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Abstract. The motion detection technology used in innovative game controlling devices like the Nintendo *Wii-Remote*® provides experiences of realistic and immersive game play. In the present study (N=62) it was tested whether this technology may also provoke stronger aggression-related effects than standard forms of interaction (i.e., keyboard and mouse). With the aid of a gesture recognition algorithm, a violent action role-playing game was developed to compare different modes of interaction within an otherwise identical game environment. In the *Embodied Gestures* condition participants performed realistic striking movements that caused the virtual character to attack and kill other in-game characters with a club or sword. In the *Standard Interaction* condition attacks resulted from simple mouse clicks. After the game session, participants showed a similar increase in negative feelings in both groups. When provided with ambiguous scenarios, however, participants in the *Embodied Gestures* condition tended to show more hostile cognitions (i.e., anger) than the *Standard Interaction* group. Results further corroborate the complexity of aggression-related effects in violent video games, especially with respect to situational factors like realistic game controls.

Keywords: Wii-Remote®, motion detection technology, gesture recognition, realistic interaction, violent video games, aggression, experiment.

1 Introduction

Video games have come a long way since their first steps some decades ago. Alongside general technological advances in computer science like, for example, improvements in graphics, so have video games developed into technologically advanced entertainment products. One particular aspect in the evolutionary process of human-computer interaction is the corresponding input and output hardware used in video games. For example, current game consoles like Nintendo *Wii*® combine accelerometer-based motion detection technology and force feedback functions, which aim at providing more direct or immersive gaming experiences. The upcoming Sony *Move* follows a related technological approach, whereas Microsoft's Xbox 360 add-on *Kinect* ("Project NATAL") does not require a controller but tracks whole body gestures and records spoken commands via a sensor device.

In the present study it was empirically tested whether technology realizing embodied gestures (e.g., *Wii-Remote*® control) may also affect psychological parameters more strongly than is the case with standard forms of interaction (i.e., keyboard and mouse)[1]. In particular, we were interested in aggression-related effects of violent video games: does performing realistic striking movements aimed at killing in-game opponents lead to greater levels of aggression than simply clicking a mouse button for the same purpose? To address this, a game was designed that allows for comparing different forms of interaction within an otherwise identical game environment. The next section describes the theoretical background of this approach.

2 Design and Implementation of a Test Game Environment

The design of a test game environment revolved around the idea of combining *Wii-Remote*® controls and keyboard/mouse controls in a single game. Commercial *Wii* games typically make exclusive usage of the *Wii-Remote*® and cannot be altered. However, there are several existing methods and toolkits for integration of that controller in other platforms than the *Wii*. Here we used a Bluetooth adapter to connect the *Wii-Remote*® to a *Windows*® PC and the C#/.NET/XNA programming environment for our implementations.

2.1 Game analysis and gesture design

For this study we modified the existing open source game *Dungeon Quest*[2]. This game is an action role-playing game based on physical aggression directed at other in-game characters. The player navigates a virtual character through an underground maze and is forced to kill other humanoid in-game characters by beating them with a club or sword to find a hidden treasure.

The game got several game mechanical modifications. In particular we enhanced it by gesture recognition and support for *Wii-Remote*® usage.In the original version of *Dungeon Quest* the player controls the virtual character with keyboard and mouse. Right and left mouse clicks cause two different hitting attacks against other in-game characters. These character attacks were mapped onto two corresponding hitting gestures performed by the player (Fig. 1). Each gesture consists of two rapid successive movements. Performing them feels natural and is relatively simple, which is in line with common gesture recognition criteria [1]. Therefore, we developed a game concept, in which the primary interaction (hitting opponents) can either be initiated by conventional mouse clicks or by mimicking the character's attack animation, moving the *Wii-Remote*® device (which required implementation).

1 The *Wii-Remote*® controlling device was used because information on this interaction device is widely available compared to similar devices respectively approaches.

2 XnaProjects, Dungeon Quest GDC, http://xnaprojects.exdream.com/Default.aspx?Name=Dungeon%20Quest%20GDC, June 2010.

2.2 Implementation

The game was set up in a way that allows controlling of game functions either by a combination of mouse and keyboard or by using the *Wii-Remote*®. This includes actual attacks as well as moving around, switching weapons or allocating skill points. We used the additional buttons of the *Wii-Remote*® to accomplish independency of the standard input devices when playing the game with the Nintendo device.

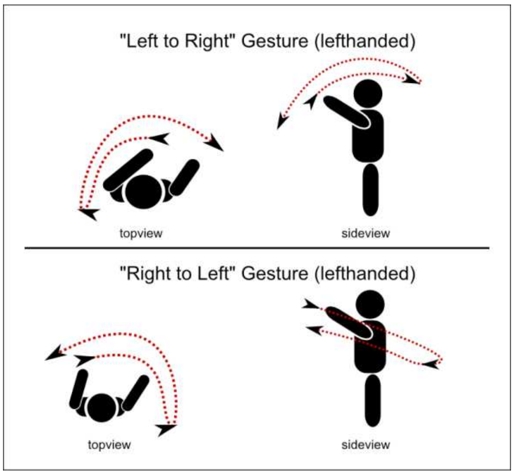

Fig. 1. Two hitting attacks in *Dungeon Quest* were mapped onto corresponding hitting gestures for the *Wii-Remote*® control.

Based on a thorough analysis of gesture recognition algorithms in computer science, the Dynamic Time Warping (DTW) approach was selected for implementation. This algorithm has been used in various fields, including speech and visual pattern recognition (cf. [2], [19]). The program code of *Dungeon Quest* had to be modified to integrate the DTW algorithm for recording, filtering and recognition of movement data from the controller. Templates for two reference gestures were recorded (section 2.1) by performing the hitting gestures. Using templates on real performed gesture ensures the natural quality of reference patterns. Therefore, the algorithm uses these gesture templates to decide whether or not a hitting movement performed with the controller is an eligible attack gesture.

3 Psychological Effects of Video Games

Psychological studies on media effects have tested various aspects of video games. Positive effects have been demonstrated for educational games and entertainment games. With regard to spatial skills, for example, video games have been shown to facilitate spatial perception and spatial visualization (cf. [3]).

Generally, however, literature on video game effects more often than not refers to negative consequences, which have mostly been analyzed with regard to the impact of violent game content. Having said this, numerous studies tested whether or not game violence leads to an increase in real aggression[3]. There is ample evidence in the literature that exposure and active use of violent video games has negative effects on several dimensions. Compared to nonviolent games violent video games increase negative affect, aggressive thoughts, physiological arousal, and aggressive behavior, but reduce pro-social behavior in the players (e.g., [5]).

The General Aggression Model (GAM, [6]) may serve as a theoretical framework for the effects of violent video games. According to GAM, aggressive behavior results from either short-term or cumulated long-term internal processes. These may be triggered by person factors and situational factors. However, simply being exposed to situational factors like violent video games does not directly cause aggression. Rather, interacting internal state variables like arousal, feelings and thoughts mediate the effects. Compared to nonviolent games, for example, violent video games are known to make aggressive concepts more accessible, resulting in faster identification of aggressively connoted words [7] or greater availability of aggressive thoughts [8].

4 Experimental Study

In contrast to research that typically focuses on game content, the present study tested the effects of violent video game exposure from a *technologically* oriented perspective: does the technology-based simulation of violent behavior increase aggressive thoughts, feelings, and even cultivate enactive bodily representations that may be recoded into aggressive gaming behavior? We were especially interested in the moderating role of the type of I/O-device used when playing violent video games. I/O-devices directly affect the interactivity of video games; a hallmark of this medium, which also makes it unique among other media [9]. Interactivity provides the player with a bi-directional, contingent flow of information between the actively involved player and the feedback of the game's underlying software. Psychologically, interactivity facilitates experiences of causality and self-efficacy [10].

To date, only few studies have addressed the role of technological form dimensions in game effects, and knowledge is still sparse. Compared to older games, for example, technological advancement (i.e., newer games) was shown to increase players' sense of presence, involvement, and arousal [11]. In addition, virtual reality (VR) provides higher levels of involvement and immersion compared to video games that were played using a standard desktop interface [12]. These findings are of particular importance for research on media violence, because involvement and immersion are known to favor the player's *identification* with a violently acting character—an important factor that is associated with learned aggression [13].

Are there any differences in psychological effects of video games with regard to I/O-devices? Does playing a violent game with a motion detection device cause more aggression than utilizing keyboard and mouse? To our knowledge, only one study directly tested this but reported zero findings [14]; playing the violent video game

[3] Typically, aggression is defined as any behavior that is intended to harm another individual, whereas the target individual is motivated to avoid the harm [4].

Manhunt 2 utilizing the *Wii-Remote*® did not lead to more aggressive cognitions than using a traditional game controller for the same game.

Of course, it is premature to dispel concerns about the potentially negative effects of motion detection controls based on a single study. For example, Markey and Scherer [14] tested cognitive effects, but not behavioral measures players' affect. Compared to nonviolent games, violent VR games were found to increase aggressive feelings, game success, and fun [12]. Apparently, thus, technological form dimensions affect both psychological factors (i.e., emotion and cognition) and objective parameters (i.e., game success). The present study therefore tested whether motion detection controls make violent in-game behavior more efficient and lead to greater levels of negative affect and aggressive cognition than standard forms of interaction.

4.1 Method

To address these hypotheses, a violent action role-playing game called *Wii Remote Dungeon Quest* was developed that allows for comparing the effects of different modes of interaction within an otherwise identical game environment. In a third person view, the player navigates a virtual character through an underground maze to find a hidden treasure. Participants either performed realistic striking movements with the *Wii-Remote*® causing the virtual character to attack other in-game characters with a club or sword, or, when playing in the *Standard Interaction* condition, they initiated attacks by pointing and clicking (section 2.1). In addition, an automatic logging function in *Wii Remote Dungeon Quest* rendered objective parameters *how* the game is played. These parameters include *"number of opponents killed"* and *"total score"*. The game strategy participants pursued was also automatically recorded: *skill points* during the game may be invested into *Attack*, *Defense*, or *Speed* that significantly changes the behavior of the character controlled by the player.

4.1.1 Design and Participants

A one-factorial design was used. *Type of interaction* served as a between-subjects variable. Thus, participants played the violent video game *Wii Remote Dungeon Quest* either performing gestures using a *Wii-Remote*® (henceforth called *Gesture* condition) or keyboard and mouse (*Standard Interaction* condition).

A total of 62 students from different faculties at the University of Luxembourg took part in the experiment. In each of the two conditions, 16 females and 15 males participated, who were naïve to the experiment. The overall mean age was 21.33 (standard deviation [*SD*] = 2.12). Students were paid 5 Euros for their participation.

4.1.2 Materials

In this section, the game used in the present study will be described (4.1.2.1), together with the measuring instruments for the dependent psychological variables (4.1.2.2).

4.1.2.1 Wii Remote Dungeon Quest

Wii Remote Dungeon Quest provides two different modes of game control; *Wii Remote*® or keyboard and mouse. With the help of the additional *configurator* tool several parameters may be adjusted. Depending on the setting, for example, gesture recognition may either be run with the unmodified reference gesture or the mirrored gesture, thus allowing both left-handed and right-handed users to play the game.

An important parameter of *Wii Remote Dungeon Quest* is the tolerance (i.e., the threshold values) of the gesture recognition. Tolerance may be set to values as low as 500 and as high as 3,000, with the latter requiring just a slight shake of the wrist to be sufficient to initiate an attack. It was determined through testing that, on average, well-performed gestures resulted in a comparison value of about 1,500 or less (cf. section 2.2). This value required participants to perform arm movements using the *Wii-Remote*®, which are similar to realistic striking movements. Hence, a value of 1,500 was set as the default value for both gestures in the present study.

4.1.2.2 Measuring instruments

The Positive and Negative Affect Schedule (PANAS, [15]) was used to measure positive and negative emotional experience. Each of the two dimensions comprises ten emotional adjectives (e.g., active, proud, afraid, hostile). We used the PANAS to assess relatively short-term fluctuations in mood (i.e., state affect). Therefore, participants rated each item on a 5-point scale ranging from 1=*very slightly or not at all* to 5=*extremely* reflecting the extent to which they experienced the emotion at the very moment (1) they entered the experimental lab, and (2) directly after the game. Internal consistency measures (α_1=.80 and α_2=.85) were within the expected range.

The so-called vignette technique was used to measure cognitive effects of violent video games. Participants were presented with four ambiguous conflict scenarios. Situations might be interpreted either as accidental or as intended acts of aggression. For example, participants were asked to imagine themselves being bumped into by another person carrying a cup of coffee resulting in large coffee stains on their white shirt. Participants rated each scenario on dimensions of anger (*"I feel angry"*), hostile attribution (*"the person did it on purpose"*), and desire for revenge (*"want to pay her back"*) on a 5-point scale ranging from 1=*no* to 5=*yes* (α=.74-.80).

It would be grossly negligent to rely on short-term indicators of aggression without paying attention to long-term characteristics that might moderate the results. Hence, individual trait aggression was measured using scales for anger (six items, e.g., *"At times I feel like a bomb ready to explode",* α=.77) and physical aggression (eight items, e.g., *"If somebody hits me, I hit back",* α=.75) from the Anger and Aggression Questionnaire [16]. Higher ratings on the 5-point scale indicated stronger affirmation.

4.1.3 Procedure

The experiment comprised, in chronological order, participants' ratings of their emotional state at the very moment they entered the lab, the training session in which participants learned how to utilize game controls, the study session in which they played *Wii Remote Dungeon Quest*, participants' ratings of their emotional state directly after playing, and the concluding questionnaire session that comprised demographical factors and ambiguous conflict scenarios. To control for potential sequential effects, half of the participants filled in trait aggression before game session whereas the other half received the trait measure after the game session.

Up to two participants were tested at the same time. By drawing a slip of paper they assigned themselves either to the *Gesture* condition or the *Standard Interaction* condition. They were then told that they would participate in testing a novel game. Neither the violent nature of the game, nor our interest in its effects was mentioned.

Fig. 2. Playing *Wii Remote Dungeon Quest* in the *Standard Interaction* condition using keyboard and mouse (*left*). Using the *Wii-Remote*® control in the *Gesture* condition (*right*) to perform striking movements causes corresponding hits performed by the in-game character.

Next, participants indicated their current positive and negative emotions by filling in the PANAS. They were then guided to a Dell PC equipped with Sennheiser HD212 pro headphones and a 22-inch Dell LCD display. In the *Gesture* condition, a slideshow explained how to use the *Wii-Remote*® control. In particular, the slideshow introduced two striking movements that cause the in-game character to perform the corresponding attack (section 2.1). In the *Standard Interaction* condition, instructions were presented how to play the game with keyboard and mouse. Attacks were initiated by pressing either the left or right mouse button. Participants were allowed five minutes to make themselves familiar with controls before they played the game for 15 minutes (Fig. 2). Immediately after the game session, participants filled in the PANAS again and provided details on demographical factors (e.g., age, gender, level of perceived game violence). They were then presented with the conflict scenarios and the trait aggression scales. The entire experiment took 40 to 50 minutes.

4.2 Results

Participants' trait aggression in the two experimental conditions will be described first (4.2.1). Next, analyses on the effects of type of interaction will be reported; participants' game performance (4.2.2), emotional experiences (4.2.3), and state aggression (i.e., cognitive effect; 4.2.4) will be compared between the *Gesture* and the *Standard Interaction* condition. Finally, additional findings will be presented (4.2.5).

4.2.1 Trait Aggression

The two experimental conditions were compared based on mean scorings in the trait aggression scales. As expected, two-sided *t*-tests (α=.05) revealed that there was no group difference with regard to trait anger ($M_{Gesture}$=2.49, *SD*=0.74; $M_{Standard\ Interaction}$=2.61, *SD*=0.82; *p*=.55) or trait physical aggression ($M_{Gesture}$=1.90, *SD*=0.49; $M_{Standard\ Interaction}$=1.80, *SD*=0.77; *p*=.54). Therefore, any differences in state aggression between groups are not reflecting stable individual characteristics. Rather, differences have to be attributed to influences caused by the type of interaction.

4.2.2 Game Performance: Objective Parameters

Analyses of game success showed that, in general, participants in the *Standard Interaction* condition were unexpectedly more successful than in the *Gesture* condition, *t*(60)=2.41, *p*=.02 (Table 1). This was also reflected by the number of opponents killed by their in-game character, *t*(60)=3.59, p<.01.

Participants in the *Standard Interaction* condition showed a greater tendency to strengthen their character's defense skills than their colleagues in the *Gesture* condition, *t*(60)=1.95, *p*=.06. With regard to attack and speed, however, both conditions showed similar patterns of game strategy, *p*s≥.39.

Table 1. Mean overall score, number of opponents killed and number of skill points allocated to the in-game characters' attack, speed, or defense skills in the two experimental conditions.

	Gesture condition		***Standard Interaction***	
	M	*SD*	***M***	*SD*
Overall score	**962.71**	355.67	**1216.06**	17.22
# of opponents killed	**54.48**	464.70	**75.77**	28.23
Attack	**3.71**	3.48	**5.45**	4.84
Speed	**1.16**	2.34	**1.03**	1.64
Defense	**3.23**	4.14	**5.45**	4.84

4.2.3 Emotional Experiences: PANAS

Apparently, playing *Wii Remote Dungeon Quest* did not affect participants' level of *positive* emotions (*M*=3.00, *SD*=0.77) compared to their reports when they had entered the lab (*M*=3.10, *SD*=0.60), *t*(59)=1.00, *p*=.32. In contrast, *negative* emotions were clearly affected; after playing the violent game (*M*=1.61, *SD*=0.58) participants felt significantly worse than before (*M*=1.31, *SD*=0.41), *t*(59)=-4.38, *p*<.01. Remarkably, this was true for both experimental groups; participants in the *Standard Interaction* condition (*M*=1.72, *SD*=0.63) and in the *Gesture* condition (*M*=1.48, *SD*=0.48) reported almost similar levels of negative feelings, *t*(60)=1.70, *p*=.09.

4.2.4 State Aggression: Cognitive Effects

Participants' responses to conflict scenarios were separately calculated with regard to anger, hostile attribution, and desire for revenge (Table 2). Participants in the *Gesture* condition tended to respond to ambiguous scenarios with greater anger than participants in the *Standard Interaction* group, *t*(60)=-1.49, *p*=.06. Although group means were in the same direction both *hostile attribution* (t=1.50) and *desire for revenge* (t=1.08) failed to reach the level of significance, $ps \geq .14$.

Table 2. Mean responses to ambiguous conflict scenarios with regard to anger, hostile attribution, and desire for revenge in the two experimental conditions.

	Gesture condition		***Standard Interaction***	
	M	*SD*	***M***	*SD*
Anger	**3.54**	0.75	**3.14**	0.88
Hostile Attribution	**2.85**	0.71	**2.56**	0.81
Desire for Revenge	**2.10**	0.92	**1.84**	0.96

4.2.5 Additional Findings

Gender effects were analyzed with a 2 x 2 analysis of variance (ANOVA) with *type of interaction* and *gender* serving as between-subjects variables and *overall score* as an indicator of game performance. Both main effects were significant, $F(1, 61) \geq 7.12$, $p \leq .01$. More importantly, the interaction barely missed significance, $F(1, 61)=3.94$, $p=.05$. With regard to game success, the advantage for male gamers over female gamers was most prominent when the game is played utilizing a traditional form of game controls (i.e., keyboard and mouse). With regard to utilizing the *Wii-Remote*®, gender differences are less pronounced (Fig. 4).

An additional 2 x 2 ANOVA with *perceived level of game violence* serving as the dependent variable revealed only one significant result; female participants (M=2.17, SD=0.62) perceived *Wii Remote Dungeon Quest* as significantly more violent[4] than male participants (M=2.77, SD=0.86), $F(1, 61)=9.62$, $p<.01$, for the main effect (all other $ps \geq .67$). Type of game controls did not affect ratings; participants in the *Gesture* condition (M=2.43, SD=0.67) and in the *Standard Interaction* condition (M=2.51, SD=0.81) reported similar levels of perceived game violence.

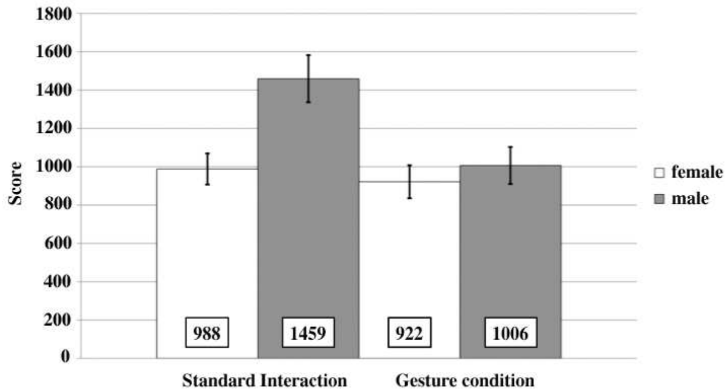

Fig. 4. Mean scores for female and male players of *Wii Remote Dungeon Quest* as a function of game controls. Error bars indicate standard deviations.

[4] The item *"how violent do you think this game was?"* was inversely coded with larger numbers indicating lesser degrees of perceived violence.

5 Discussion

The present study aimed at analyzing the effects of different forms of videogame controls on behavior, emotion, and cognition. Compared to traditional game controls (e.g., keyboard and mouse), motion detection controls have been suspected of boosting the negative effects reported for violent video games [14]. To test this hypothesis, an action role-playing game was modified that allowed for comparing the effects of different modes of interaction within an otherwise identical game environment. In the game, physical aggression aimed at killing in-game characters was exerted either by mouse clicks or by performing realistic striking movements using motion detection controls (i.e., *Wii-Remote®* control).

In contrast to studies that reported greater game success with technologies that also provide high levels of involvement and immersion ([12]), our results clearly indicated greater game success in the *Standard Interaction* condition. With regard to behavioral consequences, thus, traditional forms of playing violent video games that utilize keyboard and mouse appear to be more efficient than realistic yet time-consuming forms of interaction based on performing realistic striking movements.

However, being less efficient in attacking and killing in a violent video game does not at all imply that players will also be less affected otherwise. Rather, when presented with ambiguous conflict scenarios participants in the *Gesture* group showed more hostile cognitions (i.e., anger) than in the *Standard Interaction* condition. The same numerical pattern was found for the other two indicators of aggression (i.e., hostile attribution and desire for revenge).

Performing striking movements is likely to produce greater levels of physiological arousal than pushing mouse buttons, which may result in greater hostility. We know from aggression research that, according to excitation transfer, physiological arousal from previous bodily exertion will intensify subsequent anger reactions in conflict situations, which, in turn, makes aggressive responses of the person more likely [17].

It is important to note that self-reports on emotion clearly indicate that less game success in the *Gesture* group did not entail greater negative affect (e.g., frustration) compared to *Standard Interaction*. Rather, individual game success and the amount of reported negative emotions were significantly *positively* correlated in *both* conditions (r=.26, p=.04); higher scores were thus associated with stronger negative feelings.

Taken together, performing realistic striking movements with motion detection controls in a violent video game might be inefficient in terms of scores, but increases cognitive effects of aggression compared to standard forms of interaction. In addition, players in both conditions were put into bad mood after playing the game. The present study thus is in line with previous findings that playing violent video games increases negative feelings *per se* (e.g., [5]).

Unfortunately, however, we cannot decide whether the emotional effects in the present study result from *game content* or *type of interaction*. Because only a violent game was used, a follow-up study is needed that contrasts the effects of playing a *nonviolent* game (e.g., sport activities) using either motion detection controls or keyboard and mouse. This would clarify whether the increase in negative affect is a general by-product of the greater bodily exertion when performing natural movements (i.e., *type of interaction* effect), or whether it may be specific for violent video games (i.e., effect of *game content*).

The present study also revealed interesting insights with regard to gender differences. We found that the "general male superiority" in game success almost disappeared when participants utilized the *Wii-Remote®* control. This was the case because male players' game performance *dropped* when they utilized the *Wii-Remote®* instead of keyboard and mouse. This finding is likely to reflect differences in learned behavior based on gender specific game preferences; when exposed to a game that allows for transfer of learned forms of game controls, male players are likely to benefit from previous game experiences. There is ample evidence that previous experiences with action games positively transfer to performance in visual tasks (e.g., [18]). However, when a game requires interaction patterns, which substantially differ from previous experiences such that there is no transfer of learned behavioral patterns (as was the case in the present study with the *Wii-Remote®* control), gender differences disappear.

6 Concluding Remarks

It has been argued that higher levels of involvement and immersion in motion detection controls compared to standard game interfaces affect both psychological factors (i.e., emotion and cognition) and objective parameters (i.e., game success). As to violent video games, this effect is thought to be resulting from performing aggressive activities such as hitting virtual persons utilizing motion detection controls. However, a previous study did not find any indication that motion detection controls affect players more negatively than using traditional forms of game interfaces [14].

In the present study, however, a general increase in negative affect was shown for both groups, and cognitive effects were prominent in the *Gesture* group—especially with regard to anger reactions in conflict situations. Current models of human aggression like GAM [6] hypothesize that interacting internal state variables like arousal, feelings, and thoughts play a major role in triggering real-life aggressive behavior. Based on our findings, thus, giving the all-clear for I/O-devices like the *Wii-Remote®* control would be clearly premature. Rather, future studies will show whether or not the simulation of violent behavior with motion detection controls is indeed psychologically more dangerous than other game interfaces. It will be particularly interesting to test the effects of upcoming entertainment concepts. These include gestural gaming interfaces like Sony's *Move* or Microsoft's controller-free *Kinect* technology ("Project Natal"), which potentially provides even greater experiences of game immersion.

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