers that imposed different amounts of task-control movements and facilitated a different amount of task-related movements. To rule out the possibility that the shape of the controllers itself may be a confounding factor, a second experiment (Section 4.2) was performed in which the participants used the same controller with the difference that the amount of body motion imposed in the two conditions depended upon how the controller was used. Finally, in Section 4.3 we present an analysis of the videos captured in these two experiments to better understand the type of body movements used by the players and the experience they had in the different conditions.

4.1. Study 1: Dual-pad vs. movement-based controller

Participants and Material

Fourteen participants (age: μ=25 and σ= 4.4) were asked to play Guitar Hero[8], a music game for PlayStation. All participants were beginners and had no prior exposure to such game. The game sees the player "play" the song by pressing a number of colour-coded buttons in sequence. The timeliness of each input contributes to the score of the player. Each participant was asked to play the game in two conditions. In the first condition, the player was given a standard PlayStation DualShock controller, which only involved button pressing. In the second condition, the player was given a guitar-shaped controller that featured not only five fret buttons but also a strut bar and a whammy bar so that the device felt like, and played like, a real guitar. With this controller, raising the neck guitar upward increased the player's "star power" (energy to score more points). With the DualShock controller, the "star power" was acquired by pressing a button.

Protocol

Before playing the game, the tendency of the participant to get engaged -- a potential predictor of experiencing engagement (Brown and Cairns, 2004) -- was assessed using a revised version (GITQ)[9] of the Immersive Tendency Questionnaire (ITQ) proposed by Witmer and Singer (1998). After filling the questionnaire, the participants were let to familiarize themselves with the game and the game controllers for a period of 5 minutes. The participants were fitted with a lightweight (6kgs) exoskeleton (GIPSY by Animazoo Ltd, UK) on their upper body, arms and head, so as to provide angular measurements for each of the upper-body joints. In addition, a video camera was placed in front of the participant to record his/her body movements during play. Each participant was asked to play for 20 minutes in each condition, with each condition played over two different days. The order in which each participant played each condition was counterbalanced.

[8] http://en.wikipedia.org/wiki/Guitar_Hero [last downloaded on 6 January 2010]
[9] http://www.cs.ucl.ac.uk/staff/n.berthouze/Questionnaires/GITQR.pdf

After each condition, the engagement level of the participant was assessed using a revised version [10] of the Gaming Engagement Questionnaire (GEQ) by Chen et al. (2005).

Results

Since both GEQ and GITQ are based on the theoretical work of Sheridan (1992) who suggested that the factors that underline the concept of presence could be grouped into 4 categories (Control, Sensory, Distraction and Realism), it is reasonable to think of the tendency to get engaged as a predictor for engagement. To investigate how individual differences in engagement tendency actually related to the degree of engagement experienced, three correlation coefficients were calculated: (a) the Pearson's coefficient for the DualShock condition (condition D thereafter), (b) the Pearson's coefficient for the Guitar condition (condition G thereafter) and (c) the Pearson's coefficient when both conditions were pooled (condition D+G thereafter).

In the pooled condition, a significant correlation of $r=.610$ ($p<.01$) was obtained, thus justifying our prediction. When considering each condition separately, however, we found that this correlation was mostly accounted for by a significant correlation obtained in the G condition, $r=.810$ ($p<.01$) since the D condition showed a non-significant correlation of $r=.426$ ($p=.146$). The significance of this finding will be discussed later in the section.

To investigate the role played by the game controller in the engagement level of the participant, we performed a paired t-test on the engagement scores of the participants in each condition. The test revealed that players in the G condition returned significantly higher engagement scores ($t=3.659$, $p<.001$). This finding was corroborated by an analysis of the video recordings of the players. This analysis showed a higher incidence of task-facilitating and role-related body movements (such as keeping the beat using head and body) in the G condition that, at least qualitatively, correlates with a higher engagement. This analysis is discussed in Section 4.3.

The amount of body movements in each condition was quantified by a measure (denoted Gypsy score thereafter) computed as the normalized sum of the total angular movement over the entire duration of the song. Concretely, a sum of angular differences between each consecutive frame was computed, summed up over all frames (60 frames per second), and normalized by the number of frames in a song to account for differences in song duration.

Prior to looking into any correlations between movement and engagement, a comparison of means between conditions D and G was done on the GITQ, GEQ and Gypsy scores. Since these scores have interpersonal differences, using absolute values

[10] Items that did not relate to gaming and engagement were excluded and some of the terminology was modified to suit measuring people playing games. http://www.cs.ucl.ac.uk/staff/n.berthouze/Questionnaire/GEQR.pdf

might not be appropriate (Peter, Herbon, 2006). To standardize the scores, the Gipsy score X_n was z-transformed, i.e., demeaned and divided by the standard deviation σ: $Z_n=(X_n-\mu)\div\sigma$. Significant differences were obtained in both GEQ scores (t=-3.659, p<.001) and Gypsy scores (t=-3.264, p=.002), both obtaining higher values in the G condition. A similar significant difference was not found in GITQ scores (t=-.768, p=.444). This lack of significance in the GITQ scores was reasonable since the participant's tendency to engage should not be affected by any of the variables, including the change in game controller. Thus, these findings demonstrate significant differences between conditions.

In light of those findings, the correlations obtained earlier between the two questionnaires become significant. They suggest that providing the participants with either a more natural game controller, or affording them more movement facilitates this relationship. Given a similar GITQ score, the higher correlation obtained in the G condition demonstrates that the guitar-shaped controller enhanced the level of engagement the participants experienced.

4.2. Study 2: Removing the novelty effect

To remove the possibility that the shape of the controller (and hence its novelty), rather than the movements it afforded and elicited, could be a factor in the increased engagement level, we carried out a similar experiment with the main difference being that only the guitar-shaped controlled was used.

Participants and Protocol

In one condition (here again called D for consistency), the guitar-shaped controller was used as a dual-pad controller, i.e., the participants were taught all of those features that are controlled solely with the hands (i.e., fret buttons, strut bar and whammy bar). In the second condition (here again called G for consistency), instead, the participants were also informed about the tilt sensor in the neck of the guitar to acquire "star power". The "star power" in the D condition could be obtained by pressing a button on the body of the guitar. Eighteen participants (age: μ=20 and σ= 0.77) took part in the experiment. All participants were beginners. Each group of 9 participants was asked to play one condition only since using the guitar knowing about the tilt-sensor feature but not being allowed to use it would have been too unnatural. Each participant was asked to play for 10 minutes after which his/her engagement level was assessed using the same revised version of the Gaming Engagement Questionnaire (GEQ) mentioned earlier.

Results

After confirming that the GEQ score were normally distributed, they were analysed using a t-test. The test revealed that players in the G condition returned significantly higher engagement scores (t=5.123, p<.001) supporting the finding of the previous experiment, i.e., that the body movement imposed in the G condition appears to affect the engagement level.

To better understand how the conditions affected the engagement level, we measured the amount of motion of the players in two different ways. The first measurements were computed using the data collected with the motion capture system. For the second type of measurements, we asked 3 observers (students from the local Psychology department) to rate the amount of movement of each player over a 7-degree scale (10 minutes of video for each player). The observers were informed of the two experimental conditions and were instructed not to consider in their evaluation the periods during which players raised their arms to get "star power". To examine the validity of these two types of measures, the average of the observers' scores was computed and correlated with the motion capture scores. A strong correlation was found between both types of measurement (Pearson = 0.858, $p < 0.001$).

We then computed the correlation between amount of movement and engagement scores. The left panel in Figure 2 shows the relation between amount of movement computed on the motion capture data and the engagement score, whereas the right panel depicts the relation between engagement score and movement as evaluated by the 3 observers. Both graphs reveal a positive trend in the G condition and a negative one in the D condition. The trend in the D condition (Pearson's coefficient = -.766, $p = .016$ for the left panel) confirms the results of other studies showing that attention is correlated with a decrease in body motion not related to the task (Rugel, Cheatam, Mitchell, 1978; Farrace-Di Zinno, Douglas, Houghton, Lawrence, West, Whiting, 2001).

FIGURE 2 ABOUT HERE

In contrast, the trend in the G condition (Pearson's coefficient = .799, $p = .01$ for the left panel) appears to contradict such result as the amount of motion is positively correlated with the level of engagement in the player. We hypothesize that conditions D and G simply involve two different levels and types of engagement. In condition D, players may be driven by a desire to win the game (hard fun), leading to an increased focus on the display. In condition G, instead, engagement may also derive from the feeling of becoming a guitar player (fantasy) and from the higher level of arousal and positive experience that it generates.

4.3. Study 3: Role-play and affective experience

To verify the hypothesis above, i.e. that condition D triggers a more hard-fun type of engagement and that condition G facilitates a more easy-fun type of engagement, we performed a more extensive analysis of the players' body movements obtained in Study 1. In addition, we set out to test the hypothesis that given the larger range of movements offered in condition G, players would be more open to experience a larger set of emotions. Given that the games used in these studies are music games, we expected a larger amount of positive emotional expressions in the guitar condition (easy-fun condition) than in the dual-pad condition (hard-fun condition). Of course different types of role-games will trigger different ranges of emotional experience.

Material

From the videos collected in Study 1, we selected the clips that showed body movement that could either be related to affective expressions (see Figure 3, left) or be role-related movements (excluding raising the neck of the guitar). Twenty seven video clips, portraying 12 of the 14 participants, were obtained. As expected from the previous section, the number of clips that could be extracted from the G condition was much higher than in the D condition. Each clip included 2 seconds prior to the main motion and 2 seconds afterwards so as to provide some context. In total, the clips lasted about 5 to 8 seconds, depending on how long the expressional movements or gestures were (1 to 4 seconds). To provide a reference for the type of affective experience that may occur in non-computer games, ten clips of affective body movements from players playing a social board game were added to this pool.

FIGURE 3 ABOUT HERE

Participants and Protocol

Six observers (students from the local Psychology department) were asked to rate the body movements displayed in the video clips according to three affective dimensions (valence, arousal and power of control) on an 11-point scale. They were also asked to select, within a list of 22 affective words, the word that they felt best described the subject's emotions. This list (excited, aroused, happy, content, relaxed, satisfied, bored, depressed, sad, miserable, frustrated, annoyed, angry, alarmed, surprised, frightened, disgusted, hateful, amused, disappointed, calm, joyful) was designed on the basis of the Circumplex model of affect of Russell (1980), a list of words proposed by Bowen (2005) and by Peter and Herbon (2006), and from a pilot study we conducted. In addition, the observers were also encouraged to select their own word if they could find a more appropriate one. The observers were allowed no more than 4 viewings of each clip and each session took approximately 30 to 40 minutes.

The randomized 37 clips were shown to the 6 observers using an Apple MacBook 2.0Ghz laptop computer with a 13.3" wide-screen display. To remove any possible confounds of sound and facial expressions, the clips were shown in mute and with a semitransparent sheet covering the display. The relatively low resolution of the clips (320x240 pixels) and the relative opaqueness of the material resulted in clearly visible body movements but blurred facial expressions (see Figure 3, right).

Results

Means and standard deviations were calculated for each clip's dimensions of arousal, valence and control. The scores were in the range [-5,5]. Mean scores were used to minimize individual differences and investigate the general consensus as a whole. It showed arousal, valence and control/power mean values to range from approximately -2.5 to 3. All clips' evaluation had a standard deviation of less than 2.5, except for five clips. The third dimension was found to essentially correlate with arousal (possibly because of a misunderstanding by the observers) and was therefore discarded.

Figure 4 shows the projection of the clips in the arousal/valence space. We analyzed the data in terms of whether adjacent clips in that coordinate system would show similarities in the associated body movements. Our analysis revealed 8 clusters, as shown in Figure 5. Looking at the type of movement associated to each cluster, we can see that the high-arousal/high-valence quadrant contains movements that are related to positive emotions and to music-player role-movements. The opposite quadrant instead contains movements that can be related to negative emotions possibly expressed when the player made mistakes. Interestingly, most of the clips for condition D fall in the low-valence quadrants (predominantly around low/neutral levels of arousal). The clips from condition G fall mainly in the high-valence/high-arousal quadrant but still have a good representation in the low-valence/low-arousal quadrant. This supports our hypothesis that in condition G, the affective experience is not only related to performance in the game, but also to enjoyment derived from the music-playing role assumed by the player.

FIGURE 4 ABOUT HERE

FIGURE 5 ABOUT HERE

To rule out the possibility that the extraction of the clips could be biased, we repeated the experiment by asking 3 new observers to rate the complete videos of 6 participants (3 videos for each condition) randomly selected. The observers were asked to indicate the starting time and ending time of each negative or positive affective expressions or role-related movement (e.g., dancing, keeping the rhythm). The results showed a significant difference between conditions with a larger presence of positive affective expressions ($p < 0.0001$) as well as rhythmic movements such as dancing ($p < 0.005$) in condition G.

Whilst the subject pool for this set of studies was rather small, the results obtained indicate statistically significant relations between body movement and engagement and raise interesting questions worth further investigation. The main finding was that body movement appeared to not only increase player engagement but also modify the way players got engaged. The combined results demonstrate in fact that the controller itself played a critical role in creating a more complete experience. By enforcing and facilitating body movements that are related to the role-play of the game, the device resulted in a higher sense of player engagement and mediated a feeling of presence in the digital world. Players appeared to quickly enter in the role suggested by the game, here, a musician, and started to perform role-related motions that were not required by the game itself but instead could interfere with it (e.g., dancing). Gaming was no longer only a question of challenge; the experience itself was also seen as a reward by the players. In condition G, role-related body movements (i.e., raising the guitar upward) resulted in the player displaying more excitement. It must be noted, however, that the resulting increased "star power" could also be a contributing factor. However, even within the same condition G, engagement scores were positively correlated with the amount of movement, thus supporting our hypothesis.

5. DISCUSSION: SHIFTING BETWEEN ENGAGEMENT TYPES

The experimental results show that when game controllers afford role-related types of body movement, the player can transition from a pure attention-based and hard fun experience to a more affective experience. When the controllers do not require and do not afford natural body movements, we observe a complete lack of movement other than those necessary to facilitate the control of the game; on the other hand, when the controllers require and afford body movements that are unique to the game scenario, we observe movements that are related to role-play and enjoyment even though those movements may interfere with game performance. Figure 6 illustrates these relations and suggests that sensory feedback can facilitate the emergence of another component of engagement by triggering related body movement (grey thick arrows) if the controller (and the game) can afford it. In the next subsections, we use our experimental results to support the model.

FIGURE 6 ABOUT HERE

5.1. Hard-fun

One of the reasons players play games is hard fun, i.e., they want to test their skills, and create and test new gaming strategies. According to Csikszentmihalyi (1992), this requires the right balance between task-demand and skills. Our model hypothesizes that task-control and task-facilitating body movements can support hard fun not only by providing a larger repertoire of strategies for players to challenge themselves, but also by providing new resources that can be used to make the control of the game easier and thus making it possible to take on harder challenges. This is accomplished by recruiting embodied resources that are more appropriate to the task and that can also prime the right selection of successive parallel actions. Particularly in the case of advanced players, we observed an increased use of task-facilitating movements, consistent with Maglio et al (1994). Head movements simulating the navigation within the virtual environment in

Half-life may have facilitated the controlling of the key pressing actions to move within the environment. The music-based rhythmic foot tapping in Guitar Hero may have facilitated the right timing of the pressing of the buttons of both dual pad and guitar neck. However, as suggested by Maglio et al. (2008), extra actions are taken only if the gain in task performance is greater than the cost incurred by producing them. For example, the use of rhythmic head nodding in Guitar Hero condition D has been very limited probably because, unlike foot tapping, the continuous moving of the head (and hence of the eyes) would have interfered with the need to constantly fixate the display to read the new incoming notes and other occurring events that required immediate reactions. Conversely, the presence of head nodding (role-related movement) in Guitar Hero condition G could have resulted from criteria other than task performance being involved as will be discussed in the next section.

Thus, task-facilitating body movements could be seen as a distributed cognition strategy (embodied cognition) that reduces the cognitive load by distributing it among available, most appropriate and skilled resources (Kirsh, Maglio, 1984) that may facilitate or provide further information to correctly perform the task. However, it is important that task-control and task-facilitating movements reflect the skills of the players in order not to break the engagement process (Csikszentmihalyi, 1992). Most players that scored very high on the engagement questionnaire were very still, the only observable movements being those necessary to use the controller. In the Guitar-Hero scenario, the limited amount of task-facilitating movements observed may have indicated either that (a) the game was complex and that players (beginners) had not yet developed the skills for, or discovered, how to exploit any extra resource; or (b) that most movements would have had a high cost in a task that was highly demanding in terms of visual fixation. Non-task related movements may instead be seen as an index of disengagement. In the desktop game study reported in Section 3.1, players that scored very low on the engagement questionnaire showed a high amount of fidgeting that reflected a high level of attention to one's body needs rather than to the game (e.g., uncomfortable sitting position).

No other type of movements from the taxonomy was generally observed in relation to hard fun. Body movements very rarely expressed emotions and the expressions were mainly those of frustration or sometimes of personal triumph, i.e., hard fun emotions. This was also the case in the Wii-sports scenario where the movement patterns were purposely kept to a minimum, giving up on any resemblance with the actual sport in order to maximize the timing of the movement and hence the performance in the game.

5.2. Easy-fun

In easy fun, what captures the player's attention is the sensation of wonder, awe and mystery. The player has the desire to feel part of the game, to be the character of the game. We hypothesized that a controller that requires body movements that are natural to the game scenario facilitates easy fun. In Study 2 (condition G), when players were asked to raise the guitar neck to acquire more "star power", the number of role-related but not task-facilitating movements was significantly higher than when simply using the hands to control the guitar. Extra movements such as head nodding, raising the guitar over the head and dancing were observed even though those movements could interfere with game performance. The presence of these extra movements was also correlated with higher scores in the engagement questionnaire. Hence, task-control movements that relate to the role of the players (e.g., raising the neck of the guitar) may help the player in entering the fantasy world of the game and take up the new role. The mechanism that facilitates the shift from hard fun to easy fun could be the proprioceptive system that provides sensory motor feedback from the body configuration and movement. In fact, we saw in the sport game scenario that incongruent movement feedback from the game interface was a barrier to player engagement. Of course, other factors than the game controller itself play as inhibitors and facilitators of this shift such as player motivation (see interview in sport-game scenario), skills, personality, self-awareness, etc. Another strong obstacle to engaging with the body in a role-like manner is again the attention load that the game imposes on the player. In all our experiments, the player's attention on the display was required at all time and hence any distraction from it was very expensive score-wise. Indeed, players only briefly engaged in role-related movements that interfered with the attention level required by the game.

5.3. Affective experience

The third factor for playing games is altering and experiencing emotions. As discussed in Section 2, body movement has been shown to have strong regulatory properties on emotions. In support to our hypothesis, results from Study 2 (condition G) demonstrated that players showing role-related body movements exhibited a significantly higher number of positive emotional expressions and higher arousal. The players were not simply showing frustration or expressions of personal triumph but also expressions of general enjoyment. These positive expressions could be due to somato-sensory feedback derived from dancing movements (Riskind, J.H., Gotay, 1982). By taking up the role offered by the game, the player was led to experience not only emotions typical of the hard fun experience, but also emotions that were related to the experience of the role. Dancing and other music playing gestures may have increased the arousal of the player and the sensory motor feedback may have had an effect on her mood thus facilitating positive emotions. It is possible that a different game role may trigger a different emotional experience, but the important message here is that by entering the fantasy role, a broader emotional experience can take place. As seen in the sport game scenario, expert players decided to enact the sport movements if their aim was to change their mood. The loose Wii body-movement controller provided by the game allowed the player to decide how to engage in the game. The guitar controller did not afford such liberty of movement playing strategies; however the "raising guitar neck" movement was able to facilitate a shift from hard fun to easy fun and to a broader emotional experience.

6. BODY MOVEMENT AND THE SOCIAL FACTOR

All previously described experiments involved a single player. Here, we describe a study (Lindley, Le Couteur, Bianchi-Berthouze, 2008) aimed to explore how the quality of movement afforded by a controller can affect engagement in the *social* context of collaboration during game play. It is predicted that controllers that encourage movement will support increased social behaviour due to their stronger social affordances, and that higher levels of engagement will occur when the use of the input device entails natural movements. We propose that, as in the previous set of experiments, engagement will be linked to the experience of easy fun and altered states, and that increases in social interaction will serve to complement (rather than detract from) this experience.

6.1. Methods

Participants and Material

Engagement and social interaction between collaborators were explored in a game of Donkey Konga[11], when the input devices were bongos, which afford natural movements, and a standard game controller, which does not. Donkey Konga (developed by NamCo) was played on a Nintendo GameCube using a Nintendo bongo controller and a wireless Nintendo GameCube controller. A 21" Panasonic television was connected to the GameCube. When the bongos were used players were encouraged to tap the bongos and clap their hands in time with the music; when the controller was used these actions were performed through button presses using fingers and thumbs. The participants were 10 pairs of female university students (age: $\mu = 21$, $\sigma = 1.3$), who were recruited as friends. All had played video games prior to the study, but considered themselves novices. None had ever played Donkey Konga.

Protocol

A within-pairs design was adopted so that individual differences in engagement and social behaviour would not obscure behavioural differences resulting from the type of controller used. The independent variable was the controller, with two conditions: Donkey Konga bongos and a wireless GameCube controller. The order of the two conditions was counterbalanced across the pairs. The dependent variables were the level of engagement and the amount of social behaviour (both verbal and non-verbal). A video camera was used to record the participants. Instruction sheets were used to ensure that all participants received the same information on how to play the game. As in the previous set of experiment, a revised version of the Chen *et al.*'s Engagement Questionnaire (2005) was used to score engagement. Items that did not relate to gaming were removed and the terminology was modified to suit the context of computer games.

[11] Donkey Konga. http://donkeykonga.com/ (downloaded on 6 January 2010)

Participants played the cooperative mode of Donkey Konga, entitled ‘Jam Session’, in two-player mode (‘Duet’). The easiest skill setting, ‘Monkey’, was used. In each condition, the pairs worked their way through a pre-determined sequence of eight songs. Once the eight-song sequence was over for the first condition, the engagement questionnaire was filled in. The second condition was then undertaken, and the engagement questionnaire completed for a second time. Throughout the experiment participants sat at 45 cm from each other.

Analysis

The Engagement Questionnaire scores for each participant were totalled (after reverse scoring items that measure a lack of engagement). The scores for the participants in each pair were then summed to give a single engagement score for each pair in each condition, one for the bongos and one for the controller. Videos of the participants were analysed to give measures of social behaviour. The 10 minutes of video that followed the first two songs of each condition were analysed (the first two songs were treated as a practice phase, although participants were unaware of this).

The participants’ verbal and non-verbal behaviours were coded following definitions based on the Autism Diagnostic Observation Schedule (Lord, Risi, Lambrecht, Cook, Lenventhal, DiLavore, Pickles, Rutter, 2000), which has also previously been used for analysing the behaviour of adults of normal intellectual ability. Verbalisations were categorised as *speech* or *other utterances* (e.g., laughter and groans), and the length of time that each participant spent producing speech and other utterances was measured. These totals were added together for the two participants that comprised each pair, producing a single score for each pair.

Non-verbal behaviours were also classified according to two categories. *Instrumental gestures* were defined as those in which the action conveys a clear meaning or directs attention (e.g., pointing, shrugging, and nods of the head). *Empathic gestures* were defined as those in which the action is emotive (e.g., placing the hands to the mouth in shock). The number of gestures made in both categories were tallied and summed to give a score for each pair.

6.2. Results

A within-pairs analysis was carried out, as one participant’s behaviour cannot be said to be independent of the other participant in the same pair. To ensure that differences were not due to variations in performance, scores on the game were compared across the two conditions. A Wilcoxon’s two-tailed matched-pairs signed-ranks test showed that the type of controller had no significant effect on performance ($Z = -0.889$, $p = .414$). All further differences were evaluated for statistical significance using Wilcoxon’s one-tailed matched-pairs signed-ranks tests. The scores derived from the Engagement Questionnaire were averaged across the 10 pairs for each type of controller. The participants rated themselves as experiencing a significantly higher level of engagement ($Z = 2.803$, $p < .01$) when using the bongos (mean = 248.80, std. dev. = 23.03) than the wireless controller (mean = 198.50, std. dev. = 25.33). This suggests that the increase in body movement afforded by the input device made for a more engaging experience, and that this was not compromised by the increase in social interaction.

The amount of time each pair spent making verbalisations classified as speech and as other utterances, and the number of instrumental and empathic gestures, are given in Figure 7. The participants produced more speech ($Z = -1.478$, $p = .08$) and significantly more other utterances ($Z = -2.599$, $p < .01$) when using the bongos than the wireless controller. Although the difference for speech does not reach significance, it does approach it, and it seems likely that with a larger sample a significant difference would have been obtained. Participants also made significantly more instrumental ($Z = -1.895$, $p < .05$) and empathic ($Z = -2.5273$, $p < .01$) gestures when using the bongos than the controllers, lending further weight to the idea that there was more social interaction in this condition.

FIGURE 7 ABOUT HERE

7. DISCUSSION: THE SOCIAL FACTOR

The fourth factor of Lazzaro is the person factor, namely, that players use game as a means to engage in social interaction. In this last experiment, the results show that by adopting a controller that affords natural body movements, the degree of social interaction with a collaborator is increased. The increase in empathic gestures, which are used to express emotions rather than communicate specific information, along with utterances such as laughter and groans, suggest that when using the bongos the players became generally more emotionally involved. The use of the bongos may have supported the simple enjoyment and curiosity of experiencing the game (easy fun). The ways in which they afforded clapping and dancing may have excited positive emotions (altered states). Furthermore, the increase in instrumental gestures and the trends for speech indicate that deliberate attempts to communicate information were also affected. Finally, by creating opportunities for cooperation, performance and spectacle, the bongos were able to support the enjoyment of playing with a collaborator (the people factor). Studies in evolutionary psychology have shown that positive mood facilitates social interaction (Haviland-Jones, Rosario, Wilson, McGuire, 2005). This latter point also suggests that the increases in engagement and social interaction may be interlinked with the type of controller. Figure 8 refines the engagement model, by highlighting the relationship between positive affective experience and role-play experience as facilitators of social engagement. It also highlights the fact that players' relationship as well as the profile of each player may support or inhibit the emergence of social interaction.

FIGURE 8 ABOUT HERE

Whilst it seems probable that by encouraging social interaction, players would be drawn out of the game environment and into the 'real world', this did not have adverse consequences for engagement. Instead, engagement was found to increase alongside social behaviour when the controller afforded more natural movements. This is in keeping with the suggestion by Brown and Cairns (2004) that invisibility of control supports engagement, but does not conform to their proposal that the first step towards full engagement (or what they term immersion) has links with highly focused attention and a reduced sense of self. Perhaps this can be explained by recognising that engagement is multi-faceted, and that as shown in the previous experiments, engagement may depend on aspects of experience other than the pursuit of a goal.

In this experiment the pairs were collaborating, and the increased communication may have facilitated cooperation. It is also of interest to speculate how social behaviour might change for pairs competing with one another, or when a player is in the presence of an observer. Players may be less likely to exaggerate their movements when competing to avoid giving an advantage to their opponent. On the other hand, exertion seems to have a strong effect on enhancing not only cooperation (camaraderie) but also competitiveness as discussed by Mueller and Bianchi-Berthouze (2010) in comparing levels of trust between players after having played either an exertion game or a non-exertion game.

8. CONSIDERATIONS FOR DESIGN AND CONCLUSION

Taken together, our findings support the idea that controllers that afford the five categories of body movements listed in Section 3 could result in a more complete game experience. Players enter a loop in which the more they move the more they are affected and the more they want to move. The quality of engagement then changes from a more hard fun type to a mixture of easy fun and emotional and social experience. This is an important finding for game designers as the selection of the body movement to control the game and the degree of freedom offered by the controller will have an effect on how the player will engage with the game. Some design guidelines can be derived from the studies reported in this paper and the model.

First, to trigger this loop, it is not just the task-control body movements that need to be carefully thought through and designed, but all five categories. As pointed out in (Antle, Corness, Droumeva, 2009), the design of the controllers and the game interface in general should take into account the role-related movements more likely to be performed by the player in the context of use of the technology. Such movements should be related as much as possible to the role-play offered by the game to facilitate suspension of disbelief and entrance in the world. Slater, Steed, McCarthy, and Maringelli (1998) showed that by having the participant walk in the virtual environment, the sense of presence was enhanced. The same result was not obtained with other walking metaphors (e.g., simulated by the movement of the hands). The challenge from an implementation point of view is to simulate such movements when the physical space available does not reflect the virtual space.

A second design issue is the level of constraint that should be imposed on the execution of the task-control movements. In the Wii-study, the control of the game was based on angular displacement of the Wiimote controller. The relatively poor accuracy of the Wii sensor makes it difficult for the player to realize when and why a movement was wrong. This, however, provides space for players to explore and appropriate the way the game can be controlled. Beginners learning to play the game focus on the movement their arm (or even their body) performs rather than the movement they induce on the Wiimote (the real control movement). These opportunities for appropriation are consistent with Gaver et al. (2006). Randomness introduced by errors, which is in itself meaningless, seems to generate a richer behaviour in people, as they assign meaning to it. This is not so true for the bongo controllers and even less for the Guitar controllers, where the task-control movements are much more defined. Hence, when the task-control movements are very constrained, the space for appropriation is based on the controller affordance for the other four movement categories as observed with the Guitar Hero and Donkey Konga games. Interestingly, Dance-Dance revolution, a very successful full-body movement game for which there are competitions, offers two main forms of playing: *attacking,* which requires a perfect timing of steps supporting a hard fun time of engagement; and *freestyling* or *improvising* where the aim is to be as creative and expressive as possible. Thus, when designing the controller, the level of constraint and affordance should be parameters to tune according to the context in which the game will be used (from entertainment to fitness or health).

On a related note, it is also important to carefully design the movement feedback provided by the interface. As Ermi and Mäyrä (2005) pointed out sensory experience supports the engagement process by leading players to forget about the sensory input from the real world and focus on the sensory input from the virtual world. In movement-based games, movement is an important source of sensory (proprioceptive) feedback and therefore it is important that the interface provide believable movement feedback leading the player to feel part of the virtual world (Slater, Usoh, Steed, 1995). The congruency between proprioceptive feedback and movement feedback provided by the display can also play as reinforcement to the affective experience of the player. In mood induction experiments for example it was shown that when the stimuli and the felt emotions are congruent, the perception of the emotion produced by stimuli is heightened (Niedenthal, 2002).

The sensory feedback loop must also be exploited to support emotional experiences that can facilitate the task at hand. The five categories of movement could hence be used as mood and attitude induction mechanisms (Niedenthal et al., 2005). For example, control movements that induce positive emotions (Riskind, Gotay, 1982) should be favoured to facilitate copying capability and support motivation (Isen, Reeve, 2005) in rehabilitation and fitness games. The constraints imposed by the game setting (e.g., continuously fixating a display) on body movement and posture should be also carefully addressed. The Donkey Konga game and the Guitar Hero game required that the players continuously fixate the display. In fact, even when players in the body-movement condition clearly showed desire to engage through role-play, affective and social expressions, they had to quickly return their attention to the display and re-enter a hard-fun type of engagement. This suggests that the use of head-mounted displays or even multiple-modalities to represent feedback (the notes to be played in this case) could be an interesting avenue to explore. This should be further considered when social interaction is one of the main aims for playing the game (e.g., to facilitate social interaction in elderly population). Studies on empathy and social coordination have shown the importance of mimicry, counter-mimicry and imitation (Bandura, 1977), which in turn requires having access to the embodiment of the others. Chartrand and Bargh (1999) showed that enhancing mimicry facilitates interaction and the liking between partners. To facilitate social interaction, improving the perception of others is crucial. Again, the game settings explored in this paper do not particularly facilitate social interaction. This could be realised by reducing the importance of fixating the display, or by providing a representation of the others in terms of their expressive body.

Third, the discoverability of the mapping between body movements and commands and the perceivability of the feedback to support such mapping are also very important (Antle, Corness, Droumeva, 2009). As pointed out, various studies have shown that either the controller (Brown and Cairns, 2004) or the level of challenge of the game (Csikszentmihalyi, 1992) can be a barrier to engagement. In our context, physical challenge is an addition to what traditional types of controllers create. Designers need to go beyond simply considering the mental load imposed by the game or the difficulty of using a button-based controller. An extra challenge is posed by difficulties in performing certain types of movement as well as by the level of energy and fitness required. As shown by the Wii study (Section 3), different levels of realism should be tailored to the player's fitness, coordination skills and knowledge of the simulated scenario. This is particularly important not just from an engagement perspective but also from an ergonomics viewpoint. If the difficulties are too high, participants may find workaround strategies that could cause injuries. This calls for new methods to evaluate games that involve body movements. As body movement has cognitive, affective and physiological effects on a player, traditional evaluation methods used for mouse- or dualpad-controlled computer games need to be carefully applied to take such effects into account (Mueller and Bianchi-Berthouze, 2010). Furthermore, body-movement itself is a key to the experience. Using video observations or full-body motion capture techniques can provide a better understanding of the experience of the player. As techniques to automatically analyze these data are becoming available (Bianchi-Berthouze and Kleinsmith, 2003; Camurri, Lagerlof, Volpe, 2003; Kleinsmith and Bianchi-Berthouze, 2010; Camurri, Koštomaj, Boh, 2009), a more thorough analysis of how the body is used in the game and how it supports the various components of engagement of the player could be carried to inform the design, as well as to better understand this important modality.

Finally, other factors not explored in these experiments but highlighted in the model, need to be considered: personality, age, culture and environment could have an effect on the loop taking place. These factors may impinge on players' willingness to engage through their body movement and also to express their emotion through body language. Studies (Kleinsmith, De Silva, Bianchi-Berthouze, 2006; Butler, Lee, Gross, 2007; Matsumoto, Yoo, Nakagawa, 2008) have shown that cultural differences exist in the way people express and suppress emotions. Further investigations are needed to understand how those factors impact on the fundamental positive feedback look underlying this model, namely: the more you move, the more you experience, the more you move.

NOTES

Background.

Acknowledgments. I wish to thank the co-authors of the 2 studies that made it possible to develop the model proposed in this paper. In particular, I want to acknowledge Dr Sian Lindley (Microsoft research) and students Whan Kim, Darshak Patel and James Le Couteur who carried out the experiments reported in section 4 and 6.

Support. This research was funded by the EC under grant agreement MIRG-CT-2006-046434.

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HCI Editorial Record. (supplied by Editor)

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FOOTNOTES

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10. Items that did not relate to gaming and engagement were excluded and some of the terminology was modified to suit measuring people playing games. http://www.cs.ucl.ac.uk/staff/n.berthouze/Questionnaire/GEQR.pdf

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FIGURE CAPTIONS

Figure 1. Movement-based engagement model: Relationship between body movements and Lazzaro's engagement factors. The thick grey arrows highlight the shift mechanism from hard fun to easy fun. The circles denote inhibiting/facilitating factors.

Figure 2. Movement vs. engagement scores. On the left, the amount of movement is computed on the data collected with the motion capture. On the right, it is computed as the average of the scores of 3 observers. We can observe a positive correlation for the G condition (Δ), and a negative correlation for the D condition (X).

Figure 3. Left: Example of body movement in the selected clips. Right: Experimental setting. A semi-transparent sheet was used to blur any facial information (published with the participant's consent).

Figure 4. Projection of the clips into the arousal and valence space and their clustering according to body gestures. O = social board game, X = D condition and Δ = G condition. Each cluster is denoted by a letter. The descriptions of the gestures in each cluster are given in Table 1.

Figure 5. Typical body movements observed in the clips corresponding to the clusters shown in Figure 4 and the emotion labels used by the observers.

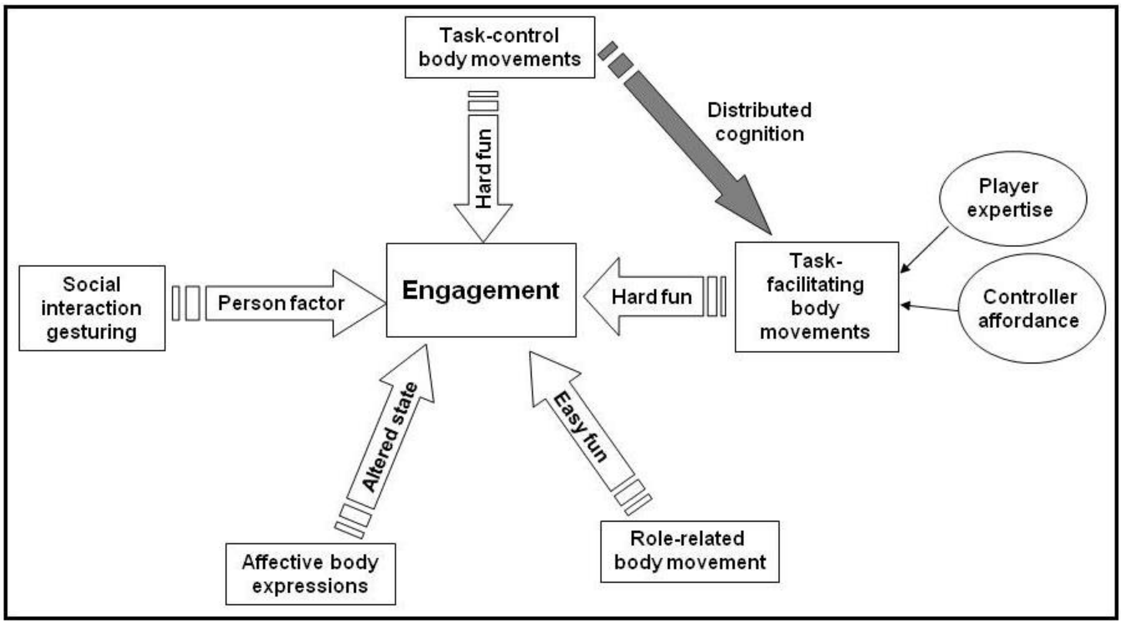
Figure 6. Refined movement-based engagement model: Easy fun and affective experience. The thick grey arrows highlight the shift mechanism from hard fun to easy fun. The circles indicate the inhibiting/facilitating factors. The hard-fun related arrows and circles are shown in dotted lines only to highlight the focus on easy fun and affective factors.

Figure 7. Means (and standard deviations) for the number of seconds each pair spent making speech and other utterances, and the number of instrumental and empathic gestures made.

Figure 8. Refined movement-based engagement model: The social factor. The thick grey arrows highlight the shift mechanism from easy fun to affective and social experience. The circles indicate the inhibiting/facilitating factors. Only the social-related arrows and circles appeared in continuous lines to highlight our focus on this aspect.

FIGURES

Figure 1. Movement-based engagement model: Relationship between body movements and Lazzaro's engagement factors. The thick grey arrows highlight the shift mechanism from hard fun to easy fun. The circles denote inhibiting/facilitating factors.



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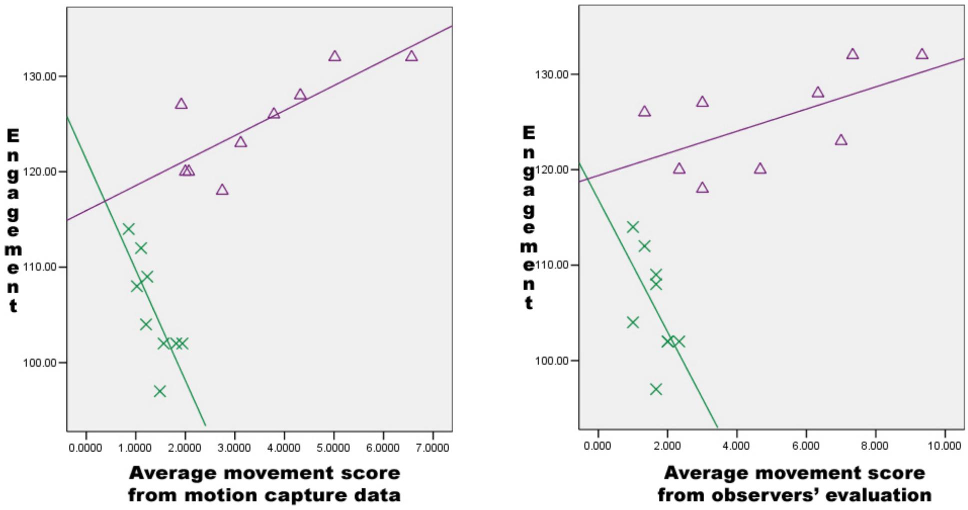

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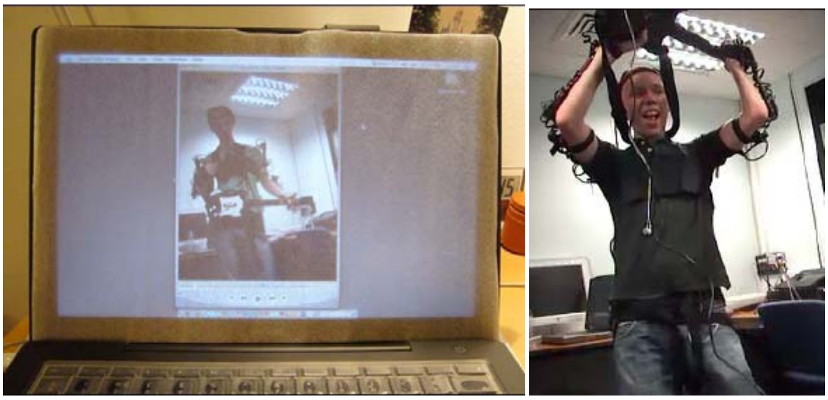

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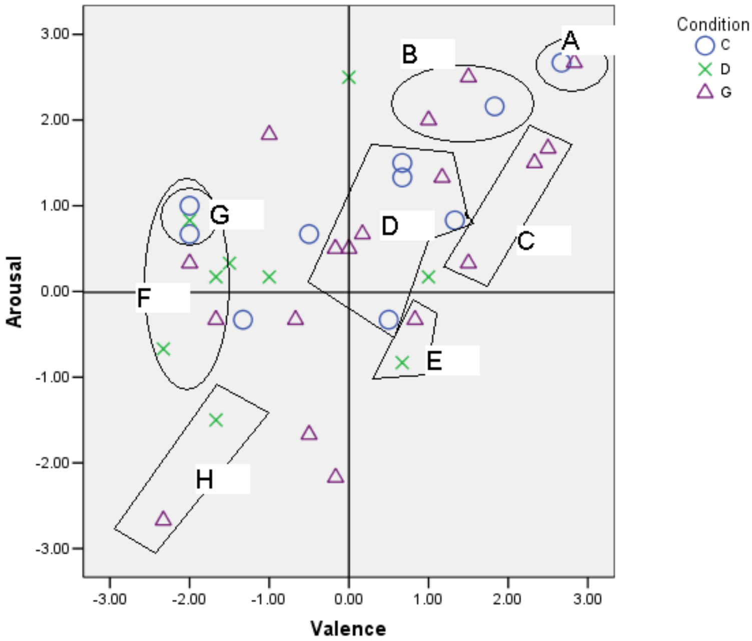

Figure 5 Typical body movements observed in the clips corresponding to the clusters shown in Figure 4 and the emotion labels used by the observers.

Cluster	Body gestures	Affective Labels
A	Raising arms up to mid air	Excited, joyful, happy
B	Shaking body in a rhythmic fashion (dancing)	Excited, content, aroused
C	Thumbs-up and arm bent	Happy, satisfied, joyful
D	Leaning back and shaking body	Amused, excited, happy, content, surprised, satisfied
E	Shaking head	Relaxed, content satisfied
F	Dropping arms	Disappointed, frustrated, calm
G	Shaking/shivering body while leaning back	Disappointed, frustrated
H	Very little movement	Bored, disappointed

Figure 6. Refined movement-based engagement model: Easy fun and affective experience. The thick grey arrows highlight the shift mechanism from hard fun to easy fun. The circles indicate the inhibiting/facilitating factors. The hard-fun related arrows and circles are shown in dotted lines only to highlight the focus on easy fun and affective factors.

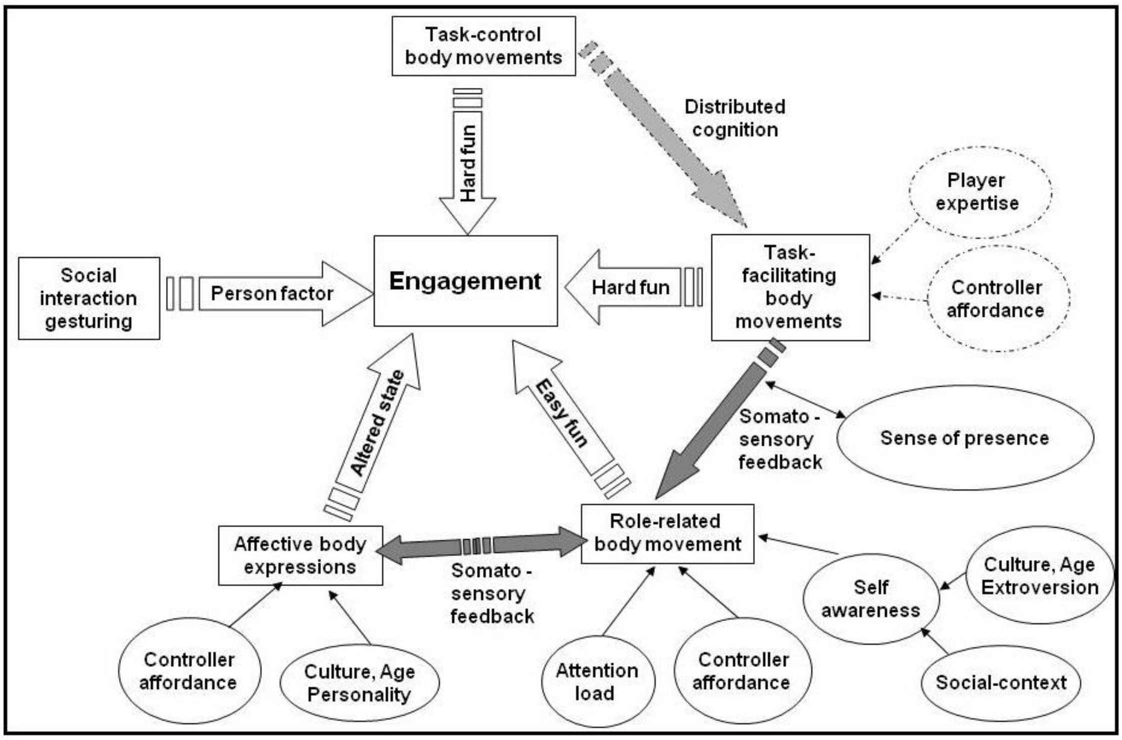

Figure 7 Means (and standard deviations) for the number of seconds each pair spent making speech and other utterances, and the number of instrumental and empathic gestures made.

Measures	Bongo	Wireless controller
Speech (sec.)	277.04 (143.67)	212.52 (101.68)
Other utterances (sec.)	57.58 (35.90)	24.01 (14.92)
Instrumental gestures (no.)	5.4 (4.67)	1.8 (1.55)
Empathic gestures (no.)	5.5 (5.62)	0.8 (1.23)

Figure 8. Refined movement-based engagement model: The social factor. The thick grey arrows highlight the shift mechanism from easy fun to affective and social experience. The circles indicate the inhibiting/facilitating factors. Only the social-related arrows and circles appeared in continuous lines to highlight our focus on this aspect.