PRESENCE: PREDICTING SENSORY AND CONTROL EFFECTS OF HOME CONSOLE VIDEO GAMES

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A dissertation submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Health Behavior and Health Education

Chapel Hill
2010

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ABSTRACT

PRESENCE: Predicting Sensory and Control Effects of Home Console Video Games
(Under the direction of Deborah Tate)

Video games may be a possible medium by which to increase activity during screen time. Both presence (the sensation of being in the game) and intrinsic motivation likely play roles in the frequency and/or intensity of video game play, but have yet to be studied in these games. The purpose of this dissertation was to investigate physiological and psychological reactions across several types of games, both active and traditional. One hundred young adult participants (N = 100) played a series of eight different video games. First, traditional and motion-sensing controllers were compared within the same game type (shooter). A small increase in energy expenditure compared to a traditionally controlled game was found in one of the motion-sensing games (18% vs 28% increase over rest, $p = .013$), and psychological reactions were varied. All games were sedentary (< 1.5 METs). Next, four game types were compared: shooter, band simulation, dance simulation, and fitness. All but the shooter games significantly increased energy expenditure compared to rest ($p < .001$). Fitness and dance simulation games produced the highest energy expenditure, with increases of 322% and 298% over rest (3.10 ± 0.89 and 2.91 ± 0.87 METs), and did not differ; band simulation games (1.28 ± 0.28, 73% increase) were more active than shooters (0.91 ± 0.16, 23% increase). Only fitness games produced moderate intensity activity (> 3.0 METs). Motivation scores were higher in band simulation games than in the other game types ($p < .001$). Finally, a path model was tested to investigate the relationships between variables in an exemplar game (dance simulation). A direct effect on energy expenditure was found for intrinsic motivation (p = .002), and indirect effects through intrinsic motivation were found for presence (p = .032) and perceived competence (p = .026). These studies suggest that psychological variables can affect energy expenditure. Presence and motivation differ across game type and are lower in active games than in some other games. There is a need for new games that include motivating aspects of traditional games and activity-encouraging aspects of active games.

ACKNOWLEDGEMENTS

Many people greatly assisted with this project. I would first like to thank the dissertation committee for their guidance and support: Deborah Tate (chair), Dianne Ward, Kurt Ribisl, Michael Bowling, and Sriram Kalyanaraman. Additionally, coworkers and fellow students at the UNC Weight Research Center graciously tolerated months of intermittent pounding, gunshots, zombie moans, and “Safety Dance.” Phillip Carr and Stephanie Komoski provided extremely helpful and reliable research assistance. Pilot and pre-pilot volunteers also helped immensely in refining the study protocol.

I also gratefully acknowledge the funders of this research at the Robert Wood Johnson Foundation and Lineberger Comprehensive Cancer Center. Funding from Health Games Research and the Cancer Control Education Program allowed us to use the best equipment available and to recruit a much larger sample than would have been possible otherwise, greatly improving the quality of this research.

Finally, thanks of course to the family, friends, and mentors (in particular Barbara Rimer, Andrea Meier, and Tara Strigo) without whom I would have never had the confidence to undertake a project of this magnitude.

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ABBREVIATIONS

BMI	Body mass index
DDR	Dance Dance Revolution
CET	Cognitive Evaluation Theory
Kcal/hr/kg	Kilocalories per hour per kilogram body weight
MET	Metabolic equivalent
MVPA	Moderate to vigorous physical activity
NEAT	Non-exercise activity thermogenesis
O_2	Oxygen
PS3	Playstation 3
SDT	Self Determination Theory
TV	Television
VO_2	Volume of oxygen uptake

CHAPTER 1

INTRODUCTION AND BACKGROUND

There is an urgent public health need for research on methods to replace sedentary screen time with more active screen time. Activity during screen time may be increased in two ways: by increasing the likelihood that individuals will play active video games or by making regular video games more active. Play of active video games has promise as a fun, reinforcing behavioral alternative to watching TV. However, active gaming will be successful in increasing activity only if games are reinforcing enough to be chosen over sedentary behaviors. Preliminary evidence indicates that when active games are played in the home, participation and play decline over time, perhaps due to boredom (Chin A Paw, Jacobs, Vaessen, Titze, & van Mechelen, 2008; Madsen, Yen, Wlasiuk, Newman, & Lustig, 2007). In addition, most research on active gaming has not been theory-based, and methodological weaknesses make it difficult to generalize beyond the specific game or circumstance.

Video games vary widely on key characteristics that influence motivation to play including story, perspective, controls, and graphics. These variations and how they affect desire to play must be investigated in rigorous designs. Self-determination theory (SDT) posits that intrinsic motivation (the desire to perform a behavior for its own sake rather than for external rewards) is a stronger predictor of behavior than extrinsic motivation (Deci & Ryan, 1985). It also proposes three components of intrinsic motivation: competence, autonomy, and relatedness. These constructs are related to presence, a concept from virtual reality research. Presence is the feeling of being in the game environment, and is affected by many variables, including competence, control, and interactivity (Lombard & Ditton, 1997). Two game characteristics that may affect presence are type of controller and player perspective. Intrinsic motivation and presence have been found to predict game play (Ryan, Rigby, & Przybylski, 2006), but have never been used to predict energy expenditure during video game play.

This research project consisted of two studies undertaken to better understand motivations for play and energy expenditure as a result of both traditional and active home console video games. First, control schemes (motion-sensing/traditional) and perspective (first person/over-the-shoulder) were varied to determine their effects on feelings of presence, intrinsic motivation for play, and total energy expenditure. Each game was carefully matched to be similar in quality, graphics, content, and gameplay. Second, four games that used potentially active controllers (guitar, drums, dance mat, and balance board) were investigated to determine the controller that contributed to greatest energy expenditure and how these games compared to traditional games from study one.

The following literature review provides background information on obesity and its relationship to physical activity, sedentary behavior, and screen time. Then, video games will be discussed in depth, including previous research on gaming and health and the rationale for applying two theoretical constructs, intrinsic motivation and presence, to the study of motivation to play video games. Finally, information on the appropriateness of young adults as a target population will be presented.

Obesity, Physical Activity, and Sedentary Behavior

Currently, over two-thirds of American adults are overweight or obese (Ogden et al., 2006). Obesity is associated with increased risk for and mortality from many different cancers, and in particular breast, colon, esophageal, kidney, ovarian, pancreatic and uterine cancers (Calle, Rodriguez, Walker-Thurmond, & Thun, 2003; Flegal, Graubard, Williamson, & Gail, 2007; Reeves et al., 2007). Obesity is also associated with increased risk of metabolic syndrome (Alexander, Landsman, & Grundy, 2008), diabetes (O'Rahilly, 2007), cardiovascular disease (Perez Perez, Ybarra Munoz, Blay Cortes, & de Pablos Velasco, 2007), psychological and social morbidities (Karnehed, Rasmussen, Hemmingsson, & Tynelius, 2008; Sachs-Ericsson et al., 2007), and premature death (Flegal et al., 2007). Over half of the U.S. population qualifies as abdominally obese, which is considered to lead to unique risk over and above overall obesity (Li, Ford, McGuire, & Mokdad, 2007).

Americans spend less time in physical activity and more time in sedentary pursuits than recommended. Rates of activity and inactivity appear to worsen from adolescence into adulthood (Gordon-Larsen, Nelson, & Popkin, 2004), creating a vicious cycle of inactivity leading to obesity and obesity leading to further inactivity (Pietilainen et al., 2008).

Physical activity has consistently been found to be a protective factor against obesity as well as negative outcomes related to obesity, including some cancers (Kruk, 2007). In the past, researchers have treated physical inactivity, or sedentariness, as the functional opposite of physical activity. Now, the definition has evolved such that inactivity and sedentary behavior describe a type of behavior that is independent of physical activity (Hamilton, Hamilton, & Zderic, 2004). That is, sedentary behavior is actually a complex set of unique behaviors, including such things as sitting, watching TV, and using a computer.

Sedentary behavior is an independent predictor of both obesity and related health outcomes (Bertrais et al., 2005; Ford, Kohl, Mokdad, & Ajani, 2005). Sedentary time is neither associated with time spent in moderate-to-vigorous physical activity (Healy, Wijndaele et al., 2008) nor light activity (Healy et al., 2007), and decreasing sedentary time can offer health benefits unique from physical activity (Hamilton, Hamilton, & Zderic, 2007). Even among adults who are routinely active, time spent sedentarily is positively associated with metabolic risk (Healy, Dunstan, Salmon, Shaw et al., 2008).

Some researchers have suggested that the metabolic processes underlying inactivity and non-exercise ambulatory activity may be different than those underlying moderate to vigorous activity (Hamilton et al., 2004). Decreased lipoprotein lipase (LPL) concentrations are associated with cardiovascular disease and other negative outcomes (Hamilton et al., 2007), and inactivity has been found to decrease LPL concentrations in inactive muscles (Bey & Hamilton, 2003). Even very low intensity muscle contractions, such as those involved in standing, can prevent or negate these changes (Zderic & Hamilton, 2006).

Long periods of sedentary time appear to be more deleterious than shorter periods. Breaks in sedentary time, regardless of their length or intensity, are associated with lower waist circumference, BMI, triglycerides, and 2 hour plasma glucose independent of total sedentary time and moderate-vigorous activity (Healy, Dunstan, Salmon, Cerin et al., 2008). In other words, even the smallest periods of very light-intensity activity can be beneficial, particularly if they interrupt what would otherwise be a long session of sedentary behavior.

Non-exercise activity thermogenesis, or NEAT, represents activities responsible for burning up to 90% of calories burned in a day (Levine, 2004). NEAT includes energy expenditure not associated with explicit exercise, metabolism of food, or resting energy expenditure. Everyday activities, such as shopping, housework, dancing, and fidgeting are considered NEAT.

NEAT appears to be quite important in achieving energy balance. Far more time is spent in NEAT than in exercise, even among the most active individuals. Individual differences in energy expended in NEAT are related to weight. Lean individuals spend 2.5 more hours per day standing than obese individuals, burning approximately 300 more calories because of this difference (Levine et al., 2005). These differences appear to be genetic preferences for sitting or movement, as these patterns are maintained even with loss or gain of weight. However, the environment does play a large role in whether those preferences are realized; environments can be changed to facilitate sitting or increased activity.

Taken together, the above information points to the importance of everyday activities in obesity prevention, treatment, and weight maintenance. Even relatively modest interventions to lessen or break up sedentary time could have a large public health impact (Spanier, Marshall, & Faulkner, 2006). The next several sections detail the most popular sedentary behavior, television watching, and strategies for making this behavior more active.

Sedentary screen time. Time spent in front of a television or computer screen, typically called screen time, is a sedentary behavior that is extremely prevalent. In fact, after sleep and work, the average American spends more time each day watching TV than in any other activity (U.S. Department of Labor, 2009). On an average weekday, 78.6% of Americans watch TV, at an average of 2.99 hours a day. On weekends and holidays the numbers increase to 81.6% and 3.80 hours.

Sedentary screen time, though mostly studied in child and adolescent populations, appears to be a major problem in adulthood as well. There is a clear relationship between time spent watching TV and obesity in adults (Bowman, 2006; Foster, Gore, & West, 2006; Hu, Li, Colditz, Willett, & Manson, 2003). Lower amounts of TV watching are associated with successful weight loss maintenance (Raynor, Phelan, Hill, & Wing, 2006).

TV watching appears to result in negative outcomes independent of physical activity or obesity. Time spent watching TV is positively associated with plasma glucose levels and triglycerides, indicating diabetes and cardiovascular risk (Dunstan et al., 2005; Gustat, Srinivasan, Elkasabany, & Berenson, 2002; Hu et al., 2003; Jakes et al., 2003; Li, Lin, Lee, & Tseng, 2007). These associations are independent of BMI or overall daily energy expenditure, and they appear to be stronger in women (Kronenberg et al., 2000). TV watching time is also associated with all-cause and cardiovascular disease mortality (Dunstan et al., 2010).

It is difficult to discern if TV watching is harmful over and above other sedentary activities, or if it is simply a proxy measure for sedentary time. There is some evidence that TV watching may have unique characteristics that make it a particularly harmful sedentary behavior. For example, the distraction associated with watching television leads to increased food intake as compared to listening to music (Blass et al., 2006). Intervention studies that decreased television watching have found that decreased energy intake, rather than increased physical activity, was associated with positive changes in weight (Epstein et al., 2008). Food commercials may also increase intake of energy dense foods (Utter, Scragg, & Schaaf, 2006). Other sedentary activities, such as video games, do not appear to increase energy intake to this degree (Epstein, Paluch, Consalvi, Riordan, & Scholl, 2002). Because there is little evidence comparing the relative impact of physical activity, sedentary behavior, and energy intake during screen time, it is difficult to determine the exact pathway by which decreased television watching leads to decreased weight.

Behavioral economics: replacing TV time with alternative behaviors. According to theories of behavioral economics, individuals may replace a behavior with a substitute if that substitute is sufficiently rewarding and easily accessible (Epstein, Kilanowski, Consalvi, & Paluch, 1999). Alternative behaviors must be equally or more valued in order to serve as sufficient substitutes. Children will choose to be physically active as a substitute for lower-valued sedentary behaviors, but not higher-valued ones (Epstein, Roemmich, Saad, & Handley, 2004).

TV watching is problematic, as it is a very reinforcing and highly valued activity. One way researchers have dealt with the problem of TV's high value is by including it as part of the substituted behavior, making TV watching contingent on physical activity (Faith et al., 2001; Saelens & Epstein, 1999). Such interventions have been successful in increasing activity but rely on adults to set up their own contingencies or parents to develop and enforce contingency plans for their children.

Because more interactive screen time is also highly valued, such substitutions ought to also be applicable to video games. Video games can, in theory, increase activity without the need for contingency if activity is part of the nature of the game itself. Some evidence suggests that this might be an appealing alternative. For example, one study has found that a video game that required active input (dancing) was chosen over exercising while playing a video game or dancing without a video game (Epstein, Beecher, Graf, & Roemmich, 2007).

The following sections discuss in detail the advantages of using active gaming as a substitute for TV watching.

Summary. Several potential pathways may exist by which a reduction in time spent watching television could impact obesity and related negative outcomes. First, time spent watching TV sedentarily could be replaced with time spent in physical activity, leading to greater energy expenditure. Second, time spent watching TV sedentarily could be replaced with time spent less sedentarily, increasing NEAT. The first pathway would necessitate short periods of moderate to high intensity activity, while the second would require longer periods of very light or light activity. A third pathway may be a biological one not yet well-understood; there may be underlying processes of sedentary behavior that cause negative outcomes independently of energy expenditure, as Hamilton and colleagues have found in their LPL studies (Hamilton et al., 2007). Finally, there are two potential pathways related to energy intake. Reducing time spent watching TV may reduce exposure to junk food advertisements, which may act as cues to eat foods high in energy density. Reducing time spent watching TV may also reduce opportunities to eat while distracted from satiety cues. In this project, the emphasis is on investigating the first two pathways by replacing time spent watching TV with time spent playing video games.

Video Games as an Alternative to Sedentary Screen Time

Though many epidemiological studies categorize all video game play as sedentary screen time, such a grouping appears to be misguided. A burgeoning literature on the active potential of video games has shown that some games can produce moderate-to-vigorous activity (Tan, Aziz, Chua, & Teh, 2002; Unnithan, Houser, & Fernhall, 2006), and even so-called sedentary or traditional games can increase energy expenditure over levels achieved while watching television (Wang & Perry, 2006). Because light, non-exercise activity appears to be just as important as more vigorous activity, both active video games and traditional video games may have the potential to greatly improve the public's health.

Video game background. Video games are a major entertainment medium: in 2008, over 11 billion dollars' worth of games were sold in the United States alone, and 42% of American homes had a video game console (Entertainment Software Association, 2009).

Video games are controversial, perhaps because of individuals' differing perceptions of what, exactly, they are. There is debate among gamers and developers as to how to categorize video games: as toys, entertainment, or art (Croal, 2007). Further complicating matters, individual games vary greatly, as do the attitudes of game developers and producers. Some games are clearly intended as toys, while others are far more equivalent to multi-million dollar Hollywood films, complete with cinematic cut-scenes (non-interactive movies during gameplay) and extensive voice acting. Big-budget games increasingly attempt to create immersive worlds with realistic environments as well as storylines and characters that react to decisions made by the player. Low-budget casual offerings and quirky mid-range games coexist with these more ambitious games, offering shorter and less sophisticated, but not necessarily inferior, experiences.

Here, the emphasis is on home console video games as opposed to games played on personal computers or cell phones. Currently, there are three major consoles available: the Sony Playstation 3 (PS3), the Microsoft Xbox360, and the Nintendo Wii. There are also two major handheld consoles: The Nintendo DS and the Sony Playstation Portable (PSP). Each console has different characteristics that affect gameplay. In this project, all of the three major home consoles were used.

The PS3 is a console with an extremely powerful processor and is known for its Blu-Ray disk playing capabilities and high-end graphics. The Xbox360 is also known for its processing power as well as for its highly-developed online system, Xbox Live. Both of these consoles will be integrating motion control in the next several years, but neither currently offer motion control in their primary controllers.

The Wii is a very different machine. It is much less powerful than the PS3 or Xbox360, with noticeably poorer graphical capabilities. The Wii's emphasis is instead on innovative gameplay. The two main controllers, the Wiimote and the Nunchuk, both combine traditional button-pressing with motion sensing controls. For example, in various games players must swing the Wiimote like a bat, point it at different objects on the screen, or swing it like a sword. The Nunchuk includes an analog stick, much like on a traditional controller, but can also be used for motion controls with the other hand.

Video games and physical activity. There is a growing literature on the intersection of video games and physical activity. Studies generally fall into one of two categories: using video games or virtual environments in conjunction with traditional exercise, or using video games specifically as an exercise tool. The use of games to supplement stationary cycling or similar machine-based exercise has met with success in increasing adherence and energy expenditure (Annesi & Mazas, 1997; Ijsselsteijn, de Kort, Westerink, & de Jager, 2006; O'Connor, Fitzgerald, Cooper, Thorman, & Boninger, 2001; Warburton et al., 2007). In addition, virtual environments can improve the mood benefits of exercise, increasing enjoyment and energy while decreasing feelings of tiredness (Plante, Aldridge, Bogden, & Hanelin, 2003a). Virtual worlds have been found to successfully decrease pain and increase distraction in clinical populations (Hoffman et al., 2004; S. M. Schneider & Hood, 2007); they may also be able to decrease activity-related pain.

Though these results are exciting, virtual reality equipment like that used in most of the above studies is not readily available to the public. Additional equipment, such as stationary bicycles or other exercise machinery, is required as well. Thus, of greater public health interest are activity-related interventions that use commercially available, popular video games. The following sections discuss research done in this area. The studies reviewed had very small sample sizes and methodological limitations that make results preliminary at best; thus, comparisons should be made cautiously. Methodological limitations are discussed in detail in a later section.

Dance Dance Revolution and Eyetoy studies. Games in the Dance Dance Revolution (DDR) series and those that use the Eyetoy peripheral controller are by far the most popular active games amongst researchers, likely because they are the most obvious analogues to traditional exercise. DDR games use a mat controller as an input device, forcing players to step and jump in order to play the game. The Eyetoy is a camera that picks up the player's motions and projects them into the game itself.

DDR play expends more energy than TV watching, traditional video game playing, and walking on a treadmill while watching TV (Lanningham-Foster et al., 2006). DDR games have been found to meet minimum American College of Sports Medicine guidelines for maintaining cardiorespiratory fitness, even at medium-intensity four-step difficulty (most DDR games go up to nine steps as the highest difficulty level) (Tan et al., 2002). Another study, which appeared to use lower difficulty levels, found that heart rate met ACSM guidelines, but average percentage of VO_2 reserve did not (Unnithan et al., 2006). One possible reason for the difference is that the first study used a sample of young adults, while the second study used children. Children, adolescents, and adults react to video games differentially (Sharar et al., 2007); it is possible that energy expenditure would differ between these age groups. The first study also provided subjects with a longer familiarization period and appeared to use a higher difficulty level; skill level is associated with higher energy expenditure (Sell, Lillie, & Taylor, 2008).

Eyetoy games show more variation across studies. Such variation is only natural, as Eyetoy games can be quite different from one another. DDR games are known for being extremely similar to one another, generally with only changes in music and characters distinguishing individual games (Ahearn, 2007; Gerstmann, 2007). Some studies have found that Eyetoy games are associated with less energy expenditure than walking (Lanningham-Foster et al., 2006), while others have found levels somewhere between walking and jogging (Maddison et al., 2007; Straker & Abbott, 2007).

Several preliminary studies have investigated the use of DDR as an exercise intervention in children (Chin A Paw et al., 2008; Madsen et al., 2007; Maloney et al., 2008). Chin A Paw and colleagues compared multiplayer DDR in a weekly class setting to at-home play in 27 children. Drop-out was significantly lower (64% vs 15%) and time spent playing over twice as high (901 vs. 376 hours over 12 weeks) in the multiplayer group. Madsen and colleagues measured DDR use over time in 30 children. No association was found between

DDR use and BMI change, but so few children actually played DDR in this study that there was very little power to detect a change. The authors reported that after week 3 of the intervention, only 2 of 21 participating children played the game at least twice a week. The third study had similar sharp drop-offs in play over time. Though no differences over time were found in physical activity, the DDR intervention led to decreased sedentary screen time (Maloney et al., 2008).

A similar intervention that used DDR and Eyetoy games as a substitute for other video games found an increase in overall activity counts, but no effect on moderate or vigorous activity or weight (Ni Mhurchu et al., 2008). Activity count differences between the intervention and control group declined over time (194 counts per minute at 6 weeks, 48 counts per minute at 12 weeks).

There was marked attrition in at-home players as opposed to group players in one study (Chin A Paw et al., 2008), and in others participant game play dropped off precipitously over time (Madsen et al., 2007; Maloney et al., 2008). The more successful study offered a greater variety of games and controllers, which may have kept players more motivated over time (Ni Mhurchu et al., 2008). However, even this study saw a decrease in activity by 12 weeks, indicating that interest may have waned over time. DDR and Eyetoy games probably lead to increased physical activity and weight loss when played consistently, but do not appear to be sufficiently fun or compelling to provoke prolonged use without additional intervention components, perhaps to promote adherence.

Energy expenditure of other games. Almost all studies of energy expenditure related to video games have concentrated on the games discussed above: DDR and Eyetoy. Games used as comparisons are rarely discussed in detail, are often mis-labeled or mis-characterized, and sometimes are not even named. Therefore, it is difficult to make any conclusions about the energy expenditure related to the games most likely to be played by a majority of gamers. In addition, differences in measurement also may make comparison across studies of traditional games difficult.

Several studies have included games that use the motion-sensing Wiimote of the Nintendo Wii (Graves, Stratton, Ridgers, & Cable, 2007). The first used an IDEEA device to measure energy expenditure, finding significantly increased energy expenditure in three of the minigames included in Wii Sports, between 2.8 and 3 kcal/minute, over an Xbox360 racing game, 1.8 kcal/minute and rest. The subsequent studies followed very similar protocol, however with the use of indirect calorimetry, the gold standard measurement tool for energy expenditure. These studies also reported energy expenditures of approximately two to three metabolic equivalents (METs, equivalent to kcal/hr/kg) (Graf, Pratt, Hester, & Short, 2009; Graves, Ridgers, & Stratton, 2008; Lanningham-Foster et al., 2009).

Table 1 below displays results across games. The numbers presented were converted from published estimates to METs to provide a common metric of energy expenditure corrected for body mass. Because these studies included samples of both children and adults, MET values are also presented as adjusted METs (calculated by dividing energy expenditure during game play by energy expenditure at rest) to account for higher energy expenditure in children (Harrell et al., 2005).

Disney's Extreme Skate Adventure was found to increase energy expenditure by 22 percent over rest, a significant difference (Lanningham-Foster et al., 2006). However, watching TV while seated increased energy expenditure by 20 percent, making the increase related to the game less impressive. Need for Speed Underground 2, when played with a wheel, was found to increase energy expenditure over watching a DVD or playing the game with a traditional controller, but "increases were not sufficient to truly differentiate it from sedentary" behavior (Straker & Abbott, 2007). "Need for Speed 2" (possibly the same game, but the edition was not specified) significantly increased energy expenditure from 1.5 kcal/minute at rest to 1.7 kcal/minute during play, but differences between rest and a second play period were not significant (Borusiak, Bouikidis, Liersch, & Russell, 2008). Project Gotham Racing 3 significantly increased energy expenditure over rest, from 1.2 to 1.8 kcal/minute (Graves et al., 2007). An "inactive" game (not identified) increased energy expenditure from 1.3 kcal/minute at rest to 1.6 during play, while comparison Eyetoy games ranged from 2.9 to 6.5 kcal/minute (Maddison et al., 2007). It should be noted that simple estimates of kcal/min may be misleading when used to compare across studies; body mass corrected estimates are reported in Table 1.

Wang and Perry reported higher heart rate estimates but similar energy expenditure to other studies during play of Tekken 3 (Wang & Perry, 2006). Participants increased heart rate (86.9 to 103.2 beats/minute) and energy expenditure (1.36 to 2.08 kcal/hour/kg) significantly from rest to play. The authors extrapolated that their sample population could lose approximately 1.8 kg per year if they played video games for 20-39 minutes per day instead of engaging in more sedentary activity.

The tone and content of the conclusions drawn by Wang and Perry differ greatly from those in the other studies discussed here. Wang and Perry conclude that traditional video games, though not active, are not necessarily sedentary and are a beneficial substitute for television watching. However, their results are quite similar to those of studies that described traditional games as sedentary. The difference appears to lie in varying definitions of the word sedentary. Percent increases from rest in energy expenditure ranged from 12% (Need for Speed Underground 2) to 49% (Tekken 3), though most were between 20 and 50%. The Eyetoy and DDR games ranged from 110% (Nicktoons Movin) to 546% (DDR in experienced adults).

Table 1.1 Comparison of Physiological Outcomes Across Games

Type of game	Study	Game and minigame	Energy Expended (METs)	Adjusted METs[a]
Dance	Graf[b]	DDR (unknown) – females	3.77	3.22
		DDR (unknown) – males	4.51	3.92
	Lanningham-Foster	DDR Ultramix 2	4.13	2.67
	Maddison	Dance UK	5.47	3.86
	Sell	DDR (unknown) – inexperienced	3.74	3.36
		DDR (unknown) – experienced	7.20	6.46
	Tan	DDR 3rd Mix	7.03	3.50
	Unnithan	DDR (unknown) – overweight	3.51	2.41
		DDR (unknown) – normal weight	3.94	3.00
Eyetoy	Lanningham-Foster	Nicktoons Movin'	3.24	2.10
	Maddison	Eyetoy: AntiGrav	4.02	2.86
		Eyetoy: Groove	3.24	229
		Eyetoy: Play 2 (Homerun)	6.57	4.69
		Eyetoy: Play 2 (Knockout)	7.00	5.00
	Straker	Eyetoy: Kinetic	7.26	--
Wii	Graves[c]	Wii Sports (Bowling)	2.58	2.20
		Wii Sports (Boxing)	3.84	3.28
		Wii Sports (Tennis)	2.88	2.44
	Graf	Wii Sports (Bowling) – females	2.20	1.89
		Wii Sports (Bowling) – males	2.86	2.08
		Wii Sports (Boxing) – females	3.85	3.29
		Wii Sports (Boxing) – males	3.94	2.89
	Lanningham-Foster	Wii Sports (Boxing) – children	5.14	4.21
		Wii Sports (Boxing) – adults	2.67	3.14
Xavix	Mellecker	Xavix Bowling	3.60	1.97
		Jackie's Action Run	9.00	5.45
Game-pad	Borusiak	"Need for Speed 2"	1.79	1.12
	Graves[c]	Project Gotham Racing 3	1.68	1.40
	Lanningham-Foster	Disney's Extreme Skate Adventure	1.88	1.21
	Maddison	"inactive video game"	1.88	1.35
	Straker	Need for Speed Underground 2	2.41	--
		Need for Speed Underground 2	2.51	--
		Need for Speed Underground 2	2.76	--
	Wang	Tekken 3	2.08	1.49

[a]Adjusted METs were calculated as reported energy expenditure during gameplay divided by reported resting energy expenditure, to account for differences in resting rates by age
[b]Two difficulty levels of were reported in this study; here, the higher difficulty level is used
[c]Because the same games were measured in the two Graves studies, represented here are the values recorded by indirect calorimetry
METs, Metabolic equivalents; DDR, Dance Dance Revolution

Clearly, the games with dedicated controllers increased energy expenditure more substantially than those with more traditional gamepad controllers. However, the traditional games also increased energy expenditure significantly as compared to rest. Researchers may be underestimating the potential of traditional games prematurely because they are less active than games like DDR.

There were large differences between games, even when comparing games that used the same controller. For example, several different trials of Eyetoy games found wide variations in energy expenditure, even though all participants used the same controller. Similarly wide variations existed between games that used the same DDR dance mat controller as well as traditional games that used a typical console controller. These differences suggest that there may be characteristics of certain games other than the controller used that encourage increased or decreased energy expenditure.

Summary. The literature on screen time-related energy expenditure is still in its infancy. However, several tentative conclusions may be drawn. Screen time, and in particular television watching, is uniquely harmful over and above a lack of moderate-to-vigorous physical activity. There appear to be separate pathways to negative outcomes for moderate-to-vigorous activity, light activity, and inactivity/sedentary behavior. Even in the presence of moderate-to-vigorous activity, separate harms from sedentary behavior exist. Thus, it is important to intervene on multiple behaviors, not just physical activity, in order to lessen the harms related to screen time.

Video games are a logical replacement for television, in that home console games involve use of the television screen while requiring interaction that is absent in traditional television watching. Different types of video games are capable of provoking light and moderate physical activity. Even the most sedentary games can increase energy expenditure and other physiological variables significantly over rest levels; thus, even quite inactive games may be useful to break up periods of sedentary time.

The potential of video games for reducing harms related to sedentary behaviors has not yet been adequately studied. The few published trials of active gaming show mixed but promising results. A major concern from these pilot studies is the lack of adherence. There has been an assumption among researchers that video games are motivating enough to encourage regular exercise, but this assumption does not appear to hold true in studies thus far. Active games that have been used in intervention trials have not been sufficiently motivating to be played regularly after a few months. It is not clear whether these games differ from other, more widely played games in terms of adherence. There appears to be something about some video games that is sufficiently motivating to finance a multi-billion dollar industry, but it is difficult to know if decreases in play over time are unique to the active games studied thus far. To take advantage of the energy expenditure of games found in lab studies, researchers must better understand why and when individuals play video games, and what characteristics of games lead to higher levels of motivation.

Motivation and Video Game Play

Self-determination theory. Self-determination theory (SDT) is a theory that is commonly used to explain the effects of motivation on behavior. From the perspective of SDT, intrinsic motivation to perform a behavior is more powerful than extrinsic motivation (Deci & Ryan, 1985; Ryan & Deci, 2000b). Intrinsic motivation has been described as the "natural inclination toward assimilation, mastery, spontaneous interest, and exploration that is so essential to cognitive and social development and that represents a principal source of enjoyment and vitality throughout life" (Ryan & Deci, 2000b). Deci and Ryan (1991) list four characteristics of intrinsically motivated behaviors: they occur in the absence of external rewards, are undertaken out of interest, provide optimal fit between their challenges and a person's abilities, and are based in innate psychological needs. Though individuals may differ in their propensity towards intrinsic motivation as a whole, here we are concerned primarily with motivation to perform specific behaviors. Intrinsic motivation to perform a behavior could be considered synonymous with enjoyment of and interest in that behavior.

Cognitive Evaluation Theory (CET) is a sub-theory of SDT that provides theoretical predictors for intrinsic motivation. CET proposes that there are three essential components of intrinsic motivation: autonomy, competence, and relatedness (Deci & Ryan, 1985). Autonomy, sometimes called self-determination, refers to feelings of volition, control, and freedom. The more control a person feels over his or her actions, the more intrinsic motivation s/he will feel (Moller, Deci, & Ryan, 2006; Moller, Ryan, & Deci, 2006). Though to some degree feelings of autonomy are based in personality, specific contexts have been found to have large effects on these feelings (Ryan & Deci, 2000b, 2000c). Here, the emphasis is on task-related needs rather than individual traits.

Perceived competence is related to a need for challenge as well as feelings of effectance. This construct is quite similar to the construct of self-efficacy. It is usually operationalized by positive feedback and mastery experiences. An important aspect of this construct is the idea of optimal challenge, or a challenge in which the difficulty of the task is well-matched to an individual's skills. A task that is too difficult may actually decrease intrinsic motivation (Reeve & Deci, 1996; Vansteenkiste & Deci, 2003).

Relatedness is discussed much less often than the other two components. Relatedness is the sense of connectedness and safety that come from social ties to others, and is well-validated as a major psychological need (Baumeister & Leary, 1995). Relatedness need not be proximal; that is, relatedness can contribute to self-determined behavior even when an individual is alone (Ryan & Deci, 2000c).

There is ample evidence of the importance of these three constructs in predicting intrinsic motivation as well as other positive psychological outcomes (La Guardia, Ryan, Couchman, & Deci, 2000; McDonough & Crocker, 2007; Reis, Sheldon, Gable, Roscoe, & Ryan, 2000; Sheldon, Elliot, Kim, & Kasser, 2001). However, their specific effects in the context of video games are not yet known. SDT has only recently been applied to video game play (Przybylski, Ryan, & Rigby, 2009; Ryan et al., 2006). Perceived competence, autonomy, and relatedness have been found to be related to choice to play particular games (Ryan et al., 2006), and these findings were later replicated (Przybylski et al., 2009). Effectance has been found to be a predictor of video game enjoyment (Klimmt, Hartmann, & Frey, 2007), and higher perceived control appears to provide a buffer against cardiovascular reactivity during a video game task (Weinstein, Quigley, & Mordkoff, 2002).

Presence

Background. Presence has been widely studied in Internet applications, virtual reality, and video games. Despite common acceptance of the concept, its definition and measurement are controversial. Probably the most widely cited definition is that presence is the “perceptual illusion of non-mediation” of a virtual environment (Lombard & Ditton, 1997). Slater proposes three aspects of presence: a sense of “being there,” the extent to which the virtual environment is the dominant environment in the user’s mind, and the extent to which users remember the virtual environment as a place they visited instead of images they saw (Slater, 1999). The International Society for Presence Research definition makes explicit the notion that “part or all of the individual’s perception fails to accurately acknowledge the role of the technology in this experience” (International Society for Presence Research, 2000). Generally, individuals will at some level be aware of technological mediation, but their perceptions will be as if the mediation does not exist.

Presence is multi-dimensional, and many of these dimensions may overlap. Spatial presence is the perception of being in another physical location. Sensory presence or perceptual realism is the perception of virtual objects and events as being similar to those in the real world. Social realism is the perception that virtual social characteristics are similar to those in the real world. Social presence, which is distinct from social realism, is the perception that the individual is communicating with other entities (whether avatars of other, real-life people, or virtual people). Finally, engagement occurs when part (or all) of an individual’s perception is oriented towards the virtual environment rather than his or her true, physical environment (International Society for Presence Research, 2000). Not all presence-related instruments measure all or most of these dimensions, and some instruments are specifically targeted to individual dimensions.

Immersion is generally conceptualized as a separate construct. Immersion is objectively measured and deals with the apparatus that make presence possible. Thus, a virtual reality headset would be, by definition, more immersive than a desktop computer interface. Presence is the subjective reaction to the immersive experience, and may not always be directly correlated with immersion.

In this project, three dimensions of presence are of interest: spatial presence, social presence, and engagement. Most presence-related instruments measure spatial presence, and many also include measures of engagement. Social presence is less commonly measured or discussed in the literature, but may also be differentially impacted by different types of video games. These three dimensions as well as overall feelings of presence will be measured.

A sense of presence has been found to correlate with pain reduction (Hoffman et al., 2004), enjoyment and motivation (Ijsselsteijn et al., 2006; Thornton et al., 2005), task performance (Nash, Edwards, Thompson, & Barfield, 2000), arousal (Ivory & Kalyanaraman, 2007), desensitization related to phobia and trauma treatment (Price & Anderson, 2007; Regenbrecht, Schubert, & Friedmann, 1998), and emotion (Riva et al., 2007). The relationship between presence and many of the above effects is probably mediated by distraction. A virtual environment that produces high feelings of presence is by definition successfully distracting an individual from his or her current surroundings and feelings. The pain reduction studies suggest that this distraction extends even to awareness of one's physical body; in fact, distraction with virtual reality has been found to decrease subjective sensory, emotional, and cognitive pain by at least 33% (Sharar et al., 2007). The ability to remove discomfort and boredom as barriers to physical activity may be a way in which virtual environments can encourage exercise.

Several studies have investigated the effects of adding virtual reality applications to exercise machines, usually stationary bicycles. These studies have found that addition of virtual reality can increase enjoyment and fitness benefits of exercise (Chuang, Sung, & Lin, 2005; Plante, Aldridge, Bogden, & Hanelin, 2003b) as well as exercise duration and intensity (Chuang et al., 2003). The quality of the virtual environment used appears to have an effect on exercise intensity; Ijsselsteijn and colleagues found that increasing presence felt in a virtual environment increased velocity while cycling (Ijsselsteijn et al., 2006).

Factors that affect presence. Researchers theorize that first-person perspectives are more likely than other perspectives to increase feelings of presence (Tamborini & Skalski, 2006). This may be because first-person games allow players to pretend to be the main character, playing as that character rather than with that character (Eastin, 2006). However, avatars, or representations of the player within the game, are important for presence as well (Eastin & Griffiths, 2006). Realism of the player's avatar (Nowak & Blocca, 2003) and matched gender of the avatar (Eastin, 2006) both affect presence. Though first-person is preferred for close-up and fine movements, traveling through environments (Salamin, Thalmann, & Vexo, 2006) and locating objects (Yang & Olson, 2002) may be easier in the third-person. A third-person perspective has also been found to lead to lower ratings of medium obtrusiveness, though perspective was not associated with involvement (Farrar, Krcmar, & Nowak, 2006). It may be that a combination perspective that combined aspects of first and third person perspectives (such that the player looked over the shoulder of his/her avatar) would optimize feelings of presence.

Control scheme may also affect presence. Video games are by their nature interactive, but control scheme can influence the degree of interactivity that is actually possible. Interactivity, or "the extent to which users can participate in modifying the form and content of a mediated environment in real time," can be affected by speed (the rate at which input affects the environment), range (the number of possibilties for actions), and mapping (how controls are mapped to changes in the environment) (Steuer, 1992). The method by which a video game is physically controlled affects all three of these factors. If one's inputs are not registered quickly and correctly by the game, the experience could not truly be considered interactive. The more control a person has over their actions in a virtual environment, it appears, the more presence s/he feels (Regenbrecht et al., 1998; Stanney et al., 1998). Poorly mapped or unrealistic controls could distract players, leading to decreased satisfaction and presence (Mikropoulos & Strouboulis, 2004).

Witmer and Singer suggest that adding motion control to virtual environments should enhance presence through sensory factors (Witmer & Singer, 1998). Rather than using button-pressing to interact with the game environment, games with motion control allow players to manipulate their character by moving their bodies. Slater and colleagues have found that motion control is related to presence, and hypothesized that more realistic motion control should further increase presence (Slater, Steed, McCarthy, & Maringelli, 1998). Preliminary studies have found that use of a bongo controller in a music game increased engagement as compared to a gamepad controller (Bianchi-Berthouze, Kim, & Patel, 2007; Lindley, Le Couteur, & Bianchi-Berthouze, 2008). The more naturally a control scheme maps to real-life actions (for example, the use of a steering wheel for racing games), the more presence and enjoyment players feel (Skalski, Lange, & Tamborini, 2006).

Feelings of competence at virtual tasks increase presence, but the relationship may be complex. As has also been found in the motivation literature, fit between task demands and skill appears to be more important than overall feelings of competence (Klimmt et al., 2007). That is, people enjoy challenges and may not be discouraged by failing at an in-game task that seemed appropriately challenging. Similarly, competence at an easy task may not be as satisfying.

Several other factors affect presence and must be taken into account in virtual environment or video game studies. Display quality and size (Duh, Lin, Kenyon, Parker, & Furness, 2002), sound quality (Zhou, Cheok, Qiu, & Yang, 2007), level of interactivity (Garau, Slater, Pertaub, & Razzaque, 2005), prior experience with the same virtual environment (Freeman, Avons, Pearson, & Ijsselsteijn, 1999), type of opponent (Ravaja et al., 2006), technological advancement of the environment (Ivory & Kalyanaraman, 2007), and story existence and quality (E. F. Schneider, Lang, Shin, & Bradley, 2004) have all been found to affect feelings of presence. Researchers must take care to create rigorously controlled experiments when dealing with virtual environments of any kind, including video games. There are many potential confounding variables related to presence, and it may be difficult to isolate individual variables from them.

Presence, Self-Determination Theory, and Video Games

The theoretical framework for this study rests on expanding the current use of SDT to include the concept of presence as a predictor of intrinsic motivation. As discussed above, feelings of presence and motivational factors may influence the games people play and how often/for how long they play them. Thus far, however, there have been no theory-based investigations into active gaming. In order to move the literature forward, more sophisticated models of game-playing are needed than simple measures of how much energy is expended in a defined period of play.

The application of SDT to games (Ryan et al., 2006) is compelling, but should be expanded by including measures of presence. The components of intrinsic motivation in SDT are very similar to several major correlates of presence. Perceived control (presence) must exist in order for a game player to feel autonomy (SDT). One's in-game abilities and choices are only possible and meaningful insofar as the control scheme adequately facilitates those abilities and choices. Perceived competence appears to be the same construct across both literatures. Feelings of relatedness (SDT) are often discussed in the presence literature as interactivity with virtual characters in the game environment, or social presence.

The direction of the relationships between these constructs is unclear. Competence and control have been generally conceptualized as predictors of presence, but they have also been considered actual components of presence and as non-directional correlates of presence. Measurement with the popular Presence Questionnaire (Witmer & Singer, 1998) adds up scores related to control, among other constructs, for a total presence score. This practice has been criticized, because such processes do not actually ever measure feelings of presence, but rather infer them from the existence of hypothesized components (Slater, 1999). Because perceived control and competence have been included in the actual calculation of presence scores in many studies, it is difficult to determine the true relationships between these constructs and presence.

Low levels of motivation to play active games in past intervention studies may be due to a lack of sufficient feelings of presence during play. Active games such as those in the Dance Dance Revolution series, Eyetoy games, and Wii Sports rarely have a storyline or realistic graphics. Players cannot explore or manipulate objects in the virtual environment. These characteristics are not necessarily bad; simple and casual games can be both fun and successful. However, games with involved storylines and high-end graphics may be more likely to be played and played for a longer period of time than those without, due to differential feelings of presence.

In the quest to quantify total energy expended during alternatives to sedentary screen time, motivation to play is an important factor. If a relatively sedentary game is more motivating, it may lead to greater total energy expenditure than if an active game is played for a short time or not at all. The energy expenditure associated with a game in lab experiments does not necessarily indicate the total energy expenditure from playing the game in a real-life setting. Only measuring physiological outcomes in health-related video game studies may be limiting researchers' ability to investigate the factors that affect play over time. Including measures of presence as well as intrinsic motivation should add to our understanding of why people play games. The more that is understood about how to integrate compelling gameplay and active control schemes, the more motivating and more active games can be developed and marketed.

The overarching goal of this research project was to investigate how to lessen the limitations of both active and traditional games as they are currently made; active games are sub-optimally compelling, while traditional games are sub-optimally active. To do so, the concept of presence was added as an additional predictor of intrinsic motivation to game. In the first study proposed in this project, two game characteristics that are hypothesized to affect presence, perspective and control scheme, were varied while controlling for other factors that also may affect presence (e.g., high quality graphics and story line). The importance of and need for such rigor is discussed in the methodological limitations section below. Then, in the second study, four games hypothesized to be more active were also investigated. Presence scores and motivation were compared and used to predict energy expenditure.

Methodological Limitations of Past Studies

Several methodological limitations make evaluating the current literature difficult. All published energy expenditure studies to date of which we are aware have used very small sample sizes (*N* < 40), and almost all have used youth under 18, making extrapolation to adults difficult (Borusiak et al., 2008; Graf et al., 2009; Graves et al., 2008; Graves et al., 2007; Lanningham-Foster et al., 2009; Lanningham-Foster et al., 2006; Maddison et al., 2007; Mellecker & McManus, 2008; Miyachi, Yamamoto, Ohkawara, & Tanaka, in press; Sell et al., 2008; Straker & Abbott, 2007; Tan et al., 2002; Unnithan et al., 2006; Wang & Perry, 2006). The studies lack theory-based covariates or mediators that might contribute to knowledge of why individuals expend more energy on different games. Differences found across studies in the energy expended while playing traditional games would suggest that not all traditional games are necessarily sedentary, and that some characteristic must be encouraging increased activity (see Table 1.1 above). It is known that technological advancement (Ivory & Kalyanaraman, 2007), graphic quality (Hoffman et al., 2006), sound quality (Hebert, Beland, Dionne-Fournelle, Crete, & Lupien, 2005; Lipscomb & Zehnder, 2004), presence and quality of story (E. F. Schneider et al., 2004), genre (Raudenbush, Esgro, Cessna, McCombs, & Yahn, 2006), violence level (Carnagey, 2007), avatar existence and gender (Eastin, 2006; Eastin & Griffiths, 2006), and type of opponent (Ravaja et al., 2006) can all greatly affect reactions to games.

Without a firm theoretical framework, health-related video game research thus far has led to comparisons that are difficult to generalize. Comparing a Dance Dance Revolution game to Disney's Extreme Skate Adventure (Lanningham-Foster et al., 2006), for example, is important and provides information about differences between these two specific games. However, the two games are so different from one another that one cannot generalize these findings to other game comparisons or derive important information for future game development. It is not unreasonable to assume that game quality and genre may have a large impact on arousal and enjoyment, and potentially also on energy expenditure. Comparisons may unintentionally arrive at confounded results because of inappropriate controls in the study design.

Results from Pilot Testing in Overweight Children and Young Adults

Prior to the initiation of the PRESENCE project, a video game protocol was pilot tested in overweight children as part of the HEALTHeFAMILIES study. Participants wore ActiGraph uniaxial accelerometers at the hip and played 4 different Nintendo Wii games: Wii Sports (tennis, baseball, and boxing minigames), Rayman Raving Rabbids (dancing minigame), Cooking Mama (1st recipe), and Wii Play (cow racing minigame). Participants played games both by themselves and against opponents. As shown in Table 1.2, the baseball minigame provoked the highest average number of activity counts, 767 per minute. Rayman Raving Rabbids and Cooking Mama provoked the lowest responses, with 177 counts per minute each. Using the Freedson equation to transform activity counts into metabolic equivalent values, these outcomes corresponded to MET values between 2.08 and 2.66 (Trost, Way, & Okely, 2006). These data were collected in true-to-life conditions, with children deciding the games they wished to play, for how long, and in what way (against other children, cooperating with other children, against the computer). Thus, numbers presented below should not be taken for objective activity counts related to standardized play, but rather broad estimates of activity provoked by free play.

Table 1.2 Activity Counts in Pilot-Tested Games

Game	*N*	Count/Min
Baseball	11	767
Boxing (vs)	8	712
Bowling	8	628
Boxing (training)	20	616
Tennis	19	428
Golf	11	248
Rabbits (dancing)	15	177
Cooking	3	177

Two analyses were performed to investigate the effects of methodological differences in active game study designs. First, the average energy expenditure over the entire play period was compared to the average during the most active three minutes of play. These categories mirrored strategies used in the published literature (Wang & Perry, 2006). Of three games tested, small but significant ($p < .05$) differences were found in two estimates (baseball and tennis). Overall average scores ranged from 2.69 to 3.13 METs, while averages of the most active three minutes ranged from 2.77 to 3.50 METs. Based on this finding, it was decided that averaging energy expenditure over the entire play period, as in most previous studies, would provide the most precise results.

Second, the effect of playing a warm-up game was tested. Seven children played the dancing rabbit (Rayman) game first and tennis game second, while 12 children played in the opposite order. This analysis was complicated by the fact that nine of the 19 children were observed to not have played the dancing rabbit game as intended. These observations were confirmed by accelerometry data, which showed activity counts under 25 per 30 seconds. Those who did not play the game as intended instead stood and watched without playing, appearing to not understand how to play. Playing the rabbit game or not was significantly associated with game order (Fisher's exact test, $p = .017$). For the tennis game, playing the rabbit game first was associated with activity counts during tennis ($F(1, 16) = 6.625$, $p = .020$). Playing a game as a warm-up appeared to lead to higher energy expenditure as well as better adherence to study protocol (likely due to better understanding of how to play the game).

Based on these and qualitative results of this pilot test, the protocol to be used in the larger study was created. The protocol was also modified to be more appropriate for the target population of interest, young adults. A second pilot test was performed prior to initiation of the larger study, using a young adult population ($N = 13$) and updated protocol and equipment (see methods and protocol section below for detailed explanations of both). A major purpose of this pilot was to determine whether energy expenditure differed by minigame in Wii Fit, as had been found in Wii Sports in the previous study. Results confirmed that aerobic and balance minigames differed significantly, with aerobic minigames producing moderate intensity (3.13 and 7.13 METs) and balance minigames producing light intensity (2.24 and 1.32 METs) physical activity ($p < .01$). Though a comparison of minigames was beyond the scope of the larger study, it was decided that both types of minigames should be played and then averaged to create a composite Wii Fit score. Reliance on one type of minigame to represent the entirety of Wii Fit would be misleading, and thus two representatives from each of the game categories (yoga and strength exercises were omitted, as these were nearly identical to traditional exercises and not unique to Wii Fit) were chosen to best represent the experience of the game within the resources of this study.

Young Adults as a Target Population

Almost all published studies of active games have used children or adolescents as their target population. Such an emphasis is understandable, as pediatric obesity is a large and high-profile problem, but youths under the age of 18 actually make up a relatively small portion of game players. More than 70% of video game players are adults, and most (47.6%) are between 18 and 49 years old (Entertainment Software Association, 2009). Studies of brain activity show that children and adolescents process the same events in virtual reality very differently, resulting in differential feelings of presence (Baumgartner, Valko, Esslen, & Jancke, 2006). Differences appear to be the result of brain maturation, suggesting that differences in feelings of presence evoked by games are probably even larger between children and adults. Moreover, adolescents showed much lower feelings of presence than children, which may mean that older people require more to be engaged than youth. Performing active game research only on children severely limits generalizability to the populations that are most likely to play games.

Games that are appropriate for youth also limit research potential. Games rated E for everyone make up about half of the console game market (Entertainment Software Association, 2009), but the most popular blockbuster titles are often rated T (teen) or M (mature). To have the most population-level impact, researchers must broaden their scope to include adult-oriented games as well as child-friendly ones.

Young adults are also at particular risk in terms of obesity and physical inactivity. As individuals move from adolescence to adulthood, physical activity declines while sedentary behavior remains constant (Gordon-Larsen et al., 2004). Young adults, ages 18-35, experience a high rate of weight gain, averaging 1 to 2 pounds per year (Truesdale et al., 2006) or 30 pounds over this period. Given the difficulties in producing sustained weight loss later in life, preventing weight gain during this high-risk period in young adulthood period is essential. Video games are a very popular sedentary activity in this age group, making active gaming a promising avenue for obesity prevention and/or treatment.

Conclusions and Specific Aims

If video games are to be used to substitute for television watching, there is a need for research on motivational factors related to their play. SDT and presence provide a framework for investigating characteristics of games that may motivate longer periods of time spent playing and higher levels of activity during play. The type of controller used appears to be a major factor that affects energy expended while playing a game, and there is evidence that controllers may also affect feelings of presence. Perspective is another potential factor that could affect feelings of presence. It is likely that presence contributes to feelings of motivation to play a game, and may even affect energy expended while playing the game. However, the pathways and directions involved in these relationships are unclear, as are the theoretical antecedents of motivation. The hypotheses for specific aims 1 and 2 below were intended to explore game characteristics and their effects on physiological and cognitive outcomes. Hypotheses for specific aim 3 were intended to investigate theoretical constructs that may be associated with motivation. Together, the conclusions drawn from tests of these hypotheses should lead to recommendations for more active and more motivating video game development and a better understanding of how theory relates to research in video game study.

Specific Aim One: To compare the effects of control scheme and perspective in traditional video games on energy expenditure, presence, and intrinsic motivation. The purpose of this aim was to study six traditional games. To investigate the effects of control scheme, two popular game franchises were used: Medal of Honor and Resident Evil. For each franchise, two games were compared: one played with a typical gamepad controller and one played with a motion-sensing controller. Other than control scheme, the games were extremely similar with nearly identical storylines and gameplay. Next, to investigate perspective, the first-person Medal of Honor games were compared to the over-the-shoulder perspective Resident Evil games. A final comparison was added, consisting of two additional Resident Evil games that shared the same story: one with a third-person perspective and typical controls, and one with a first-person perspective and motion-sensing controls. These games were compared to test the combined effect of change in both perspective and control scheme.

Hypothesis 1.1: Game play with motion control will result in greater ratings of presence, intrinsic motivation, and energy expenditure compared to play using traditional controls.

Hypothesis 1.2: A game with over-the-shoulder perspective will result in greater ratings of presence and intrinsic motivation in players than a game with a first-person perspective.

Hypothesis 1.3: In two games with the same story, presence ratings, intrinsic motivation, and energy expenditure will be greater in the first-person motion controlled game than with the third person traditionally controlled game. In addition, the difference here will be larger than in above hypotheses 1.1 and 1.2.

Specific Aim Two: To compare the effects of four potentially active games that use specific, unique controllers, both to each other and to traditional video games. The purpose of this aim was to study four games that were hypothesized to be active. Each game was played with a unique controller made specifically for that game. Guitar Hero used a guitar, Rock Band used a drum set, Dance Dance Revolution used a dance mat, and Wii Fit used a balance board. Intrinsic motivation, presence, and energy expenditure were compared across the four games in study two, and then across all games.

Hypothesis 2.1: Among the four game categories, energy expenditure will be greatest in DDR followed by Wii Fit.

Hypothesis 2.2: Study one (traditionally-controlled shooter) games will result in higher presence and intrinsic motivation scores than study two games.

Hypothesis 2.3: Study two games will result in higher energy expenditure than traditional games from study one.

Specific Aim Three: To investigate relationships between presence, intrinsic motivation, and other potential predictors of video game play motivation. Here, relationships between the theoretical predictors of interest were explored. Using path analysis, a mediation model was tested in which intrinsic motivation mediated the effects of presence, perceived competence, and perceived control on energy expended during play of one game. The DDR game was chosen as an exemplar due to the prevalence of this franchise in the active gaming literature.

Hypothesis 3.1**:** Presence, perceived competence, and perceived control will each independently predict intrinsic motivation.

Hypothesis 3.2: Intrinsic motivation will, in turn, predict energy expenditure.

Hypothesis 3.3: Intrinsic motivation will mediate the effects of presence, perceived competence, and perceived control on energy expenditure.

CHAPTER 2

MEASUREMENTS AND PROTOCOL

Participant Recruitment

One hundred participants ages 18-35 were recruited, with equal numbers of males and females. The project was split into two parts: in Study One (corresponding to Aim One) the 100 participants were divided into two groups of 50, and in Study Two (corresponding to Aims Two and Three) all 100 played each game. Because this study is novel, there were no direct comparisons from the literature for power calculations. Below are two presence-related studies (Eastin, 2006; Eastin & Griffiths, 2006) and three active game studies (Graves et al., 2007; Lanningham-Foster et al., 2006; Wang & Perry, 2006) to provide a range of possible group differences for the major outcomes.

Table 2.1 Sample Size and Power[a]

Category	Comparison	Group 1 mean (sd)	Group 2 mean (sd)	Size needed per group
Presence	VR vs. console	4.49 (.77)	5.07 (.60)	18
	Gender of avatar	4.43 (.83)	4.00 (.70)	39
Energy expenditure	Baseline vs. Tekken 3	1.36 (.44)	2.08 (.47)	5
	Rest vs. PG Racing	81.3 (17.2)	125.5 (13.7)	2
	Eyetoy vs. DDR	13.61 (4.2)	17.26 (4.28)	17

[a](alpha = .05, beta = .80); VR, virtual reality; PG, Project Gotham; DDR, Dance Dance Revolution

It was hypothesized that differences due to perspective would be smaller than those between virtual reality and console games but larger than those between the same game with differently gendered avatars. With 50 people in each condition in Study one, and all 100 playing the four games in Study two, this project was adequately powered given the calculations above. In fact, the sample size was much larger than any previously published active games research, which have generally used samples of 10 to 20 participants. We intentionally recruited 50 males and 50 females to have reasonable sample size to stratify by gender if necessary, as gender has been found to be an important covariate.

Participants were recruited primarily through university email lists at major local universities as well as through television advertisements. Exclusion criteria included being under 18 or over 35 years of age, having a pre-existing medical condition precluding physical activity, weighing over 300 pounds (a requirement for the Wii Fit balance board), being unwilling to fast for 2.5 hours prior to the study protocol (a requirement of measurement equipment) and being unable to find transportation to the study location.

Pre-experimental Measures

Anthropometric measures were taken in light street clothing without shoes on a calibrated scale (Tanita, Arlington Heights, IL). Two measures were completed and the average of the two were used. Height was assessed with a wall-mounted stadiometer (Perspective Enterprises, Inc., Kalamazoo, MI).

Participants completed an initial questionnaire at the beginning of the lab protocol, prior to fitting the calorimeter. The questionnaire included measures of uses and gratifications of game play, immersive tendencies, physical activity, sedentary behavior, other video game-related items, and sociodemographic characteristics.

Uses and gratifications of game play. Uses and gratifications of video game play were measured by Sherry and colleagues' uses and gratifications instrument (Sherry, Greenberg, Lucas, & Lachlan, 2006). The instrument measures six different uses and gratifications, all with Chronbach's alphas of between .79 and .89: competition, challenge, social interaction, diversion, fantasy, and arousal (Lucas & Sherry, 2004).

Immersive tendencies. The Immersive Tendencies Questionnaire (Witmer & Singer, 1998) contains 19 items that measure personality characteristics of individuals that may affect their predisposition towards feelings of presence in virtual environments. This measure is often used in presence studies, as both a major variable and a covariate (Kim, Kim, Kim, Ko, & Kim, 2005; Murray, Fox, & Pettifer, 2007; Tortell & Morie, 2006). It has been found to have a Chronbach's alpha of .81 (for the 18 items that are quantitative; one item is categorical and was not included in reliability analyses) and three subscales: involvement, focus, and games. Involvement has to do with tendencies to become involved in activities such as reading or watching movies. Focus deals with ability to concentrate and avoid distractions. The two games-related items ask about frequency of play and tendencies towards feeling presence when playing games.

Physical activity and sedentary behavior. The Paffenbarger Physical Activity Questionnaire (Paffenbarger, Wing, & Hyde, 1978) was used to assess regular physical activity. This measure consists of three items, which measure energy expenditure related to walking, climbing stairs, and sports over the past year. It has been used extensively and has shown adequate reliability and validity (Catenacci et al., 2008; Sesso, Paffenbarger, & Lee, 2000; Washburn, Smith, Goldfield, & McKinlay, 1991).

Sedentary behavior was measured with a series of questions adapted from those used in the National Health and Nutrition Examination Survey (Evenson & McGinn, 2005). Sedentary behaviors previously measured in the literature (sitting/lying down and reading, listening to music, talking on the phone, relaxing, and other hobbies) were added to the questions on television and computer use (Salmon, Owen, Crawford, Bauman, & Sallis, 2003). All of these items have shown adequate reliability and have been widely used. A similar item to measure video game use was also included.

Other items. Previous video game experience and current video game-related behavior were measured using an inventory created by the author. Items asked about overall video game experience, consoles owned, approximate spending on video games per month, genre preferences, and amount of time spent playing video games per day and per week. Most of these items were adapted from Ivory and Kalyanaraman (2007) and genres listed by Smith (2006).

In addition, sociodemographic information was collected. Specifically, participants were asked to provide information on their age, gender, race/ethnicity, and education.

Objective Measures

Energy expenditure both at rest and during game play was measured using indirect calorimetry (Ultima CPX, Medgraphics, St. Paul, MN). The Ultima CPX measures O_2 intake and CO_2 expiration on a breath-by-breath basis using an open pneumotach and neoprene face mask. The calorimeter was calibrated daily using a 3 liter syringe, and was additionally calibrated prior to each test using certified gasses. The umbilical hose connecting participants to the cart was routed behind the body in games that required standing. During seated games, the umbilical was routed to the side. Participants were instructed to arrive at the laboratory after a 2.5 hour fasting period to ensure that food metabolism did not bias energy expenditure estimates.

Participants wore a dualaxial accelerometer device (SenseWear Armband, Body Media, Inc., Pittsburgh, PA) on the upper arm during all gameplay, an Actigraph triaxial accelerometer (Actigraph, LLC, Pensacola, FL) on the waistband, and a POLAR heart rate monitor across the chest. Energy expenditure estimates from the two accelerometers will be compared to the indirect calorimetry for potential use in future studies.

Self-Report Measures

Presence. The SUS (Slater-Usoh-Steed) Presence Scale is a brief, commonly-used measure. There is significant controversy in the presence literature as to the best measurement strategy. From a review of the literature, the most common measures appeared to be the SUS (Usoh, Catena, Arman, & Slater, 2000) and the Presence Questionnaire (Witmer & Singer, 1998). Though these two questionnaires are highly correlated (Usoh et al., 2000), the SUS is much shorter and thus less burdensome for participants. Though this measure has been used in many projects (Banos et al., 2008; Murray et al., 2007; Nunez & Blake, 2003; Slater, Steed, McCarthy, & Maringelli, 1998), reliability has not been reported. Its correlation to the Presence Questionnaire offers some evidence of validity, though any claims of validity in questionnaire-based presence measurements must be made extremely cautiously.

The SUS scale has traditionally been scored such that responses to items in this scale of 6 or 7 (on a 1 – 7 Likert scale) count as one point. These points are summed to create the presence score (range: 0 – 6). Though this method of scoring may be appropriate for virtual reality studies, where this measure is commonly used, it does not appear appropriate for use in video game studies. When this method of scoring was tried for this sample, between 64 and 81 percent of the sample received scores of 0, depending on game type. When a scoring system that averaged scores from the six items into an overall mean score, only 3 – 14% received the lowest score (1.0). It appears that, in the types of video games used in this study, for participants to truly feel that the game is a form of reality might not be expected. Therefore, to reflect the full range of scores, it was decided that the mean of item responses would be used to create the presence score in this study (range: 1 – 7).

In addition to the SUS, portions of the Temple Presence Inventory (sometimes called the Lombard and Ditton measure) (Lombard & Ditton, 2004; Lombard et al., 2000) were used. This measure has subscales that may provide further insight into the types of presence that are most important in video games, without the length of the Presence Questionnaire. The factors used in this project were spatial presence, social presence (actor within medium), and engagement. Several items were removed due to their inapplicability to the games being used. All items showed high loadings onto their respective factors (over .75) in reported factor analyses. Spatial presence had a Chronbach's alpha of .91 and an eigenvalue of 4.19, the social presence scales had an alpha of .90 and eigenvalue of 4.08, and engagement had values of .90 and 3.61. The Temple Presence Inventory has been used in several studies

(Chatting, Galpin, & Donath, 2006; Takatalo, 2002), and its components come from well-validated past measures found in a literature search by the instrument's creators (Lombard et al., 2000).

Intrinsic motivation. Intrinsic motivation was measured using the interest/enjoyment portion of the Intrinsic Motivation Inventory (McAuley, Duncan, & Tammen, 1989). This measure has been used in research similar to the proposed project in the past. Reliability of the interest/enjoyment subscale (.91) and perceived competence (.81) have been found to be quite high (Markland & Hardy, 1997). Both subscales can differentiate between two levels of immersion, and have been successfully used in presence experiments (Ijsselsteijn et al., 2006).

Perceived control. The Presence Questionnaire (PQ) contains a subscale for control and immersion factors (Witmer & Singer, 1998). From this subscale, the five questions related to perceived control were included. Factor analyses subsequent to the original publication of the PQ have found that control and immersion factors from the original subscale load onto different factors (Takatalo, Nyman, & Laaksonen, 2008). No presence measures other than the PQ measure control issues as such; generally, items related to control of events in a virtual environment are worded so as to be about the realism and naturalness of the control scheme. These five questions appeared to be the best available for measuring perceived control specifically in the context of video gaming, and have been used before to measure perceived control in isolation (Cavazza, Lugrin, & Buehner, 2007).

Perceived competence. Perceived competence was measured using the perceived competence subscale of the Intrinsic Motivation Inventory. This instrument included items related to both personal feelings of competence as well as personal feelings of competence in comparison to others. The items related to comparing one's competence to others should remove any bias introduced by difficult gameplay. Several of the games used in this study may have been difficult, and many participants failed or their character died one or more times over the course of the 13-minute play periods. If participants felt that the game was difficult, and that the difficulty was the casual factor in their poor play, then the comparative items should be able to measure those feelings accurately. Thus, this instrument measured both fit of the participant's skills to the demands of the game as well as overall feelings of competence.

Perceived exertion. Perceived exertion was measured using the Borg Rating of Perceived Exertion (RPE) Scale (Borg, 1998). Participants rated their perceived exertion on a scale from 6 (no exertion at all) to 20 (maximal exertion). This measure has been very commonly used in exercise settings as well as virtual environment and virtual environment-supplemented exercise research (Plante et al., 2003; Van Schaik, Blake, Pernet, Spears, & Fencott, 2008). The RPE has shown adequate to high validity, with higher validity in exercise tasks that are less common (Chen, Fan, & Moe, 2002).

Intention to play. Participants were asked how likely they would be to play each of the games again (using a likert scale from 1-7). At the conclusion of the study, they were asked to rank the games in order of likelihood of future play.

Other items. Several other items were adapted from Ivory and Kalyanaraman (2007). Participants rated their frustration with the game, whether they had ever played the game in the past, and whether they have ever played similar games in the past.

Study Protocol

These randomized laboratory studies employed a 2 (condition) x 3 (game) design (Study One) and an entirely within-subjects design (Study Two). Studies were performed back-to-back (in randomized order) as part of a single protocol.

The studies were conducted in a University-owned building convenient to major local thoroughfares. Participants were screened via telephone or email for inclusion/interest in the study and instructed to arrive at the laboratory after a 2.5 hour fasting period. Upon arrival, participants were taken to a private room for initial measurement and orientation. Prior to any measurement, informed consent was solicited and any questions about the project answered. Participants completed the pre-experimental questionnaire, and their height and weight were measured by project staff. Participants were then taken to a room with a comfortable chair, widescreen television, and appropriate game consoles/controllers. A staff member gave instructions and fit the physiological measurement equipment.

Participants rested in the darkened room for 20 minutes. Measurements from the last five minutes of the rest period were averaged to estimate resting energy expenditure. Upon completion of the initial rest period, the game play protocol began. Participants played eight games: three shooter games in Study One, and five games that used dedicated controllers in

Study Two. (Four separate games were played in Study Two, but two different minigames from Wii Fit were played, bringing the total of play periods to five.)

Prior to arrival, randomization for each participant was performed. Study order (Study One or Two first), game order within study, controller group in Study One, and Wii Fit minigame group in Study Two were all randomized. Though the games within a study were always played together, order of both the studies as well as the games within them were always randomized.

Each game was played for a total of 13 minutes, with energy expenditure and heart rate measured continuously. The first three minutes were considered an orientation/training period, during which the study coordinator provided game instruction. Measurements from this period were not included in analyses. For each game, all participants were given a laminated sheet with a large, clear picture of the controller(s) s/he would use, with character actions labeled on appropriate parts of the picture.

In between games, participants were allowed to rest for between five and 10 minutes. During this time, participants completed questionnaires including self-report measures of game reactions. The mask used by the indirect calorimeter was removed at the start of each rest period, then re-attached and tested for leaks at their conclusion. Participants could use the restroom and/or drink water as they wished during each rest period. Heart rate was monitored prior to the beginning of the next game, and play was not begun until heart rate decreased to near baseline levels (within one standard deviation).

The entire protocol lasted approximately four hours per participant. At the conclusion of all measurements, participants were given a $50 check and offered snacks and beverages of his/her choice.

The protocol was pilot tested (*N* = 13) and refined prior to study initiation. All sessions were videotaped for quality control and to explore future hypotheses.

Brief Game Descriptions

Study One. Three pairs of games were played during Study One, corresponding to three different perspectives: first person, over-the-shoulder, and a combination (third person compared to first person). Within each pair, one game was played using a traditional gamepad controller and one was played using a motion-sensing controller.

First person pair. The Medal of Honor series of games are first-person shooters. In this genre of game, the protagonist is not seen on the screen. Instead, the player participates as that character, seeing the world through his or her eyes.

Medal of Honor: Airborne is a first-person shooter game released in 2007 for the PS3, rated T for blood, mild language, and violence. Participants played the first campaign on the easiest difficulty level. The basic gameplay was simple: players parachuted onto the battlefield and then ran, took cover, provided covering fire for other soldiers, and shot opposing soldiers. To move the character, aim, and shoot the player uses the analog stick and buttons on the PS3 controller.

Medal of Honor: Heroes 2 was also released in 2007 and rated T for violence. Gameplay was very similar to in Airborne, but used motion control in conjunction with button-based control. Participants played the third campaign, the city, to best match Airborne’s setting. To play, participants used the analog stick on the Nunchuk to move around the battlefield, aiming using the Wiimote to point at the screen. Players could also move the Wiimote to point at the sides of the screen to look around the environment. Other motion-sensing aspects of the game include throwing grenades by making a throwing motion, cocking a shotgun, and turning cranks.

Over-the-shoulder pair. Originally released in 2005 for the Nintendo Gamecube, Resident Evil 4 (RE4) was later released in editions for the Playstation 2 and the Wii. Resident Evil 4 uses an over-the-shoulder perspective. The player looks over the shoulder of the player character avatar, seeing the world from his perspective while also being able to see his back. This perspective combines the immersive qualities of first-person with the existence of an avatar. When a player takes damage, s/he actually sees the protagonist bleed and become wounded or die. The protagonist's avatar can also dodge and sometimes fight off enemies who attempt to hurt him.

Resident Evil 4 is rated M, for mature, for blood and gore, intense violence, and language. The typical control version was the PS2 version, played on a PS3. The PS3 up-converted the graphics of PS2 games slightly, meaning that the graphical quality of this game should be on par with that of the Wii version.

The Wii version of the game is virtually identical to the other but for the implementation of motion control. Players pointed the Wiimote to aim and pulled the trigger to shoot. There were also several gesture inputs. Waving the Wiimote while pressing the trigger reloaded weapons, and waving the Wiimote while pressing the C button slashed with a knife.

Combination pair. The original Resident Evil game popularized the genre of survival horror. The remake, released in 2002 for the Nintendo Gamecube, updated the game without drastically changing the story or characters. Participants played as the male protagonist in third-person perspective, which meant that an avatar was visible but players did not see from the avatar's perspective. Gameplay included exploring and shooting several zombies. This game is rated M for blood and gore and violence.

Resident Evil: Umbrella Chronicles (UC) reprises the stories of older Resident Evil games using motion control and a first person perspective. Players aimed with the Wiimote and shot by pressing the trigger. Shaking the Nunchuk reloaded the current weapon, and waving the Wiimote slashed with a knife. Participants played the section devoted to Resident Evil, which occured in the same mansion as the original game with the same two characters. The story and progression of game events were the same as in the original. The rating was M, for blood and gore and violence.

Study Two. Five games were played during Study Two, including two band simulation games, one dance simulation games, and two minigames from a fitness game.

Band simulation. Two band simulation games were played, Guitar Hero III and Rock Band 2. The Guitar Hero and Rock Band franchises are very similar, but at the time of study planning only Rock Band included drumming in gameplay. Thus, the Guitar Hero game was used to represent guitar gameplay, and the Rock Band game was used to represent drum gameplay. Guitar Hero III: Legends of Rock is rated T for lyrics and mild suggestive themes.

Guitar Hero III is an extremely popular music/rhythm game in which players use a guitar controller to play along with songs in the game. The controller uses both fret buttons and a strum bar as its major inputs. When the properly-colored buttons scrolled onto the colored circles on-screen, the player must strum while holding down the appropriately-colored fret button.

Participants played “Hit Me With Your Best Shot” on easy difficulty in practice mode during the training period. Once the song was complete, they played “Slow Ride” on easy difficulty in quick play mode. Participants were allowed to choose songs and difficulty level once this song was completed.

Play of Rock Band 2 was similar. Participants sat at a plastic drum set controller that consisted of four colored drum pads and a foot pedal. Players hit the correctly-colored drum pad with their drum sticks when colored bars scrolled across the screen. A similar protocol was followed as in Guitar Hero: “Celebrity Skin” was played on easy difficulty in practice mode during the training period, and “Rebel Girl” was played on easy difficulty in regular mode at the start of the measured play period. Participants chose song and difficulty once that song was complete. This game was also rated T for lyrics and mild suggestive themes.

Dance simulation. Dance Dance Revolution (DDR) is a franchise of music/rhythm games known for its use of a dance mat as a peripheral controller. The DDR game used for this study was Dance Dance Revolution: Universe 2, which was rated E10+ for mild lyrics. Gameplay in DDR games is typical for rhythm games and very similar to that in Guitar Hero and Rock Band, except that arrows scroll across the screen rather than colored bars or circles. The direction of the arrow corresponds to up, down, left, and right arrows on the dance mat used as the controller. During the training period, participants danced to “Take Me Out” in practice mode on beginner difficulty (though Guitar Hero and Rock Band use easy, medium, hard, and expert difficulty, this DDR game used beginner, basic, difficult, and expert). Next, participants played “Safety Dance” on beginner difficulty in the typical play mode. As in the other two music-oriented games, once these songs were completed participants could choose song and difficulty for the rest of the play period.

Fitness. Wii Fit is a minigame collection played with a dedicated balance board controller that uses body weight and its distribution as inputs. Some minigames also use motion-sensing inputs from the Wiimote controller as well. Four minigames were chosen for inclusion in this study: two from the aerobic minigames and two from the balance minigames. Wii Fit also contains strength and yoga exercise sections, but those “minigames” consist of performing exercise moves after a virtual personal trainer rather than participating in a game or game-like activity. This game is rated E for comic mischief.

The two balance games chosen were the skiing minigame and penguin sliding minigame. In the skiing minigame, players shifted their weight on the balance board in order to steer their avatar down a slope. The purpose of the game was to complete the course in as little time as possible while navigating successfully through a series of flags. In the penguin slide minigame, players shifted their weight on the balance board in order to tip an iceberg. A penguin that stood on the iceberg slid based on how the iceberg tilted. The purpose of the game was to move the penguin such that it ate as many fish as possible by timing one’s movements appropriately.

The two aerobic games chosen were the hula hooping and jogging minigames. In the hula hooping minigame, players swung their hips in a circle while standing on top of the balance board. Occasionally, non-player characters would throw additional hoops that would have to be caught while continuing to hula hoop. The purpose of the game was to complete as many spins of the hula hoops as possible within a discrete time period. In the jogging game, players held a Wiimote while jogging in place. Their avatar traveled through a virtual environment at a speed based on the rate at which the player jogged. No explicit goal was given to players other than to jog for the entire play period attempting to cover as much ground as possible.

Each participant played one aerobic and one balance game. Games were randomized such that participants played either the jogging and penguin games or the hula hoop and skiing games.

Analysis Plans

Specific Aim One. Hypotheses 1.1 to 1.3 were tested through a series of three mixed models, with energy expenditure, presence, and intrinsic motivation as dependent variables. Game was the repeated measure, and controller the predictor of interest. Gender and BMI were included in the model as covariates. Interaction terms were included in each model. As necessary, these terms were investigated using effect slices and post-hoc contrasts.

Specific Aim Two. Four categories were created, representing shooter (all study one games), band simulation (Guitar Hero and Rock Band), dance simulation (DDR), and fitness (Wii Fit) games. These categories were used as levels of the independent variable, game. As in Aim 1, three mixed models were created using energy expenditure, presence, and intrinsic motivation as the dependent variables. Gender and weight status (BMI was dichotomized for clarity) were included in the models.

Specific Aim Three. A path model was specified and tested in which presence, perceived competence, and perceived control predicted energy expenditure, with intrinsic motivation as an intervening variable. BMI was also included as a predictor of energy expenditure, but was not hypothesized to covary with the other predictors.

CHAPTER 3

EFFECTS OF MOTION CONTROL ON PRESENCE, MOTIVATION, AND ENERGY EXPENDITURE DURING VIDEO GAME PLAY: DIFFERENCES BETWEEN WIIMOTE AND TRADITIONAL CONTROLLERS

Abstract

Background. Physically active video gaming has been suggested as a method for increasing energy expenditure during screen time. Though fitness and sports video games that use motion control have been found to be physically active, it is not clear whether motion control would increase energy expenditure when applied to more traditional action/adventure games. It is also unclear how control type and other game characteristics may affect psychological reactions that have been found to predict play over time, such as presence (the feeling of being in the game).

Methods. One hundred young adults 18-35 years old (50 female) were randomized to play a series of three video games using either a traditional or motion-sensing controller. Each participant played one first person perspective game, one over-the-shoulder perspective game, and a game chosen to include maximally presence-inducing perspective and control (first person motion control) or minimally presence-inducing perspective and control (third person traditional control). Energy expenditure and self-reported feelings of presence and motivation were measured.

Results. No main effects were found. Interactions existed such that the maximized game produced significantly higher energy expenditure than the minimized game ($p = .013$) and the over-the-shoulder motion controlled game ($p = .003$). The minimized game was rated lower in presence ($p = .029$) and motivation ($p < .001$) than the maximized game; it was also lower in both variables than the traditionally controlled over-the-shoulder and first person games ($p < .001$).

Conclusions. Motion control is a promising method for increasing energy expended during play of traditional video games, but as currently implemented it is unlikely to produce light or moderate intensity physical activity.

Background

Sedentary screen time is a major public health problem. Sedentary behavior and in particular television (TV) watching presents unique risks in addition to risks from inactivity (Bellissimo, Pencharz, Thomas, & Anderson, 2007; Dunstan et al., 2007; Ekelund et al., 2006); even individuals who are very active show increased metabolic risk with higher amounts of TV watching (Healy, Dunstan, Salmon, Shaw et al., 2008). A potentially healthier alternative is home console video gaming, which is an engaging pastime that has been found to be less sedentary than TV watching (Swinburn & Shelly, 2008).

Games vary widely in activity level produced during play. Here, games that produce moderate to vigorous physical activity during their play are referred to as physically active games. These games can be contrasted with traditional games, which are sedentary. The type of controller used to play a game appears to have a large influence on energy expenditure:

dance and fitness-themed games using dance mat and camera-based controllers consistently show higher levels of activity during play when compared to games that use more traditional gamepad controllers (Lanningham-Foster et al., 2006; Maddison et al., 2007; Sell et al., 2008; Straker & Abbott, 2007; Tan et al., 2002; Unnithan et al., 2006). However, the sustainability of physically active games is unclear. Despite the recent popularity of fitness games, traditional action/adventure games remain the most widely played genre (Entertainment Software Association, 2009). Preliminary intervention studies using active games have had disappointing results, which appear to at least partially result from declines in play over time (Chin A Paw et al., 2008; Madsen et al., 2007). It may be that the games used (usually dance simulation games) are insufficiently motivating to encourage repeated play over time.

Cognitive Evaluation Theory posits that intrinsic motivation, or the desire to engage in a behavior in the absence of external rewards, is a more powerful predictor of behavior than extrinsic motivation (Ryan & Deci, 2000a). Several studies have found that intrinsic motivation predicts subsequent video game play (Przybylski et al., 2009; Ryan et al., 2006) as well as energy expended during play of a virtual reality exercise game (Ijsselsteijn et al., 2006).

One potential reason that some active games may be less motivating than other games is that they lack characteristics known to be associated with feelings of presence. Essentially, presence is a measure of distraction from the real world while attention is selectively paid to a virtual one. Feelings of presence are positively associated with intrinsic motivation to play a video game (Ryan et al., 2006).

Addition of bodily motion to traditional action/adventure video games may be a way to increase energy expended during play while retaining the motivational characteristics that make these games popular. In fact, motion control may increase feelings of presence if motions are perceived to be natural and meaningful (Bianchi-Berthouze et al., 2007; Lindley et al., 2008; Skalski et al., 2006). Several researchers have proposed a feedback loop in which body movement during game play increases feelings of presence and engagement, which in turn increase body movement (Bianchi-Berthouze, 2009).

The Nintendo Wii console comes packaged with a controller, the Wiimote, which includes both buttons and motion-sensing functionality. Many of the same types of games available for other consoles can be played on the Wii console, but Wii versions of the games generally change the control scheme to include motion control for such actions as aiming a weapon or throwing grenades. The effects of motion control in these games on energy expenditure, presence, and motivation are as yet unknown.

In addition to control scheme, other game characteristics may also have effects. A first-person perspective in which the player sees out of his or her character's eyes has long been thought to increase feelings of presence and engagement (Tamborini & Skalski, 2006). However, avatars (visual representations of the player character) are also associated with presence (Bailey, Wise, & Bolls, 2009). Several recent games have used a perspective that combines aspects of first and third person perspectives by placing the camera over the shoulder of the player character. Thus, the player can see the back of their character's avatar while seeing the game world from his perspective. It is possible that feelings of presence could be different for this type of game due to the mixture of first and third person aspects.

The purpose of this study was to investigate the effects of motion-sensing controllers as well as perspective on physiological and psychological responses during play of shooter games, a popular subgenre of action/adventure games. Three pairs of games were used, with the two games in each pair being different versions of the same game. The pairs differed such that in one pair, the game perspective was first-person, and in another, the perspective was over-the-shoulder (combining a first person perspective with a visible avatar). In the third pair, the games used both different controllers and perspectives. It was hypothesized that motion controlled games would produce greater energy expenditure, presence, and intrinsic motivation than the traditionally controlled games. A secondary hypothesis was that the over-the-shoulder pair would produce greater presence and intrinsic motivation than the first person pair, due to the combination of first person perspective and a visible avatar. Finally, it was also hypothesized that differences within pair on these outcomes would be greater in the third (different controllers and perspectives) pair than in the other two pairs.

Methods

Study participants and protocol. Participants were 100 18-35 year olds, equal numbers of men and women, recruited through a University online mailing list and television advertisements. To be included, participants were required to weigh <300 pounds (necessary for the use of other game controllers not discussed here), to have played video games at least 3 times over the past year, to be willing to fast 2.5 hours and be videotaped during the study protocol, and to have transportation to the study location. Of 757 individuals who requested information and eligibility criteria, 325 completed eligibility information; of those 325, 169 potential participants were scheduled, and 100 completed the protocol. Eligible participants who did not attend their appointments (N = 49) were considered drop-outs, and 156 eligible participants were wait-listed.

All data were collected between April and August of 2009. The study was powered to be able to detect differences both in physiological as well as psychosocial variables even if stratified by gender, based on published estimates of presence differences across similar games (Eastin, 2006; Eastin & Griffiths, 2006).

After providing informed consent, anthropometric measures (height, weight) were taken in light street clothes without shoes. Baseline psychological variables were assessed via a pre-experimental questionnaire. Participants were led to a darkened video gaming laboratory and fitted with measurement equipment, then rested for 20 minutes. Controller type (traditional gamepad or motion Wiimote motion controller) was assigned randomly, and games were played in random order. Each game was played initially for a three-minute training period. All participants were provided with a visual aid to assist in learning controls, and study staff gave a brief introduction to the basic story and mechanics of the games. Once this period was complete, participants played on their own for 10 minutes. Self-report variables were measured immediately after play of each game by questionnaire.

Games were played on a 58" high-definition television with optimized settings for each console. Participants sat in a gaming chair with speakers in the headrest that provided surround sound. The chair was placed approximately six feet from the television. Snack foods and drinks were available immediately after data collection concluded and water was available during rest periods. This protocol was approved by the University of North Carolina Public Health-Nursing Institutional Review Board.

Games. The three pairs of games used were chosen due to the popularity of their franchises as well as their close similarities to one another, to control for other differences that might affect the hypotheses of interest. All games would be considered part of the broad category of action/adventure games, either as first-person shooters or survival horror, and were rated M for Mature. The games were released between the years of 2002 and 2007.

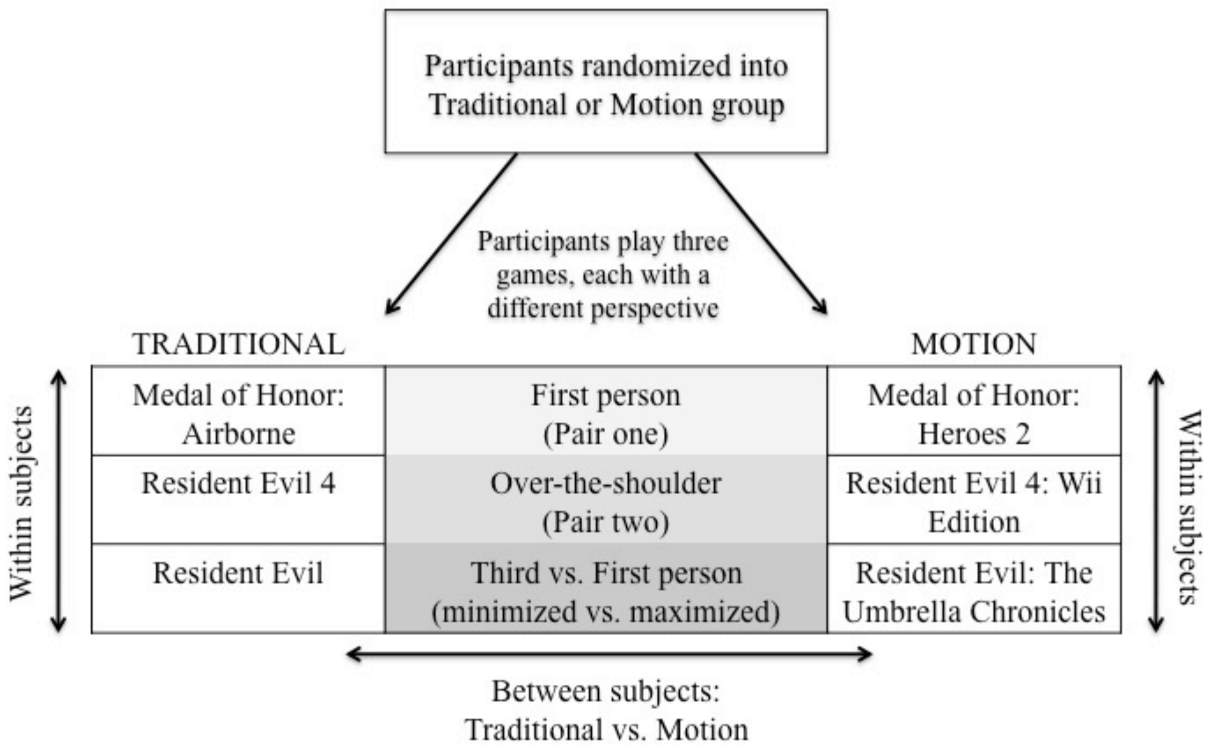
The controllers used for the traditional play condition were the Playstation 3 (PS3) Dualshock controller and the Gamecube controller. Both controllers were of the traditional button-based gamepad type. The motion-sensing controllers used were the Wiimote and Nunchuk combination. The Wiimote, shaped like a remote control, was held in the right hand and used for both button and motion-based inputs. The Nunchuk was held in the left hand and used only for its button-based inputs.

Figure 1 shows the study design. The over-the-shoulder game pair included two versions of the same game, Resident Evil 4, with identical stories and basic gameplay. Instead of seeing only the hands of the player character, as in a typical first-person shooter, the player's view was over the shoulder of their character.

The first person game pair (Medal of Honor: Airborne for PS3 and Medal of Honor: Heroes 2 for Wii) were nearly identical first-person shooters in which players viewed the game environment through the eyes of their character (no visible avatar).

The games in the combination game pair (Resident Evil for Gamecube and Resident Evil: The Umbrella Chronicles for Wii) were chosen to be similar (each told the same story with the same characters and setting) but to differ on both of the variables of interest. Resident Evil was a third person traditionally controlled game, while Resident Evil: The Umbrella Chronicles was a first person motion controlled game. The games are referred to as the "minimized" (Resident Evil) and "maximized" (Resident Evil: The Umbrella Chronicles) presence games. Perspectives and controllers were contrasted in this pair to represent game characteristics accepted in published literature and theory to be more (first person, motion control) or less (third person, traditional control) presence-inducing.

Figure 3.1. Study Design



Measures. Energy expenditure was measured via indirect calorimetry (Ultima CPX, Medgraphics, St. Paul, MN) using a neoprene mask and open pneumotach. The indirect calorimeter was calibrated daily using a 3 liter syringe as well as prior to each test using certified gases. Oxygen consumption (VO_2) and carbon dioxide expiration (VCO_2) were measured on a breath-by-breath basis.

Feelings of presence were measured using the Slater-Usoh-Steed (SUS) scale, with questions slightly altered to refer to video game play rather than virtual reality. The SUS scale is a six-question measure commonly used in the presence literature (Usoh et al., 2000). Questions included "Please rate your sense of being in the game environment" and "to what extent were there times during the experience when the game environment was the reality for you." Responses were averaged to create the presence score (range: 1 – 7).

The enjoyment subscale of the Intrinsic Motivation Inventory was used to measure intrinsic motivation. This measure has been found to be reliable (Markland & Hardy, 1997; McAuley et al., 1989) and has been used in past experiments related to presence and virtual reality (Ijsselsteijn et al., 2006). Participants ranked their agreement with a series of seven statements on a Likert scale of one (not at all true) to seven (very true). Slight changes to wording were made to specifically reference video game playing. Items included "this game was fun to play" and "I thought this game was quite enjoyable." Responses were averaged to create the intrinsic motivation score (range: 1-7).

Weight and height were measured using a calibrated scale (Tanita, Arlington Heights, IL) and wall-mounted stadiometer (Perspective Enterprises, Inc., Kalamazoo, MI).

Data preparation and analysis. Energy expenditure data were collected at every three breaths, then averaged over the ten-minute play period and corrected for body mass (kcal/hr/kg). Cut-points for sedentary behavior and light and moderate physical activity were taken from Pate, O'Neill, and Lobelo (2008). Energy expenditure < 1.5 metabolic equivalents (METs, equivalent to kcal/hr/kg) was considered sedentary, 1.5 - 2.9 METs considered light intensity physical activity, and > 3 METs considered moderate intensity physical activity. A series of mixed models were created, with perspective (game pair) as a repeated measure and controller as independent variable. Degrees of freedom were calculated using the Kenward-

Roger method, and all tests of mean differences took into account row-wise degrees of freedom. Because several studies of energy expenditure during video game play have found effects of BMI and gender (Graves et al., 2007; Unnithan et al., 2006), these variables were included in each model. Interaction terms for perspective x controller were also included in all models. To investigate interactions, simple effect tests and post-hoc contrasts with Tukey-Kramer corrections were used. Where necessary, games were contrasted within pairs and/or with the other games in their controller group (motion or traditional). Independent sample t-tests were also used for simple comparisons between groups. Males, the motion control condition, and the combination game pair were coded as reference groups. The SAS software package (Cary, NC) version 9.2 was used for all analyses.

Results

Table 3.1 displays participant characteristics. The sample was 73% White, 15% Black, 8% Asian, and 4% other race, with a mean age of 23.76 ± 3.96 years old. Six participants were of Hispanic ethnicity. Most participants were college graduates (49%), followed by those with some college education (32%), those with graduate education (13%), and high school graduates (6%). There were no significant differences between groups on any sociodemographic variables. Fifty-five percent of participants were overweight (mean BMI = 27.12 ± 6.52 kg/m^2).

Table 3.1. Participant Characteristics, Mean (SD)

Characteristic	Traditional (*N* = 50)	Motion (*N* = 50)	Total (*N* = 100)
Age	23.78 (4.02)	23.74 (3.95)	23.76 (3.96)
Height (cm)	171.65 (10.76)	173.12 (8.77)	172.38 (9.79)
Weight (kg)	79.44 (20.65)	81.37 (20.74)	80.40 (20.62)
BMI (kg/m^2)	26.82 (6.02)	27.42 (7.04)	27.12 (6.52)
Resting energy expenditure (kcal/hr/kg)	0.76 (0.18)	0.78 (0.17)	0.77 (0.18)

Cm, centimeter; kg, kilogram; m, meter; kcal, kilocalories; hr, hour

Energy expenditure. Means and standard deviations for each outcome are displayed in Table 3.2. For body mass corrected energy expenditure (kcal/hr/kg), no main effect was found for controller ($F(1, 96) = 2.45$, $p = .121$) or perspective ($F(2, 196) = 0.68$, $p = .510$). However, an interaction between perspective and controller was found ($F(2, 196) = 5.63$, $p = .004$). A main effect was found for BMI (β(SE) = -0.01(0.00), $F(1, 96) = 23.25$, $p < .001$) such that participants with a lower BMI expended more energy during play. No main effect was found for gender (β(SE) = -0.01(0.04), $F(1, 96) = 0.21$, $p = .645$). Figure 3.2 shows differences in energy expenditure by perspective and controller.

A difference between controller groups occurred in the combination pair ($F(1, 163) = 8.43$, $p = .004$) such that energy expenditure in the maximized game (0.96 ± 0.20 kcal/hr/kg) was higher than in the minimized game (0.86 ± 0.17 kcal/hr/kg). There were no differences in the over-the-shoulder ($F(1, 163) = 0.00$, $p = .996$) or first person ($F(1, 163) = 1.34$, $p = .245$) pairs.

Significant differences by perspective existed in the motion control condition ($F(2, 196) = 4.70$, $p = .010$) but not in the traditional control condition ($F(2, 196) = 1.60$, $p = .205$). The maximized game from the combination pair (0.96 ± 0.20 kcal/hr/kg) produced significantly higher energy expenditure than the motion-controlled game in the over-the-shoulder pair (0.90 ± 0.18 kcal/hr/kg, $t = 3.06$, $p = .029$). No differences were found between the maximized and first person games (t = 1.41, p = .723) or first person and over-the-shoulder games (t = 1.66, p = .562).

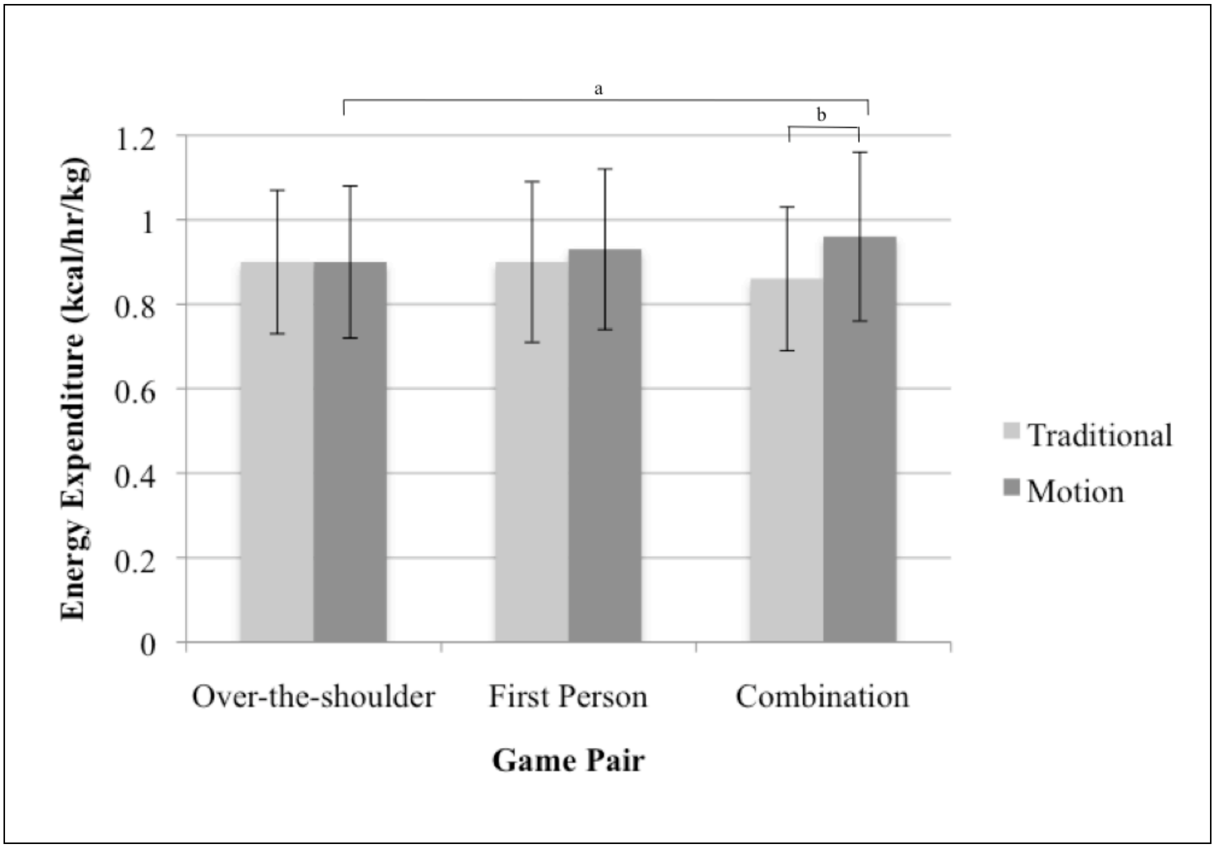
The over-the-shoulder pair increased energy expenditure over rest by 23 and 19 percent in the traditional and motion controlled groups, respectively; the first person pair increased energy expenditure by 22 and 25 percent, and the combination pair increased energy expenditure by 18 and 28 percent.

Table 3.2. Differences in Outcomes by Controller Type and Perspective, Mean (SD)

Outcome	Over-the-Shoulder Pair		First-person Pair		Combination Pair	
	Trad.	Motion	Trad.	Motion	Trad.	Motion
Energy Expenditure (kcal/hr/kg)	0.90 (0.17)	0.90^{b} (0.18)	0.90 (0.19)	0.93 (0.19)	0.86^{a} (0.17)	$0.96^{a, b}$ (0.20)
Presence	$3.92^{a, b}$ (1.56)	3.30^{a} (1.34)	3.77^{b} (1.48)	3.34 (1.41)	$2.68^{a, b}$ (1.34)	3.30^{a} (1.20)
Intrinsic Motivation	4.29^{b} (1.38)	4.08 (1.61)	4.48^{b} (1.74)	4.15 (1.74)	$2.97^{a, b}$ (1.40)	4.38^{a} (1.40)

Trad, traditional; kcal, kilocalories; hr, hour; kg, kilogram
[a]Significant differences between two games in game pair
[b]Significant differences across games in controller group

Figure 3.2. Energy Expenditure in Traditional and Motion Control Groups by Game Pair



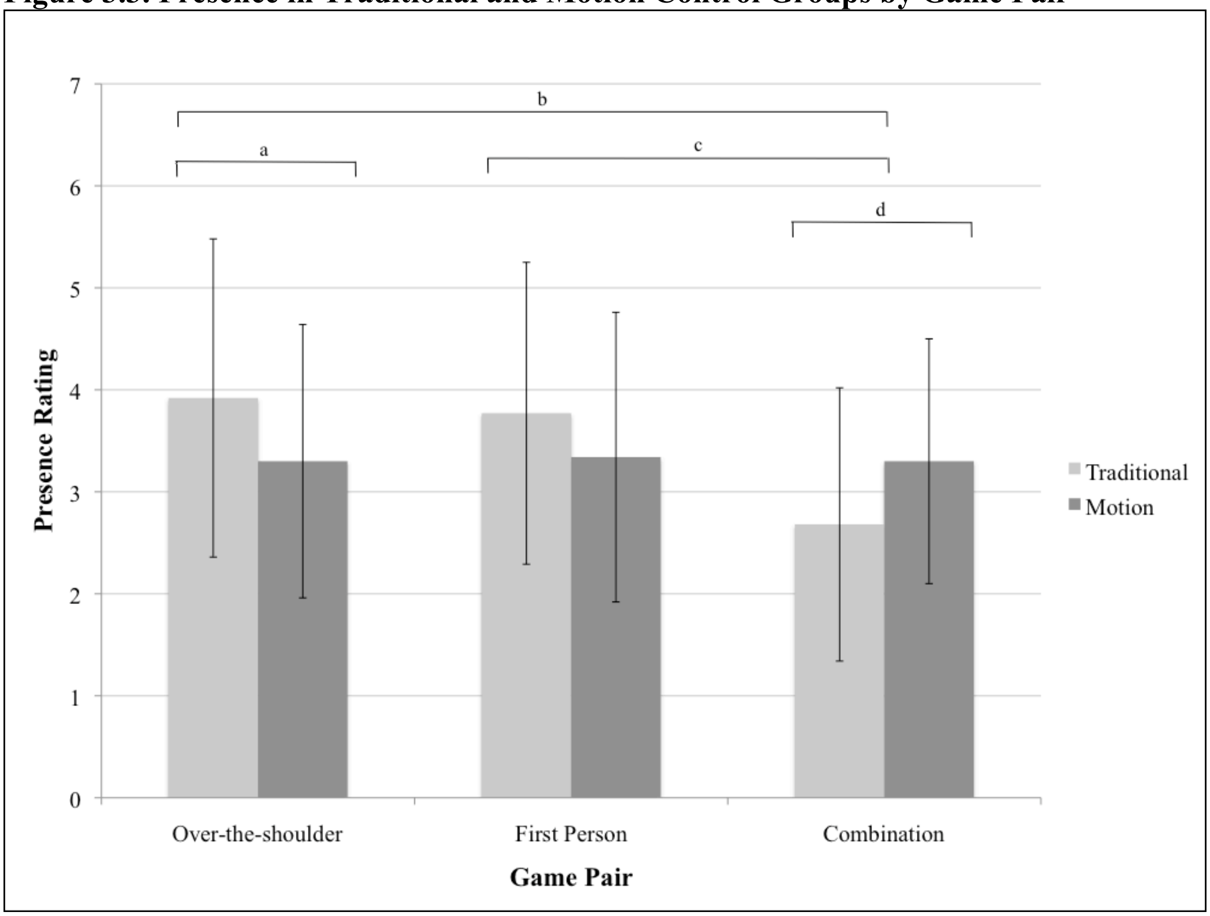
[a]Differences between maximized game and over-the-shoulder motion control game, $p = .029$
[b]Differences in combination pair, $p = .004$

Presence. For presence, there was a main effect of perspective ($F(2, 196) = 15.48$, $p < .001$) but not of controller ($F(1, 96) = 0.40$, $p = .528$). An interaction between perspective and controller was found ($F(2, 196) = 14.50$, $p < .001$). The effect of gender approached significance (β(SE) = -0.46, $F(1, 96) = 3.76$, $p = .056$). BMI had no significant main effect (β(SE) = 0.01(0.02), $F(1, 96) = 0.53$, $p = .470$).

There was a difference between the two controller groups in the over-the-shoulder perspective ($F(1, 167) = 5.15$, $p = .024$) and combination ($F(1, 167) = 4.84$, $p = .029$) pairs. In the over-the-shoulder pair, the traditionally controlled version received higher presence scores than the motion controlled version. In the combination pair, the maximized game received higher presence scores than the minimized game.

Differences by perspective were found in the traditionally controlled group ($F(2, 196) = 29.93$, $p < .001$) but not in the motion controlled group ($F(2, 196) = 0.04$, $p = .963$). The over-the-shoulder (3.92 ± 1.56) and first person (3.77 ± 1.48) perspective traditionally controlled games received higher presence scores than the minimized game from the combination group (2.68 ± 1.34, $t = 7.10$, $p < .001$ and $t = 6.21$, $p < .001$). There was no difference between over-the-shoulder and first person perspective ($t = -0.90$, $p = .947$).

Figure 3.3. Presence in Traditional and Motion Control Groups by Game Pair



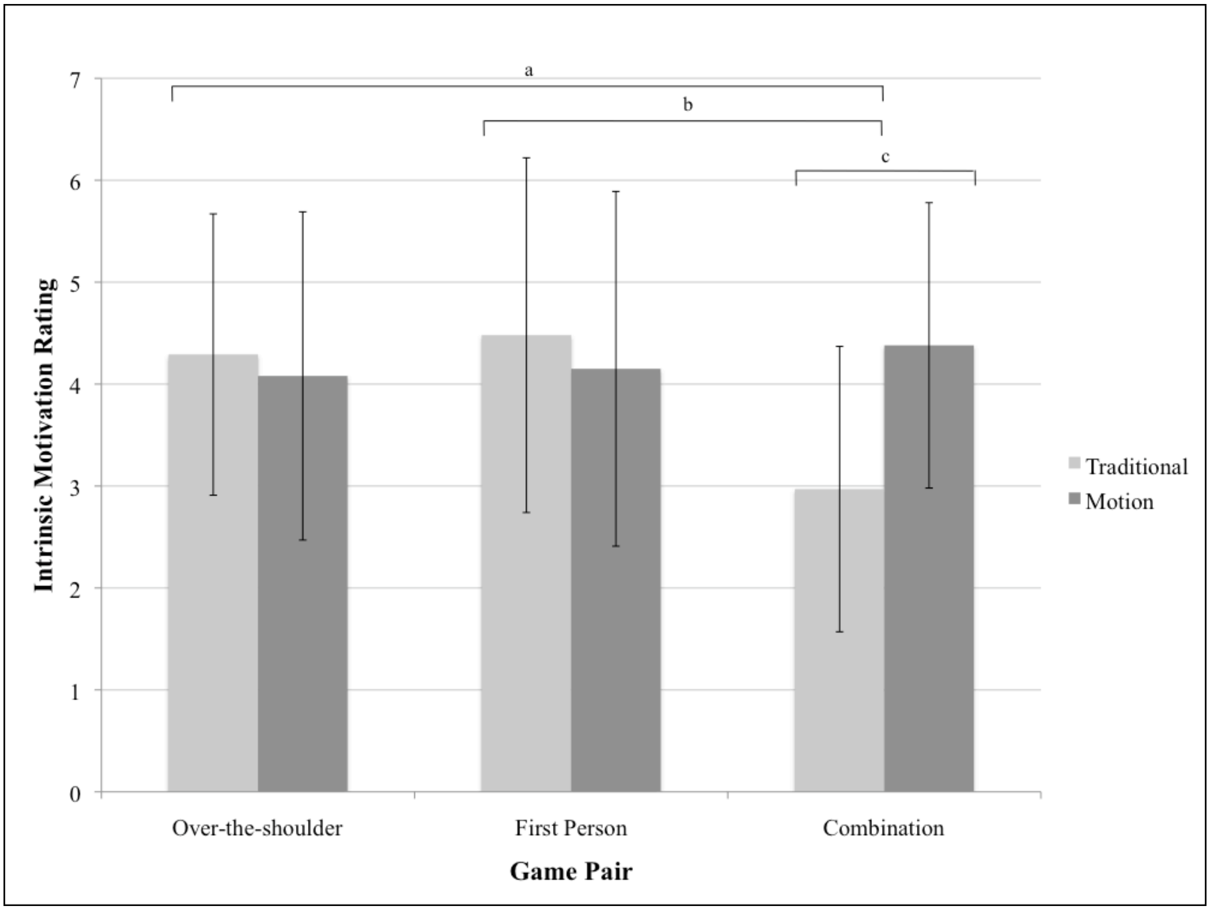
[a]Differences in over-the-shoulder pair, $p = .024$
[c]Differences between minimal game and traditional over-the-shoulder game, $p < .001$
[d]Differences between minimal game and traditional first person game, $p < .001$
[d]Differences in combination pair, $p = .029$

Intrinsic motivation. For intrinsic motivation, a main effect was found for perspective ($F(2, 196) = 7.68$, $p < .001$) but not controller ($F(1, 96) = 1.83$, $p = .180$), and the interaction between the two was significant ($F(2, 196) = 15.89$, $p < .001$). There was a main effect of gender ($\beta(SE) = -1.19(0.20)$, $F(1, 96) = 35.29$, $p < .001$) as well as of BMI ($\beta(SE) = 0.03(0.02)$, $F(1, 96) = 5.00$, $p = .028$). Males and participants with higher BMI had higher motivation scores than females and lower BMI participants. Figure 3.4 shows differences in motivation by perspective and controller.

A difference in controller group was found in the combination pair such that the maximized game (4.38 ± 1.40) produced significantly higher motivation than the minimized game (2.97 ± 1.40; $F(1, 256) = 24.24$, $p < .001$). Games in the over-the-shoulder and first person pairs did not differ ($F(1, 256) = .068$, $p = .412$ and $F(1, 256) = 1.48$, $p = .228$).

Differences in perspective existed in the traditional control group ($F(2, 196) = 22.73$, $p < .001$) but not in the motion control group ($F(2, 196) = 0.84$, $p = .435$). The minimized game (2.97 ± 1.40) was found to be less motivating than both the traditionally controlled over-the-shoulder (4.29 ± 1.38, $t = -5.41$, $p < .001$) and first person (4.48 ± 1.74, $t = -6.17$, $p < .001$) games.

Figure 3.4. Intrinsic Motivation in Traditional and Motion Control Groups by Game Pair



[a]Difference between minimized game and traditional over-the-shoulder game, $p < .001$
[b]Difference between minimized game and traditional first person game, $p < .001$
[c]Differences in combination pair, $p < .001$

Discussion

Contrary to our hypothesis, play of shooter games with motion-sensing controllers did not produce greater energy expenditure than play of similar games with traditional gamepad controllers. Only the motion controlled game that was chosen to optimize presence-inducing aspects produced significantly greater energy expenditure than its comparison game; however, it also produced significantly greater energy expenditure than the over-the-shoulder motion controlled game. Clearly, variables other than simple differences in controllers influence energy expended during video game play.

The hypothesis that energy expenditure differences in the third pair, which contrasted both perspective and controller, would be larger than in the other two pairs was accepted; a significant difference was found in this pair where no difference was found in the others. It was predicted that the maximized game would produce greater energy expenditure than the minimized game due to differences in presence, which has been found to be associated with energy expenditure (Ijsselsteijn et al., 2006), but this does not appear to have been the case. Though both energy expenditure and presence were higher in the maximized game than in the minimized game, energy expenditure was also higher in the maximized game than in the motion controlled over-the-shoulder game. Presence levels between these two games, however, did not differ. It is unlikely that presence or motivation were the primary causes of the energy expenditure differences found. However, it is also possible that the presence measure used was insufficiently precise, missing differences that truly existed.

The traditional and motion controlled games studied here produced average energy expenditures of 0.89 and 0.93 kcal/hr/kg, respectively, representing increases of 22 and 25 percent over rest measurements. Previous studies have found that use of the Wiimote motion-sensing controller can produce light (1.5 - 3 METs; note that METs are equivalent to kcal/hr/kg) to moderate (> 3 METs) intensity physical activity in fitness and sports-themed games increasing energy expenditure over rest up to 328% (Graf et al., 2009; Graves et al., 2007). The motion controlled shooter games studied here more closely resembled published estimates from traditional sedentary (< 1.5 METs) games (Borusiak et al., 2008; Lanningham-Foster et al., 2006).

These results suggest that the addition of motion control to traditional games, such as shooter games or other action/adventure games, is not sufficient to produce light or moderate intensity physical activity and will only sometimes produce an improvement in activity intensity as compared to traditional controllers. They do, however, represent approximately 15% greater energy expenditure than would be expended while watching TV (Lanningham-Foster et al., 2009; Lanningham-Foster et al., 2006). Even such a small increase may, when combined with other small changes in lifestyle, contribute to energy balance. It has been estimated that the average daily energy surplus is 100 kilocalories (Hill, Wyatt, Reed, & Peters, 2003); replacement of TV watching (at an average of 3 hours per day) with motion controlled video game play could burn an additional 30 calories per day in an 80kg individual.

A possible reason for the differences between other Wii games and those studied here may be that only some types of games tend to produce clinically significant energy expenditure increases. It is likely that the maximized game either required or encouraged more movement as part of its gameplay than the motion-controlled over-the-shoulder game or minimized game. Though the overall motions necessary to play were very similar across the motion-controlled games (waggle the Wiimote to reload a weapon, point to aim, slice with the arm to use a knife), the pace of the game or speed with which motions were necessary may have differed. Having enemies appear on screen in quicker succession could lead to a greater speed of aiming, which would create greater energy expenditure.

Previous studies have found equivocal effects of body mass on energy expenditure during video game play. In one study, significant differences between lean and overweight players were found in absolute estimates, but differences disappeared when those estimates were corrected for body mass (Unnithan et al., 2006). In another study, overweight children expended less energy during play of a sedentary video game than lean children, but their increase in energy expenditure over rest was not significantly different from increases in lean children (Lanningham-Foster et al., 2006). Here, BMI was found to negatively predict body mass adjusted estimates of energy expenditure regardless of controller or game. Gender, which has also produced equivocal results (Graves et al., 2007; Maddison et al., 2007; Straker & Abbott, 2007), was not found to be a significant predictor of energy expenditure. There was a trend towards an effect of gender on presence, with males reporting higher levels of presence than females. Both BMI and gender predicted intrinsic motivation. Males and participants with a higher BMI rated the games as more motivating than females and lighter participants. Future laboratory and intervention studies should be powered to include tests of moderation, as personal characteristics may influence outcomes.

The minimized game received lower scores on presence and intrinsic motivation than its comparator, as predicted; surprisingly, this game was also rated lower than the other two traditionally controlled games. Though careful consideration was given to games selected for inclusion in this study in order to ensure similarity, unanticipated differences may have made this game less appealing than the other two traditionally controlled games. Perceptions of control over the game and competence are associated with motivation (Ryan et al., 2006); it may be that the minimized game was found to be more difficult or complicated than the others. This game was chosen to minimize presence reactions based on the two characteristics of interest here (perspective and control type), but it was not expected to be so dissimilar from the other traditionally controlled games. The game, Resident Evil (2002 Gamecube edition), has received extremely high critical scores. Though critical reception was positive (for an example, see http://cube.ign.com/articles/358/358101p1.html), characteristics valued by video game reviewers may differ from those valued by participants in this study.

Video games are often very different from one another and can produce different reactions. These reactions may be related to personal preferences, demographic characteristics of the player (such as gender (Tan et al., 2002) and skill level (Sell et al., 2008), for example), or a number of other factors that have yet to be studied. The six games used here are much more similar on more characteristics than games previously studied in the health literature; and yet, one game was found to be quite different from the others in its ability to produce feelings of presence and intrinsic motivation. The differences found in this study across games very similar to one another suggest a need for more laboratory and formative research, to better understand how and why particular characteristics of games and players influence reactions to game play.

Strengths and limitations. This study is the first to our knowledge that has compared energy expenditure in different types of traditional shooter games. These games are very popular, and thus efforts to make their play less sedentary could have a broad public health impact. Previous studies have compared use of motion control in explicitly fitness or sports-oriented games (i.e., games designed to be physically active) to traditional games but have yet to investigate the effects of motion control across the same type of game.

There were, however, several limitations of the study design and measures. In the first person and combination pairs, the contrasted games were similar and from the same franchise but were not two versions of the exact same game. Thus, though control scheme is largely the only difference, other game play features may have also differed. Similarly, though the pairs of games were very similar in setting, violence level, and gameplay, other less obvious factors in addition to perspective likely differed and may have affected results.

The gold standard of energy expenditure measurement, indirect calorimetry, was used in this study, but it is possible that the machine used underestimated energy expenditure slightly. The Ultima CPX has been found to be more reliable at higher activity intensity levels than at rest or sedentary levels (Cooper et al., 2009). Both resting and traditional game play estimates reported here are very similar to those found in the literature, however (Lanningham-Foster et al., 2009); it is unlikely that measurement with another device would have produced substantially different results.

Conclusion. Motion controlled games hold potential to significantly increase energy expenditure during screen time as compared to similar traditionally controlled games. However, results of this study suggest that most likely do not. This study demonstrated that differences in game characteristics as well as player characteristics, such as gender and BMI, affect responses to video games. How motion control is integrated into game play likely plays a role in determining energy expended during play and possibly levels of presence and intrinsic motivation as well. More research into motion control implementation and differences across games is needed to investigate methods of encouraging more physically active video game play.

CHAPTER 4

MOTIVATION AND ENERGY EXPENDITURE DURING VIDEO GAME PLAY IN YOUNG ADULTS: DIFFERENCES IN SHOOTER, MUSIC-BASED, AND FITNESS GAMES

Abstract

Context. Play of physically active video games may be a way to increase physical activity and/or decrease sedentary behavior, but variability of activity level across game type and sustainability are concerns. Active games may differ from traditional video games in several respects, which may affect how often these games are played and the intensity of physical activity produced.

Objective. To investigate differences in presence (the sense of being in the game environment), motivation, and energy expenditure across four game types: shooter (played with traditional controllers), band simulation (guitar or drum controller), dance simulation (dance mat controller), and fitness (balance board controller).

Design. Within-subjects laboratory study

Setting. University weight research laboratory

Participants. 100 young adults (50 females) <300 pounds with at least minimal video game experience

Main outcome measures. Energy expenditure, presence, and intrinsic motivation

Results. All games except the shooter games significantly increased energy expenditure over rest ($p < .001$). Fitness and dance games increased energy expenditure by 322 (3.10 ± 0.89 METs) and 298 (2.91 ± 0.87 METs) percent. Energy expenditure in these games was greater than that produced by band simulation (73%, 1.28 ± .28 METs) and shooter games (23%, 0.91 ± 0.16 METs). However, motivation was higher in band simulation games than in the other game types ($p < .001$). Differences in energy expenditure were found between normal and overweight participants and in motivation by gender.

Conclusions. Energy expenditure, presence, and motivation differ across game types. Play of non-traditional video games may represent a more active alternative to sedentary screen time, but the games that are most active may not be those most likely to be played. Player and game characteristics can affect activity intensity and game enjoyment. Further research measuring both physiological and psychological reactions is needed to determine the sustainability of activity promotion through video games.

Background

Screen time, or time spent in front of a television or computer screen, is a prevalent sedentary behavior; American adults spend more time watching television (2-3 hours per day) than any other activity besides working or sleeping (U.S. Department of Labor, 2009). Sedentary screen time is associated with obesity (Hamilton et al., 2007; Hu et al., 2003; Sugiyama, Healy, Dunstan, Salmon, & Owen, 2008) as well as a number of negative health outcomes (Mark & Janssen, 2008; Martinez-Gomez, Tucker, Heelan, Welk, & Eisenmann, 2009) independently of physical activity levels (Healy, Dunstan, Salmon, Shaw et al., 2008; Vandelanotte, Sugiyama, Gardiner, & Owen, 2009).

One strategy for decreasing sedentary behavior may be to increase the energy expended during screen time through play of active video games. The term active video game or exergame has been used to describe games in which body movement is necessary or encouraged by the game's control scheme (as opposed to traditional gameplay in which only fingers are used to interact with the game). Typically, active games use a dedicated peripheral controller rather than a traditional gamepad style controller. These controllers may take the form of mats, boards, motion-sensing cameras, or hand-held motion sensing devices.

Laboratory studies of active games have found significant energy expenditure increases over rest. Most games studied produced moderate-intensity activity (Graf et al., 2009; Lanningham-Foster et al., 2006; Maddison et al., 2007), though some active games produced light (Graves et al., 2007) or vigorous levels (Sell et al., 2008). Dance simulation and sports/fitness themed games that used dedicated controllers produced the highest intensity activity. Play of active video games appears to be able to consistently produce moderate-vigorous physical activity; however, published studies thus far have been hampered by methodological limitations. Nearly all have used small sample sizes ($N < 25$) of mostly male youths comparing a small number of games. Energy expenditure estimates have ranged widely even in nearly identical games; for example, estimates range between 3.5 and 7.2 metabolic equivalents (METs) for dance simulation games (Lanningham-Foster et al., 2006; Maddison et al., 2007; Sell et al., 2008; Tan et al., 2002; Unnithan et al., 2006). Motivational reactions have rarely been measured and have not been used to compare active to traditional games.

Most of the above research was performed in children, but active gaming is particularly attractive for implementation in young adult populations. Approximately 75% of gamers are adults, most (49%) between 18 and 49 years old (Entertainment Software Association, 2009). As individuals move from adolescence to adulthood, their physical activity declines while sedentary behavior stays the same (Gordon-Larsen et al., 2004). Young adults (18-35) experience a large weight gain during this period, averaging 1 to 2 pounds per year (Truesdale et al., 2006), or 30 lbs by age 35. It has been estimated that even small changes in energy balance of approximately 100 calories per day could prevent weight gain (Hill et al., 2003); supplanting some sedentary time with more active pursuits might be one of several strategies for maintaining healthy weight in this age group.

Though active gaming holds promise for intervention in this population, it is not without potential problems. It is unclear whether game-based activity is more sustainable than more typical forms of activity, as has been hypothesized. In order to replace a sedentary behavior with a more active alternative, the alternative must be equally or more reinforcing than the original behavior (Epstein et al., 2004). Active gaming will be successful in increasing activity only if active games are reinforcing enough to be played regularly over time. Additionally, if these games are to serve as a healthier alternative to sedentary screen time, they must be reinforcing enough to be chosen over sedentary gaming or TV watching. There is preliminary evidence that in interventions using active in-home gaming, participation and play decline over time, perhaps due to a loss of interest (Chin A Paw et al., 2008; Madsen et al., 2007). There is also evidence that gaming during exercise may be more motivating than exercise without gaming (Plante et al., 2003), but differences between active and sedentary games are not yet known.

According to Self-Determination Theory, intrinsic motivation, or the desire to perform an action for its own sake rather than for external rewards, is a more powerful predictor of behavior than extrinsic motivation (Ryan & Deci, 2000b). In video gaming, feelings of presence, or the feeling of being in a virtual environment without actively noticing that it is technologically mediated, predict intrinsic motivation to play a game, which in turn predicts future play (Ryan et al., 2006). Both presence and intrinsic motivation have been found to predict activity intensity during a virtual reality exercise task (Ijsselsteijn et al., 2006).

Presence is, in essence, distraction from the real world, and distraction has long been used to improve adherence to physical activity. Use of virtual reality and video game distraction has been found to decrease perception of pain (Gold, Belmont, & Thomas, 2007; Raudenbush, Koon, Cessna, & McCombs, 2009) and increase adherence to exercise (Warburton et al., 2007), intensity of exercise (Warburton et al., 2009), and mood benefits of exercise (Plante et al., 2003). Particularly in sedentary and overweight individuals, for whom exercise is more painful than for active, normal weight individuals, distraction from discomfort during PA is important for encouraging adherence (Ekkekakis & Lind, 2006).

It is possible that some active games may produce higher levels of presence and motivation than sedentary games. Use of full-body movement in a dance game has been found to be more reinforcing than play of the same game with a traditional gamepad controller (Epstein et al., 2007), and body movement has been found to increase feelings of engagement, which is a sub-type of presence (Bianchi-Berthouze et al., 2007; Lindley et al., 2008). It may be that some active games more effectively increase presence than others due to differences in the movements required to play or in other game characteristics.

The purpose of this study was to investigate physiological and psychological reactions to a variety of popular video game genres that represent a range of hypothesized activity levels. Traditional shooter games, instrument-based band simulation games, dance simulation games, and fitness games were compared to determine whether differences exist in presence, motivation, and/or energy expended during play. It was hypothesized that the band simulation games would produce relatively higher levels of presence and motivation but lower levels of energy expenditure, while the dance simulation and fitness games would produce the opposite pattern.

Methods

Sample. One-hundred 18-35 year old participants, equal numbers male and female, were recruited using a University online mailing list and television advertisements. To be included, participants were required to weigh <300 pounds (a requirement for the Wii Fit balance board), to have played video games at least 3 times over the past year, to have adequate transportation to the study site, and to be willing to be videotaped and to fast at least 2.5 hours prior to their appointment. Of 757 individuals who requested information and eligibility criteria, 325 completed eligibility information; of those 325, 169 potential participants were scheduled, and 100 completed the protocol. Eligible participants who did not attend their appointments (N=49) were considered drop-outs, and 156 eligible participants were wait-listed. This study was powered to detect differences of 0.72 METs (kcal/hr/kg) in energy expenditure and 0.43 in individual presence items (on a Likert scale of 1-7) (Eastin, 2006; Eastin & Griffiths, 2006; Wang & Perry, 2006).

Games and Procedure. The study was conducted in a dedicated lab in a University-owned office building between April and August of 2009. The room included a 58" high definition television, game chair with surround sound speakers, and measurement equipment. Participants provided written informed consent, and anthropometric (height, weight) and questionnaire measures were taken. The mask for indirect calorimetry was then fitted, adjusted, and tested as needed prior to a 20 minute rest period. Games were played in randomized order for 13 minutes each, with the first three minutes considered a training period. During the training period, the study coordinator provided verbal game instructions as well as a visual aid showing controller functions. Psychological variables were measured by questionnaire at the conclusion of each game. Participants rested 5-10 minutes between games to allow heart rates to return to within a standard deviation of baseline levels (approximately 10-15 beats/minute). During rest periods, masks were removed and water was provided. The protocol lasted approximately four hours per participant and was approved by the University of North Carolina at Chapel Hill Public Health-Nursing Institutional Review Board.

Games were chosen purposefully to represent the most popular game genres and franchises as well as the most common controllers and most popular consoles. Each participant played three shooter games using a traditional gamepad controller (50 participants) or Wiimote (50 participants). Participants either played Medal of Honor: Airborne, Resident Evil 4, and Resident Evil (gamepad) or Medal of Honor: Heroes 2, Resident Evil: Wii Edition, and Resident Evil: The Umbrella Chronicles (Wiimote). All shooter games were played on a Sony Playstation 3 or Nintendo Wii console.

Participants also played four games with specific dedicated controllers. The two band simulation games were Guitar Hero III: Legends of Rock and Rock Band 2. For Guitar Hero, participants played along with on-screen prompts on a plastic guitar. The guitar was played by pressing colored fret buttons and strumming a bar meant to mimic the feel of strumming guitar strings. For Rock Band, participants used drum sticks to hit four colored drum pads on a drum set controller. The dance simulation game was Dance Dance Revolution: Universe 2. Participants stepped on up, down, left, or right arrows on a mat controller as prompted by arrows appearing on the screen. All three music games were played on a Microsoft Xbox 360 console. For each music game, all participants played the same song on the same (easiest) difficulty level before moving on to choose their preferred songs and difficulty.

The fitness game used was Wii Fit, played on a Nintendo Wii console using Wiimote and Balance Board controllers. The Wiimote included an accelerometer and used player movement as a game input. Players stood on the Balance Board, which measured shifts in their weight distribution as game inputs. Wii Fit is made up of different types of minigames. Pilot testing showed that minigame categories (aerobic, balance, yoga, and strength) differed in activity intensity. To represent the widest range of possible activities within the game, participants were randomized to play two minigames (one balance, one aerobic) out of four possibilities. Half of the sample played the jogging and penguin slide minigames, and half played the hula hoop and skiing minigames.

Measurement. Energy expenditure was measured via indirect calorimetry (Ultima CPX, Medgraphics, St. Paul, MN) using a neoprene mask and open pneumotach. The calorimeter was calibrated daily using a 3 liter syringe as well as prior to each test using certified gases. The umbilical hose connecting participants and the metabolic cart was routed behind each participant's body and was sufficiently long to allow movements required for each game. Height and weight were measured in light street clothes without shoes, using a wall-mounted stadiometer (Perspective Enterprises, Inc., Kalamazoo, MI) and calibrated scale (Tanita, Arlington Heights, IL).

Feelings of presence were measured using the Slater-Usoh-Steed (SUS) scale, with questions slightly altered to refer to video game play rather than virtual reality (Usoh et al., 2000). Questions included “Please rate your sense of being in the game environment” and “to what extent were there times during the experience when the game environment was the reality for you.” Responses were averaged to create the presence score (range: 1 – 7).

The enjoyment subscale of the Intrinsic Motivation Inventory was used to measure motivation (McAuley et al., 1989). Participants ranked their agreement with each statement on a Likert scale of one (not at all true) to seven (very true). Slight changes to wording were made to specifically reference video game playing. Items included “this game was fun to play” and “I thought this game was quite enjoyable.” Responses were averaged to create the intrinsic motivation score (range: 1 - 7).

Data analysis. Energy expenditure estimates were averaged over the last 10 minutes of play (excluding the initial three-minute training). Resting energy expenditure was taken from the final five minutes of the 20-minute rest period. Estimates for the three shooter games were averaged for each variable to create composite shooter game scores. Similarly, estimates for the two band simulation games were also averaged into composite variables. For Wii Fit, the balance and aerobic minigames were averaged. Energy expenditure (METs, equivalent to kcal/hr/kg) during each game play period was divided by energy expenditure during rest to create percent increase estimates. Definitions and cut-points for sedentary and light, moderate, and vigorous intensity activity were taken from Pate, O'Neill, and Lobelo (2008).

To investigate differences across game types, three mixed models were created using motivation, presence, and energy expenditure as dependent variables and game type as the repeated measure. Degrees of freedom were calculated using the Kenward-Roger method, and all tests of mean differences took into account row-wise degrees of freedom. Because several studies of energy expenditure during video game play have found differences by gender and weight status (lean or overweight) (Graves et al., 2007; Unnithan et al., 2006), these variables as well as interaction terms were also included. Non-significant interactions were removed from final models. For the energy expenditure analysis, five levels of the game variable were included (rest, shooter, band simulation, dance simulation, fitness game). For all others, only the four game types were included. To investigate interactions, simple effect tests were used to determine whether significant differences in one variable existed at levels of another. Where more specific comparisons were necessary, contrasts with Tukey-Kramer corrections were used. Females, non-overweight participants, and resting rates were coded as reference groups (in analyses not including rest, shooter games were the reference group). All analyses were performed using SAS statistical software version 9.2 (SAS, Cary, NC).

Results

Table 4.1 displays participant characteristics. Participants were 23.76 ± 3.96 years old, with a mean height of 172.03 ± 10.26 cm and weight of 80.40 ± 20.62 kg. The mean BMI was 27.12 ± 6.52 kg/m^2. Mean resting energy expenditure for the sample was 0.77 ± 0.18 kcal/hr/kg. Males and females differed significantly in height and weight, but not in

BMI or any other personal characteristics. Seventy-three percent of participants were white, 15% black, 8% Asian, and 4% other. Six percent were of Hispanic ethnicity. Most were college graduates (49%) or had some college education (32%). A slight majority (55%) were overweight.

Table 4.1. Participant Characteristics

Characteristic	Male			Female			Total
	Over (*N* = 30)	Non-Over (*N* = 20)	All Male (*N* = 50)	Over (*N* = 25)	Non-Over (*N* = 25)	All Female (*N* = 50)	
Age	25.00 (4.90)	22.75 (2.69)	23.96 (4.25)	25.00 (3.99)	22.12 (2.74)	23.56 (3.69)	23.76 (3.96)
Weight (kg)	96.57 (16.11)	73.66 (8.77)	87.40[a] (17.66)	87.46 (21.43)	59.35 (6.42)	73.40[a] (21.13)	80.40 (20.62)
Height (cm)	179.47 (7.38)	179.52 (6.74)	179.49[a] (7.06)	165.67 (7.32)	164.88 (5.37)	165.27[a] (6.37)	172.03 (10.26)
BMI (kg/m^2)	30.55 (5.60)	22.81 (1.87)	27.45 (5.88)	31.76 (7.05)	21.80 (1.73)	26.78 (7.15)	27.12 (6.52)

Over, overweight; non-over, non-overweight; [a]Gender differences, $P<.05$

Energy Expenditure. Means and standard deviations for energy expenditure are displayed in Table 4.2. There was a main effect of game type ($F(4, 392) = 509.31$, $p < .001$) and weight status ($F(1, 97) = 17.36$, $p < .001$) and an interaction between game and weight status ($F(4, 392) = 2.97$, $p = .019$) such that non-overweight participants expended more energy than overweight (BMI ≥ 25) participants in some games. Differences in games existed in both non-overweight ($F(4, 392) = 270.92$, $p < .001$) and overweight ($F(4, 392) = 238.79$, $p < .001$) participants. Gender was not a significant predictor of energy expenditure ($F(1, 97) = 1.64$, $p = .204$). Other interactions were found to be non-significant, and were dropped from the final model (game x gender, $F(4, 384) = 0.43$, $p = .788$; game x gender x overweight, $F(5, 371) = 0.95$, $p = .448$).

Shooter games produced the lowest levels of energy expenditure (0.91 ± 0.16 METs), which did not differ significantly from resting rates (0.77 ± 0.18 METs; $t = 2.01$, $p = .261$). Band simulation games (1.28 ± 0.28 METs) were significantly higher than both shooters ($t = 5.29$, $p < .001$) and rest ($t = 7.31$, $p < .001$). Dance simulation (2.91 ± 0.87 METs) and fitness games (3.10 ± 0.89 METs) produced significantly greater amounts of energy expenditure than the other games (dance vs. rest, $t = 30.52$; dance vs. shooter, $t = 28.50$; dance vs. band, $t = 23.21$; fitness vs. rest, $t = 33.05$; fitness vs. shooter, $t = 31.04$; fitness vs. band, $t = 25.74$; all $p < .001$), and there was a trend towards higher energy expenditure in the fitness game (t = 2.54, $p = .086$). Non-overweight participants expended more energy than overweight participants during the dance simulation game ($F(1, 414) = 22.43$, $p < .001$) and fitness games ($F(1, 414) = 12.39$, $p < .001$). No significant differences by weight status were found for the other games (rest, $F(1, 414) = 2.03$, $p = .156$; shooter, $F(1, 414) = 1.56$, $p = .213$; band simulation, $F(1, 414) = 2.92$, $p = .088$). Figure 4.1 displays the differences in energy expenditure across games by weight status.

Table 4.2. Energy Expenditure Outcomes by Game Type, Gender, and Weight Status, Mean (SD)

	Male			Female			Totals		
	Over (*N* = 30)	Non-Over (*N* = 20)	Total (*N* = 50)	Over (*N* = 25)	Non-Over (*N* = 25)	Total (*N* = 50)	Over (*N* = 55)	Non-over (*N* = 45)	Overall (*N* = 100)
Energy Expenditure (METs)									
Rest	0.72 (0.79)	0.89 (0.15)	0.79 (0.18)	0.67 (0.14)	0.83 (0.16)	0.74 (0.17)	0.70 (0.16)	0.86 (0.16)	0.77 (0.18)
Shooter	0.86 (0.15)	0.96 (0.14)	0.91 (0.16)	0.84 (0.15)	1.00 (0.16)	0.92 (0.17)	0.85 (0.15)	0.98 (0.16)	0.91 (0.16)
Band	1.29 (0.29)	1.45 (0.23)	1.35 (0.28)	1.08 (0.19)	1.34 (0.26)	1.21 (0.26)	1.20 (0.27)	1.39 (0.25)	1.28[a, b] (0.28)
Dance	2.69 (0.86)	3.31 (1.22)	2.93 (1.05)	2.72 (0.65)	3.05 (0.63)	2.88 (0.65)	2.70[d] (0.76)	3.17[d] (0.93)	2.91[a, b, c] (0.87)
Fitness	3.01 (0.97)	3.35 (1.13)	3.15 (1.04)	2.82 (0.62)	3.28 (0.73)	3.05 (0.71)	2.92[d] (0.83)	3.31[d] (0.92)	3.10[a, b, c] (0.89)

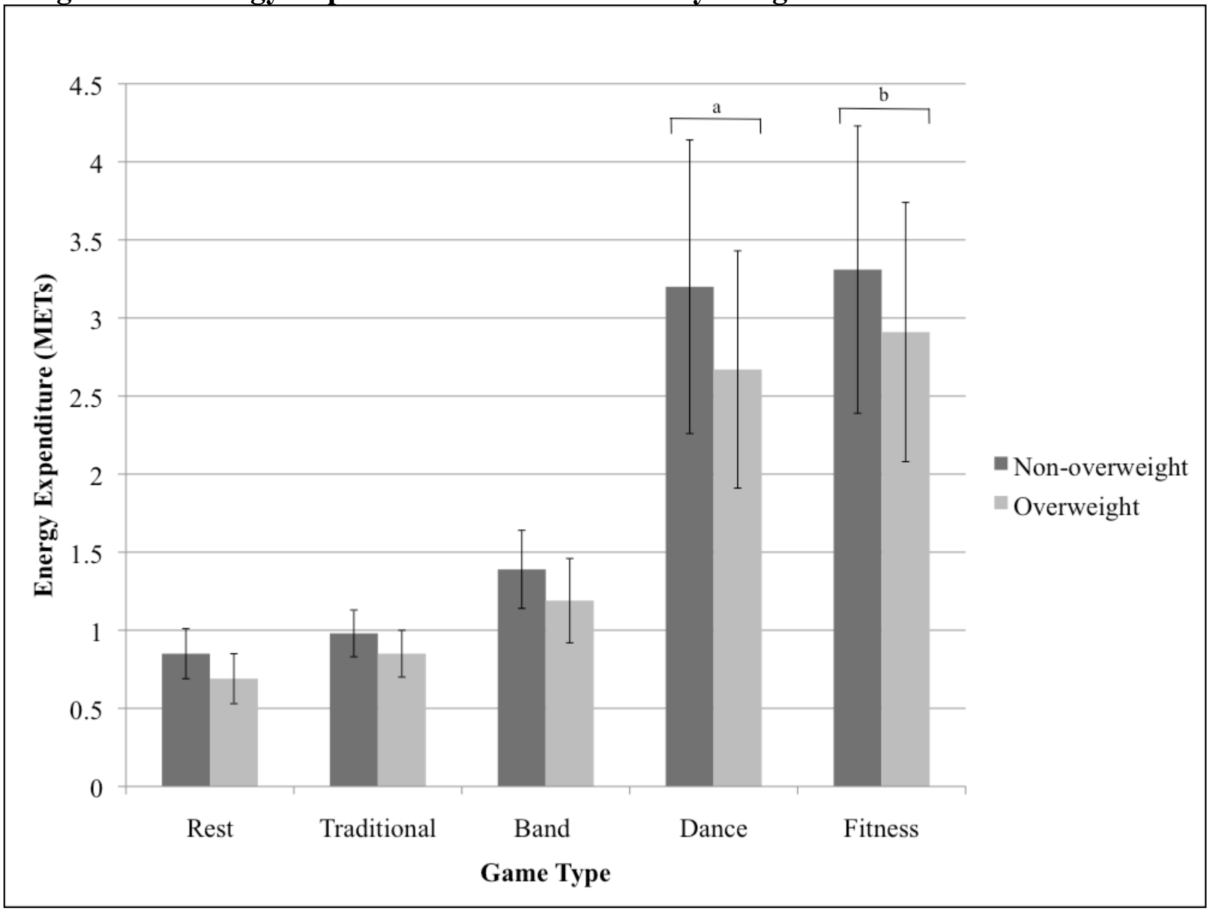
Kcal, Kilocalories; Hr, hour; Kg, kilogram; Over, overweight; Non-over, non-overweight; [a]Significantly higher than rest; [b]Significantly higher than shooters; [c]Significantly higher than band simulation; [d]Difference by weight status

Table 4.3 Presence and Intrinsic Motivation Outcomes by Game Type, Gender, and Weight Status, Mean (SD)

	Male			Female			Totals		
	Over ($N = 30$)	Non-Over ($N = 20$)	Total ($N = 50$)	Over ($N = 25$)	Non-Over ($N = 25$)	Total ($N = 50$)	Over ($N = 55$)	Non-Over ($N = 45$)	Overall ($N = 100$)
Presence									
Shooter	3.75 (1.27)	3.42 (1.20)	3.62 (1.24)	3.27 (1.34)	3.03 (0.84)	3.15 (1.11)	3.54 (1.31)	3.20 (1.02)	3.39[c] (1.20)
Band	3.00 (1.39)	3.25 (1.54)	3.09 (1.44)	3.16 (1.47)	2.86 (1.16)	3.01 (1.32)	3.07 (1.42)	3.03 (1.34)	3.05[c] (1.38)
Dance	2.42 (1.49)	2.73 (1.55)	2.55 (1.52)	2.79 (1.48)	2.51 (1.28)	2.65 (1.38)	2.59 (1.44)	2.61 (1.40)	2.60 (1.44)
Fitness	3.30 (1.39)	3.06 (1.58)	3.21 (1.46)	3.28 (1.59)	2.90 (1.30)	3.09 (1.45)	3.29 (1.49)	2.97 (1.42)	3.15[c] (1.49)
Motivation									
Shooter	4.81 (0.92)	4.44 (0.97)	4.67[d, e] (0.95)	3.71 (1.28)	3.19 (0.84)	3.45[e] (1.10)	4.31 (1.23)	3.75 (1.09)	4.06 (1.19)
Band	6.05 (0.60)	5.61 (0.81)	5.87[a, c, d] (0.72)	6.14 (0.92)	5.59 (1.16)	5.86[a, c, d] (1.07)	6.09 (0.76)	5.60 (1.01)	5.87 (0.91)
Dance	4.50 (1.82)	4.24 (1.40)	4.39[e] (1.66)	5.14 (1.31)	4.88 (1.52)	5.01[a, d, e] (1.41)	4.79 (1.63)	4.60 (1.48)	4.70 (1.56)
Fitness	4.15 (1.34)	3.86 (1.55)	4.04 (1.42)	4.06 (1.54)	4.25 (1.10)	4.16 (1.33)	4.11 (1.42)	4.08 (1.32)	4.10 (1.37)

Over, overweight; non-over, non-overweight; [a]Significantly higher than shooter games; [b]Significantly higher than band simulation games; [c]Significantly higher than dance simulation game; [d]Significantly higher than fitness game; [e]Significant gender difference

Figure 4.1. Energy Expenditure Across Games By Weight Status



[a]Significant difference by weight status, $p < .001$
[b]Significant difference by weight status, $p < .001$

Presence. A main effect of game was found on presence ratings ($F(3, 297) = 12.35$, $p < .001$). Presence was significantly lower in the dance simulation (2.60 ± 1.44) than in the shooter (3.39 ± 1.20; $t = -5.93$, $p < .001$), band simulation (3.05 ± 1.38; $t = -3.42$, $p = .004$), and fitness (3.15 ± 1.45; $t = -4.14$, $p < .001$) games. The difference between shooter and band simulation games approached significance ($t = 2.52$, $p = .060$). There were no other differences (shooter vs. fitness, $t = 1.79$, $p = .280$; band simulation vs. fitness, $t = -0.73$, $p = .887$).

Neither weight status ($F(1, 97) = 0.48$, $p = .489$) nor gender ($F(1, 97) = 0.32$, $p = .574$) were significant predictors of presence. No interaction effects were found (game x weight status, $F(3, 288) = 0.84$, $p = .475$; game x gender, $F(3, 288) = 1.24$, $p = .295$; game x weight status x gender, $F(4, 287) = 0.69$, $p = .595$). Table 4.2 shows means and standard deviations for presence and motivation

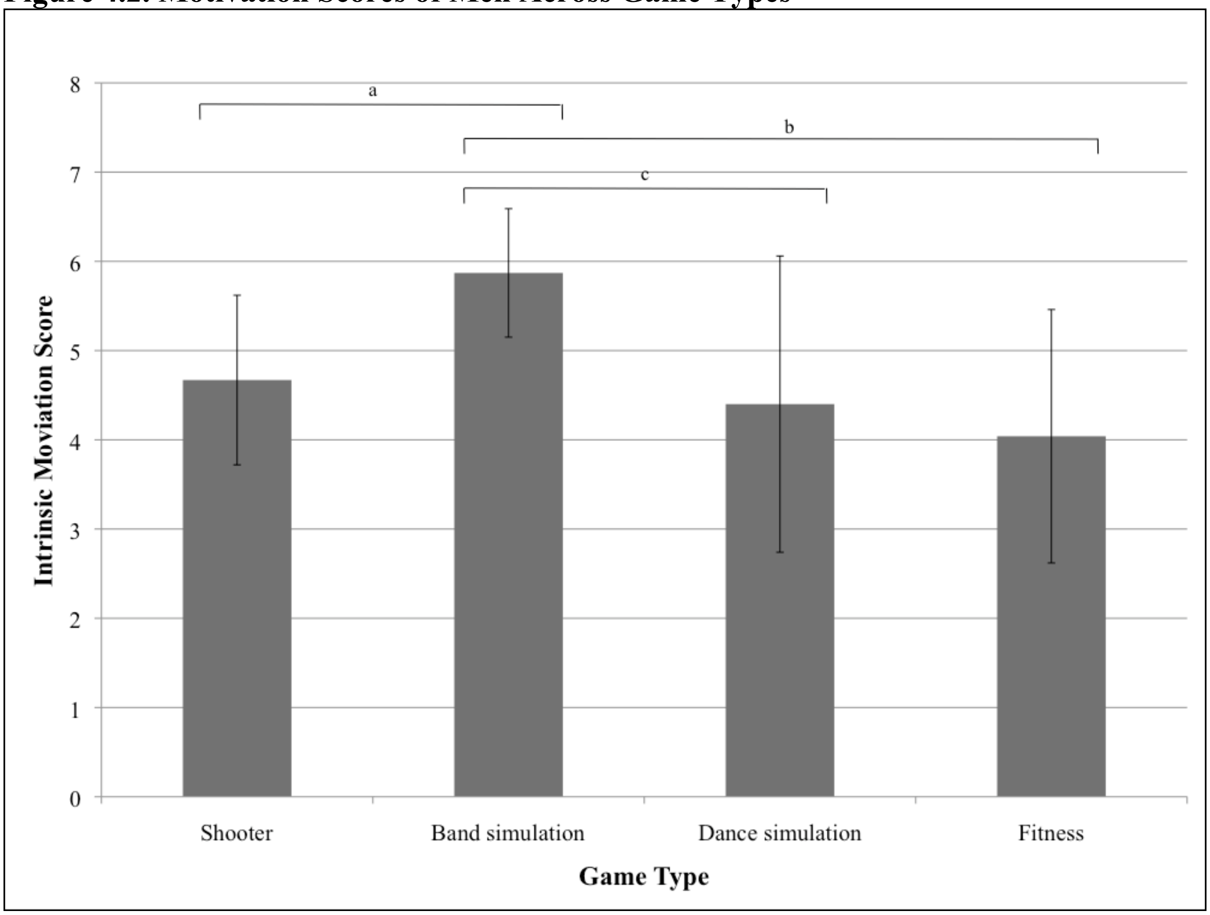
Intrinsic motivation. A main effect of game ($F(3, 294) = 52.84$, $p < .001$) and an interaction between game and gender ($F(3, 294) = 11.19$, $p < .001$) were found on intrinsic motivation. Differences across games existed for both genders (female, $F(3, 294) = 40.60$, $p < .001$; male, $F(3, 294) = 23.43$, $p < .001$). The main effect of weight status was also significant, (β(SE) = 0.313(0.144), $F(1, 97) = 4.73$, $p = .032$), with overweight participants rating games as more motivating than did non-overweight participants. There was no main effect of gender (β(SE) = 1.19(0.25), $F(1, 97) = 0.42$, $p = .519$). Other interactions were not significant (game x overweight, $F(3, 288) = 0.79$, $p = .503$; game x overweight x gender, $F(4, 287) = 0.33$, $p = .861$) and were not included in the reported model.

Differences in motivation between males and females were found in two games. Males rated shooter games as more motivating than females ($F(1, 375) = 23.37$, $p < .001$), whereas females rated dance simulation games more motivating than males ($F(1, 375) = 6.66$, $p = .010$).

Motivation differences across games varied by gender. Both genders rated band simulation games as more motivating than the shooter (females, $t = 10.39$, $p < .001$; males, $t = 5.19$, $p < .001$), dance simulation (females, $t = 3.67$, $p = .006$; males, $t = 6.35$, $p < .001$), and fitness (females, $t = 7.36$, $p < .001$; males, $t = 7.89$, $p < .001$) games. Females rated dance simulation games as significantly more motivating than shooter ($t = 6.72$, $p < .001$) and fitness ($t = 3.68$, $p = .007$) games, whereas in males there was no difference between dance simulation games and the other two types (shooter, $t = 1.16$, $p = .651$; fitness, $t = 1.54$, $p = .882$). The shooter and fitness games were ranked similarly by males ($t = 2.70$, $p = .126$), but in females a trend toward ranking the fitness game higher than shooters approached significance ($t = 3.04$, $p = .052$).

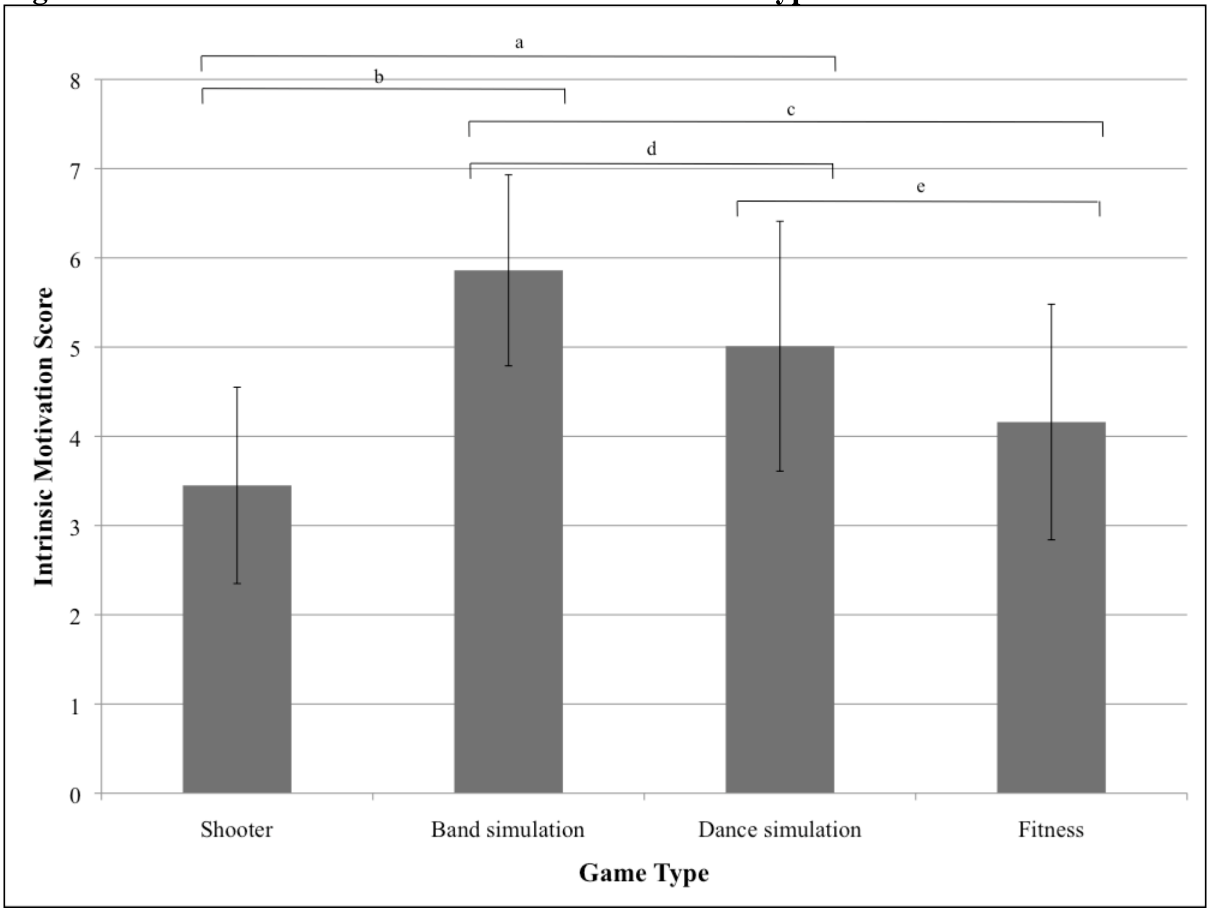
Figure 4.2 shows the patterns of motivation scores for males, and Figure 4.3 shows the patterns of motivation for scores females across the four game types.

Figure 4.2. Motivation Scores of Men Across Game Types



[a]Difference between shooter and band simulation, $p < .001$
[b]Difference between band simulation and dance simulation, $p < .001$
[c]Difference between band simulation and fitness, $p < .001$

Figure 4.3. Motivation Scores of Women Across Game Types



[a]Difference between shooter and dance simulation, $p < .001$
[b]Difference between shooter and band simulation, $p < .001$
[c]Difference between dance simulation and fitness, $p = .006$
[d]Difference between band simulation and dance simulation, $p = .007$
[e]Difference between band simulation and fitness, $p < .001$

Discussion

Energy expenditure and psychological reactions to play differ across types of video games. On average, the games studied here produced an increase in energy expenditure over rest of 23% for shooter, 73% for band simulation, 298% for dance simulation, and 322% for fitness games. Presence ratings were lower in dance simulation games than in the other three game types. Intrinsic motivation results were complex. There was a significant effect of weight status on motivation, with overweight participants finding the games more motivating than lean participants. Differences by gender were found in two games: males found shooter games more motivating than females did, and females found the dance simulation game more motivating than males did. Both females and males rated band simulation games as more motivating than all other game types, but preferences otherwise differed by gender. Females found dance simulation games more motivating than shooter and fitness games. In males, none of these games differed. These results suggest that both game and player characteristics can be quite influential in both physiological and psychological reactions to video game play.

Energy expenditure estimates for these games, ranging between 0.91 and 3.10 METs (23 to 322% increase over rest), were lower than in several previous reports of energy expenditure during play of dance simulation and Wii Sports games (Graves et al., 2007; Lanningham-Foster et al., 2006; Maddison et al., 2007; Tan et al., 2002; Unnithan et al., 2006), but those estimates came from samples of children, not adults. Even corrected for body mass, children expend more energy than older individuals both at rest and during exercise, making comparisons of results across age groups difficult to interpret (Harrell et al., 2005).

We are aware of only three published studies of active gaming that have measured energy expenditure in adults. A study of Wii Fit play in 12 adults (seven male) reported energy expenditure of 2.0 METs in balance minigames and 3.4 METs in aerobic minigames (Miyachi et al., in press). These results are similar to our estimate of 3.10 METs during Wii Fit play, which averaged results from two balance and two aerobic minigames.

A study of Dance Dance Revolution found energy expenditure of 3.74 METs in a sample of seven inexperienced male players and 7.20 METs in 12 experienced male players (Sell et al., 2008). (Note: these estimates were converted from reported VO_2 by the authors to provide a common metric.) Our finding of lower energy expenditure (2.91 METs) during play of a game from the same franchise (Dance Dance Revolution) may have been due to a larger and more diverse sample size (*N* = 100 vs. *N*= 19) that included women.

The other published study of adults compared energy expenditure in adults and children, reporting energy expenditure during play of Wii Sports Boxing of 2.67 METs in adults compared to 5.14 METs in children (Lanningham-Foster et al., 2009). The energy expenditure found in the adult sample is similar to our findings for dance simulation and fitness games. The large difference between adult and child estimates suggests that energy expenditure outcomes from studies using child samples are likely not generalizable to adult populations.

The energy expenditure found in dance simulation and fitness games is approximately equivalent to moderate intensity physical activity, with dance simulation games producing activity just slightly below the cut-point for moderate intensity (3 METs). Higher motivation may lead to overall greater amounts of physical activity over time due to increased frequency of exercise.

The games that produced the highest levels of energy expenditure (fitness and dance simulation), however, were not the games rated as most motivating/enjoyable (band simulation). Because levels of intrinsic motivation have been found to be related to video game play (Ijsselsteijn et al., 2006; Ryan et al., 2006), young adults may be less likely to play the games that could provide the greatest fitness improvements, instead favoring games that are less strenuous. There are several possible reasons for this preference. These results may simply point to a preference for sedentary entertainment. However, laboratory studies of sedentary behaviors and physical activity have found that physical activities are chosen over sedentary behaviors under some circumstances. To be chosen, the activities must be as or more reinforcing than the sedentary alternative (Epstein et al., 2004). It is possible that characteristics of band simulation games make them more attractive than other games, or that characteristics of fitness games make them less attractive. More research is needed to better understand the impact of gameplay elements and other characteristics of games that may produce sustained play over time.

The most motivating games, band simulation games, did not produce moderate-vigorous physical activity levels in young adults in this study. However, replacement of television watching with play of these games may be a tactic for reducing sedentary behavior. Light intensity activity predicts obesity independently of moderate-vigorous activity and sedentary behavior (Healy et al., 2007); increasingly, evidence shows that replacing sedentary time with even brief periods of light physical activity would be beneficial to health (Hamilton et al., 2007; Healy, Dunstan, Salmon, Cerin et al., 2008; Macfarlane, Taylor, & Cuddihy, 2006).

Player characteristics were found to influence both energy expenditure and intrinsic motivation. Non-overweight players expended more energy (corrected for body mass) than overweight players. In fact, overweight participants in this study did not expend sufficient energy in any of the games to produce moderate intensity activity (> 3 METs). However, overweight participants found the games more motivating than did non-overweight participants. This weight difference suggests that the use of video games for exercise may be particularly attractive for overweight individuals. Though overweight participants expended less energy than lighter participants in two of the games, they may play the games for longer durations due to high levels of motivation and thus accumulate greater physical activity over time.

Gender effects on motivation varied across the four game types. Participants of both sexes rated band simulation games as the most motivating. After band simulation games, males found the other three types to be equivalently motivating. Women, however, found the dance simulation game more motivating than shooters or the fitness game. Women also found the dance simulation game more motivating than did men. Formative work will be essential prior to game selection in future gaming studies, and in particular testing of different game possibilities across gender, weight, and age groups. Game(s) that are disliked or found unmotivating by a portion of the study sample could affect physical activity outcomes.

Strengths and limitations. This study had many strengths: it was by far the largest laboratory study of active video games to date and included the most diverse sample. A wide variety of extremely popular games were tested, including both traditional and potentially active games. Beyond measurement of energy expenditure, psychological variables were also measured, providing insight into differences in motivating power across games. Differences by gender and weight status were also investigated.

Despite its many strengths, this study also had several limitations. Resting energy expenditure in this sample was lower than the assumed rate of 1.0 kcal/hr/kg. Though other studies have found similar resting rates (Byrne, Hills, Hunter, Weinsier, & Schutz, 2005; Lanningham-Foster et al., 2009), participants in this sample may have expended less energy than previously studied samples, or measurement equipment may have underestimated energy expenditure. Additionally, the target population of this study was young adults; these results may not be applicable to youth or elderly gamers.

Conclusions. Video games are differentially active and motivating. Dance simulation and fitness games appear to have potential as more active alternatives to sedentary television watching, but these types of games may be less motivating than other, more sedentary, video games. Though band simulation games did not produce physical activity, these games may also have potential for sustainable intervention due to higher motivation levels than other game types. Further study of motivating game characteristics could improve future active games and, potentially, game implementation. Long-term randomized controlled trials are necessary to determine whether active games can be implemented and maintained as an effective physical activity and sedentary behavior intervention.

CHAPTER 5

THE RELATIONSHIP BETWEEN PRESENCE, MOTIVATION, AND ENERGY EXPENDITURE DURING ACTIVE VIDEO GAME PLAY

Abstract

Objective. Play of active video games can produce moderate levels of physical activity, but little is known about how these games motivate players to be active. Perceptions of competence and control have been found to predict intrinsic motivation to play a video game. Presence, or the feeling of being in the game, may also affect intrinsic motivation, which in turn has been hypothesized to affect energy expended during game play. However, these relationships have yet to be tested in physically active video game research. Better understanding of how these psychological reactions affect energy expenditure and intentions could lead to improvements in future games and selection of games for health interventions.

Design. Young adults aged 18-35 (N = 97, 50 female) < 300 pounds played a Dance Dance Revolution game for 13 minutes while energy expenditure was measured using indirect calorimetry. Self reported measures of presence, perceived competence and control, and intrinsic motivation were taken immediately afterwards.

Main outcome measures. Energy expenditure (METs)

Results. A path model in which presence, perceived competence, and perceived control predicted intrinsic motivation, which in turn predicted energy expenditure, was a good fit to

the data. Significant indirect effects of presence (.086, 95% CI .008; .164) and perceived competence (.108, 95% CI .013; .203) as well as direct effects of intrinsic motivation (β = .153, p = .004) and BMI (β = -.034, p = .001) were found on energy expenditure.

Conclusion. Presence and perceived competence were found to have an indirect effect on energy expenditure via intrinsic motivation. These findings suggest that dance simulation games that are found to be more enjoyable result in greater motivation for play, which in turn produces more intense activity. Developers, practitioners, and researchers should consider characteristics that influence these predictors when creating, recommending, or implementing active video games.

Background

Physical inactivity is a major and pervasive public health problem. Exercise-themed video games are popular, and the addition of physical activity to video gaming has been suggested as a method for increasing physical activity during leisure time. Little is known about the mechanisms by which video games may increase activity levels. Several theoretical predictors have been suggested, but the relationships between these variables as well as their relative importance in predicting energy expenditure are as yet unclear.

The most commonly tested predictor of energy expenditure during virtual reality or video game enhanced exercise is intrinsic motivation, which is the desire to perform an activity in the absence of external rewards. Intrinsic motivation, which is often conceptualized as enjoyment, has been found to be a more powerful predictor of behavior than extrinsic motivation (Ryan & Deci, 2000a). There is evidence that intrinsic motivation predicts activity intensity during exercise (Ijsselsteijn et al., 2006) as well as future play of a video game (Ryan et al., 2006). In studies of exercise combined with gaming or virtual reality (VR), researchers have found that individuals who were distracted by virtual environments exercised more frequently (Annesi & Mazas, 1997; Warburton et al., 2007) and for longer durations (Chuang et al., 2003) than those who exercised without distraction. Active video games may increase physical activity over time by increasing intrinsic motivation, or enjoyment, thus increasing activity frequency and/or duration. Cognitive Evaluation Theory (CET) proposes two theoretical predictors of intrinsic motivation: perceived competence and autonomy (also conceptualized as control); both have been found to predict intrinsic motivation in video game studies (Przybylski et al., 2009; Ryan et al., 2006).

Active games may also influence energy expenditure by influencing activity intensity. In addition to effects on frequency and duration, exercise with video games has been found to produce higher intensity physical activity than in exercise without distraction (Ijsselsteijn et al., 2006; Warburton et al., 2009). Feelings of presence may play a role in how gaming affects intensity. Presence has been defined as the sense of "being there" (Slater, 1999) or the "perceptual illusion of non-mediation;" (Lombard & Ditton, 1997) essentially, presence is a measure of the extent to which a user's attention is oriented more towards a virtual environment than his or her physical environment. Presence may affect energy expenditure due to its distracting effects: higher levels of presence in a video game have been associated with greater decreases in pain perception (Hoffman et al., 2004) as well as increased intensity and duration of exercise (Ijsselsteijn et al., 2006).

Presence has also been found to impact intrinsic motivation (Ijsselsteijn et al., 2006), and thus it is possible that presence may have a direct or indirect effect (via motivation) on energy expenditure. Presence is also associated with perceptions of competence and control (Przybylski et al., 2009; Ryan et al., 2006), but the directionality of these relationships is unclear. Additionally, perceived competence and control may have a direct effect on energy expenditure; skill level in some active games can have a large effect on expenditure (Sell et al., 2008).

The literature on gaming and physical activity suggests that presence, intrinsic motivation, and perceptions of competence and control all have an effect on energy expended during active game play. How these variables relate to one another and whether their effects on energy expenditure are direct or indirect is not known. The purpose of this study was to investigate a hypothesized path model of each of these variables and their relationships to each other and to energy expenditure. Direct effects of presence, perceived competence, and perceived control as well as indirect effects of each through intrinsic motivation were proposed and tested. An alternate model that included gender was also tested.

Methods

Sample. One-hundred 18-35 year old participants, equal numbers male and female, were recruited using a University online mailing list and television advertisements. To be included, participants were required to weigh <300 pounds (necessary for the use of other game controllers not discussed here), to have played video games at least 3 times over the past year, to be willing to fast 2.5 hours and be videotaped during the study protocol, and to have transportation to the study location. Of 757 individuals who requested information and eligibility criteria, 325 completed eligibility information; of those 325, 169 potential participants were scheduled, and 100 completed the protocol. Eligible participants who did not attend their appointments (*N* = 49) were considered drop-outs, and 156 eligible participants were wait-listed.

Games and Procedure. The study was conducted in a dedicated lab in a University-owned office building between April and August of 2009. The room included a 58" television, game chair with surround sound speakers, and measurement equipment. After participants provided informed consent, preliminary anthropometric (height, weight) and pre-experimental questionnaire measures were taken. The mask for indirect calorimetry was then fitted, adjusted, and tested as needed prior to a 20 minute rest period. Eight games were played in randomized order for 13 minutes each, with the first three minutes considered a training period. During the training period, the study coordinator provided verbal game instructions as well as a visual aid showing controller functions. Psychological variables were measured by questionnaire at the conclusion of each game. Participants rested at least five minutes (up to ten minutes) between games; during rest periods, masks were removed and participants were provided with water. The protocol lasted approximately four hours per participant.

For this study, only measures taken during play of a dance simulation game were used. The dance simulation game played was Dance Dance Revolution: Universe 2 (DDR), for the Xbox360 console. DDR is a dancing game based on traditional rhythm gameplay, in which players use a dance mat rather than a traditional controller. The mat (in this instance, a thin plastic mat such that comes bundled with the game) is square in shape, with arrows at the top and bottom and left and right. To play, the participant steps on the appropriate arrows as patterns of up, down, left, and right arrows scroll across the screen in time with the beat of a song. Participants practiced on one song and then played one song on the easiest difficulty setting, then were free to choose subsequent songs and difficulty levels for the rest of the play period (approximately 10 minutes).

Measurement. Energy expenditure was measured via indirect calorimetry (Ultima CPX, Medgraphics, St. Paul, MN) using a neoprene mask and open pneumotach. The calorimeter was calibrated daily using a 3 liter syringe as well as prior to each test using certified gases. The umbilical hose connecting participants and the metabolic cart was routed behind the participants' body and was sufficiently long to allow movements required for each game. Height and weight were measured in street clothes without shoes using a wall-mounted stadiometer (Perspective Enterprises, Inc., Kalamazoo, MI) and calibrated scale (Tanita, Arlington Heights, IL).

Feelings of presence were measured using the Slater-Usoh-Steed (SUS) scale, with questions slightly altered to refer to video game play rather than virtual reality. The SUS scale is a six-question measure commonly used in the presence literature that has shown adequate validity (Usoh et al., 2000). Questions included "Please rate your sense of being in the game environment" and "to what extent were there times during the experience when the game environment was the reality for you." Responses were averaged to create the presence score (range: 1 – 7).

From the Intrinsic Motivation Inventory, the seven-item enjoyment subscale was used to measure motivation and the six-item competence subscale was used to measure perceived competence. This measure has shown adequate validity and reliability (McAuley et al., 1989). Participants ranked their agreement with each statement on a Likert scale of one (not at all true) to seven (very true). Slight changes to wording were made to specifically reference video game playing. Items in the motivation subscale included “this game was fun to play” and “I thought this game was quite enjoyable.” Items in the competence subscale included “I was pretty skilled at this game.” Responses for each scale were averaged to create intrinsic motivation and perceived competence scores (range: 1 - 7).

Perceived control was measured using five items from the Presence Questionnaire’s control and immersion factors subscale that have been found to load onto a single control-related factor (Takatalo et al., 2008; Witmer & Singer, 1998). These items have been used for the purpose of measuring perceived control during video game play in past studies (Cavazza et al., 2007). Items included “how much were you able to control events” and how responsive was the environment to actions you initiated (or performed)?” Responses were summed to create a perceived control score, which (range 7 – 35).

Data analysis. Energy expenditure estimates were averaged over the last 10 minutes of play (excluding the three-minute training period). Prior to analysis, data were examined for the existence of outliers. Residual analysis found two outliers of note, with Cook’s *D* statistics > 0.04 (using a cut point of $4 / [N - k - 1]$) (Fox, 1991). Video taken during play showed that both of these participants set the game to expert difficulty, whereas nearly all other participants played on beginner or basic. They also expended more energy (> 3 standard deviations from the mean) than others and reported extensive experience with dance simulation games (data not reported). The hypothesized model was tested using the entire data set and compared to the model reported below, which did not contain outliers. Overall, results were similar. The relationships between perceived competence, perceived control, and energy expenditure differed across the two analyses, but these differences did not affect significance. These players' much greater experience than average may have altered the relationship between their perceptions of competence and control and their energy expenditure. The two participants were judged to be extreme outliers and removed from the data set.

One other individual was removed due to incomplete data, bringing the study *N* to 97. Data were tested for heteroskedasticity and normality using Breusch-Pagan and Shapiro-Wilks tests. No significant results were found for either test.

Descriptive statistics and residual analysis were performed using SPSS Statistics version 17.0 (SPSS, Inc., Chicago, IL, 2008). The Breusch-Pagan test was performed using SAS version 9.2 (SAS, Cary, NC, 2008). Relationships between variables were tested via path analysis using the MPlus software package version 5.2 (Muthén and Muthén, Los Angeles, CA, 2008). Energy expenditure was the dependent variable and intrinsic motivation the intervening (mediating) variable. Presence, perceived competence, and perceived control were independent variables. BMI was also included, with a hypothesized path leading to energy expenditure. The independent variables were predicted to covary. Gender has been found in other analyses using these data to be associated with intrinsic motivation in some games (data not presented). Thus, a second model was also tested to determine the effect of gender, identical to the first but for the addition of a path from gender to intrinsic motivation.

Both direct and indirect effects of the independent variables on the dependent variable were calculated using maximum likelihood estimation with code adapted from MacKinnon (Mackinnon, 2008). Use of path analysis rather than the more common causal steps method of testing mediation (Baron & Kenny, 1986) reduced the potential for Type I error by testing the independent variables simultaneously and provided greater statistical power. This method also allowed for the testing of indirect effects that might occur in the absence of significant direct or total effects; these effects would not be found due to failure at step one of the causal steps method. Because bootstrapping has been found to artificially inflate standard error estimates in sample sizes < 100, the delta method was used to estimate standard errors of indirect effects (Nevitt & Hancock, 2004). All variables measured with scales were treated as observed rather than latent variables due to insufficient power for a full structural equation model. All path coefficients presented are standardized estimates.

Model fit was evaluated using chi-square, Root Mean Square Error of the Approximation (RMSEA), and the Comparative Fit Index (CFI). A non-significant chi-square statistic, RMSEA ≤ .05 and a CFI > 0.9 were used to indicate acceptable fit of the model to the data. Alpha was set at .05.

Results

Participant characteristics. Sample characteristics and mean values for each variable of interest are shown in Table 5.1. The sample (*N* = 97, 50 female) was 23.80 ± 4.01 years old and overweight with a mean BMI of 27.17 ± 6.61 kg/m^2. 72% of the sample was White, 16% Black, 8% Asian, and 4% Other. 6% reported Hispanic ethnicity. 80% of participants listed college graduation or some college, 13% graduate work, and 6% a high school diploma.

Table 5.1. Participant Characteristics

Characteristic	Mean (SD)
Age	23.80 (4.01)
Height (cm)	171.60 (10.10)
Weight (kg)	80.18 (20.89)
BMI (kg/m^2)	27.17 (6.61)
Resting energy expenditure (kcal/hr/kg)	0.76 (0.18)
DDR energy expenditure (kcal/hr/kg)	2.85 (0.72)
DDR oxygen consumption (VO_2, mL/kg/min)	9.98 (2.52)
Presence	2.62 (1.44)
Perceived competence	3.77 (1.44)
Perceived control	25.79 (6.00)
Intrinsic motivation	4.73 (1.52)

Path analysis. A theory-based model was tested which included direct paths from the theoretical predictors and intrinsic motivation to energy expenditure as well as indirect paths from presence, perceived competence, and perceived control through intrinsic motivation. A path led from BMI to energy expenditure. Independent variables were predicted to covary.

The model was an adequate fit to the data: $\chi^2(1, N = 97) = 1.63$, $p = .202$; CFI = .989; RMSEA = .081, 95% CI = .000; .297; $p = .255$. Significant direct effects were found on energy expenditure for intrinsic motivation, ($\beta = .326$, $p = .002$), and BMI ($\beta = -.296$, $p < .001$). Contrary to hypotheses, no significant direct effect of presence ($\beta = .038$, $p = .700$), perceived competence ($\beta = -.082$, $p = .481$), or perceived control ($\beta = .112$, $p = .313$) were found. The effects of presence and perceived competence on intrinsic motivation were significant (presence, $\beta = .263$, $p = .002$; perceived competence, $\beta = .332$, $p = .001$), but the effect of perceived control was not ($\beta = .172$, $p = .080$). The three predictors were correlated (see Table 5.2 for correlations of all variables).

Indirect effects from presence, perceived competence, and perceived control to energy expenditure via intrinsic motivation were calculated. Indirect effects of presence ($\beta_{indirect}$ = .086, p = .032) and perceived competence ($\beta_{indirect}$ = .108, p = .026) were significant, but the indirect effect of perceived control was not ($\beta_{indirect}$ = .056, p = .129). For presence, the total effect (indirect + direct) was β_{total} = .124, The total effect for perceived competence was β_{total} = .026. Neither the direct nor indirect effect of perceived control was significant. The model accounted for approximately 23% of the variation found in energy expenditure (R^2 = .227). Standardized estimates of direct and indirect effects are displayed in Table 5.3, and the path model is displayed in Figure 5.1. Elimination of non-significant paths to produce a reduced model resulted in improved fit, $\chi^2(3, N = 97) = 0.595$, p = .898; CFI = 1.00; RMSEA < .05; 95% CI .000; .075; p = .926.

Gender effect. An additional model was also tested, which added a path from gender to intrinsic motivation. Fit of the model was not greatly changed, $\chi^2(2, N = 97) = 2.62$, p = .271; CFI = .990; RMSEA = .056; 95% CI .000; .218; p = .353. The added path was significant (β = -.190, p = .017, indicating that women rated the game as more motivating than men did. Significance of all other direct and indirect effects was unchanged. This model improved fit and proportion of the variance explained (R^2 = .230) only slightly.

Table 5.2 Correlations for the Six Variables Included in the Path Analysis

	Presence	Perceived Competence	Perceived Control	Intrinsic Motivation	BMI
Presence					
Perceived Competence	.310**				
Perceived Control	.267**	.554***			
Intrinsic Motivation	.403***	.513***	.426***		
BMI	.032	.045	-.086	.079	
Energy Expenditure	.163	.146	.244*	.322**	-.305**

*$p < .05$
**$p < .01$
***$p < .001$

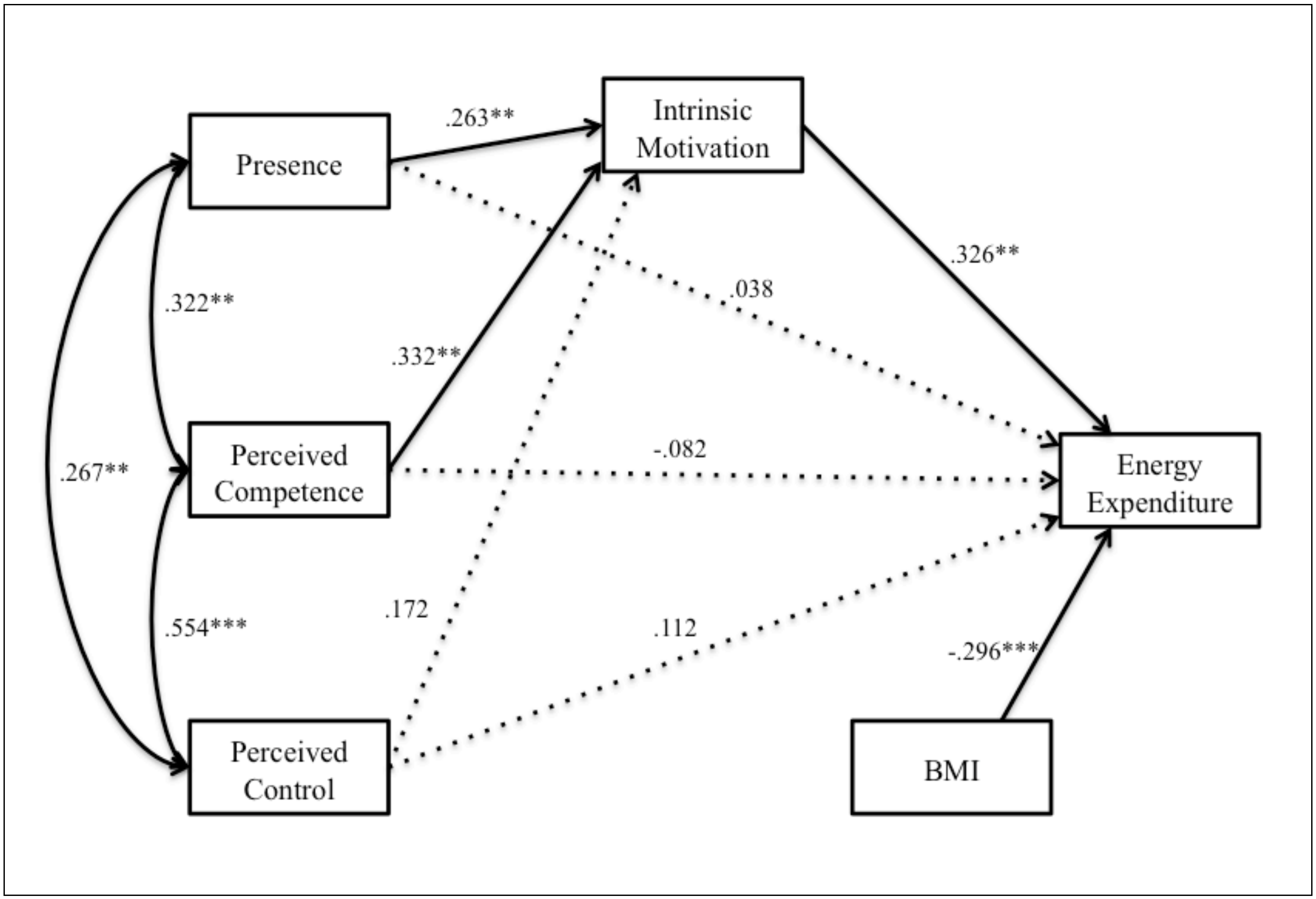
Table 5.3. Standardized Path Coefficients and Indirect Effects

Path	β	SE	95% CI	
Direct effect				
Presence to motivation	.263**	.085	.097	.430
Presence to EE	.038	.099	-.157	.233
Competence to motivation	.332*	.097	.141	.523
Competence to EE	-.082	.116	-.310	.146
Control to motivation	.172	.098	-.020	.364
Control to EE	.112	.111	-.106	.330
Intrinsic motivation to EE	.326**	.107	.115	.536
BMI to EE	-.296***	.087	-.467	-.125
Presence with competence	.322**	.091	.143	.500
Presence with control	.267**	.094	.083	.452
Competence with control	.554***	.070	.416	.692
Indirect effect (via motivation)				
Presence to EE	.086*	.040	.008	.164
Competence to EE	.108*	.049	.013	.203
Control to EE	.056	.037	-.016	.128

β, standardized path coefficient; SE, standard error; CI, confidence interval; Competence, perceived competence; Control, perceived control; EE, energy expenditure

*p < .05; **p <.01; ***p < .001

Figure 5.1. Path Model



Dotted lines are non-significant paths
*p < .05; ** p < .01; *** p < .001

Discussion

Presence, perceived competence, and intrinsic motivation all influenced energy expended during play of an active video game. Presence and perceived competence indirectly affected energy expenditure via intrinsic motivation, while perceived control did not. None of the three predictors directly affected energy expenditure; only intrinsic motivation and BMI had direct effects.

These findings partially replicate those of past studies, which have found presence, perceived competence, and perceived control to predict intrinsic motivation to play a video game (Przybylski et al., 2009; Ryan et al., 2006). These results also extend previous findings to apply to physically active video games, and show that some of these predictors also affect energy expenditure. Both Cognitive Evaluation Theory and the concept of presence provide a useful framework for active video game research. Active games that are considered more enjoyable and motivating may encourage greater energy expenditure than those felt to be less motivating. Because motivation affects future play of a game, there may be an additive effect in which more enjoyable games produce physical activity more often and at a greater intensity than less enjoyable games.

It should be noted, however, that perceived control did not significantly predict intrinsic motivation in this study. It is possible that the measure used was not precise enough to capture a true difference if it existed; the effect showed a trend toward significance (p = .080). It is also possible that differences exist between autonomy to play a game (i.e., control over how leisure time is spent) and control of events within a game. Though these results support perceived competence as a predictor of intrinsic motivation as well as the addition of presence when applying CET to video game studies, they did not support effects of perceived control.

The indirect effects of presence and perceived competence on energy expenditure occurred in the absence of a correlation between the predictors and outcome. Though mediation has long been conceptualized as requiring a significant total effect (i.e., an association between predictor and outcome), it is possible for a significant indirect effect to exist where a significant association between a predictor and outcome does not (Hayes, 2009). One possible explanation for the lack of a total effect is that presence and perceived competence may be positively associated with an unmeasured mediator that is negatively associated with energy expenditure; thus, the total effect of these negative and the measured positive pathways would be near zero and thus non-significant.

The lack of a direct effect between presence and energy expenditure in particular was unexpected. Previous studies that measured presence used video games as a distraction from traditional exercise (such as cycling); it may be that presence produces an effect in that situation but not during a video game that itself requires activity. Games played for distraction purposes during exercise may also differ from DDR in various characteristics that impact presence and, potentially, its relationship to energy expenditure.

Previous studies have found effects of difficulty level in energy expended during play of a DDR game (Sell et al., 2008). Here, perceptions of competence were found to indirectly but not directly influence energy expenditure. The extent to which perceptions of competence are related to difficulty setting and objective competence is unclear. Further investigation of how perceived competence and objective measures related to competence predict energy expenditure is needed.

Greater feelings of presence and perceived competence predicted greater intrinsic motivation. Unfortunately, currently available active games contain fewer of the characteristics associated with these feelings than most traditional, sedentary games. For example, there is evidence that quality of graphics (Duh et al., 2002), a highly interactive game environment (Garau et al., 2005), and an involved storyline (E. F. Schneider et al., 2004) increase feelings of presence. Though these characteristics are common in very popular games (e.g., "AAA" releases that are extremely high profile, such as Call of Duty: Modern Warfare 2 or Super Mario Galaxy), they are less often included in active or exer-games.

Though these results are encouraging, they also present a challenge: how can active games be made more motivating, in order to take advantage of associated energy expenditure increases? Though Dance Dance Revolution produced energy expenditure greater than several other games we have tested, when compared to other popular music-based games it was rated as less motivating and presence-inducing (data not presented). More studies are needed that examine predictors and outcomes related to motivation, so that these insights can be applied to game development.

These results also have implications for intervention studies of active video games. If a game is not enjoyable or engaging, participants may not play the game very often and may expend less energy during each play period. Formative research specific to the game of interest as well as the target population will be necessary in future intervention trials to select games with these characteristics. Assignment of different games to different groups may also be necessary as more and more varied active games are released, which may cater to different demographics or interests.

Limitations. This study consisted of play of a single style of game for ten minutes. Because types of games played and play periods range widely, these results should be generalized with caution. Other active games may produce different results. Though the sample was much larger and included more females than previous active game studies, these results are not necessarily generalizable to other age groups. Differences have been found between children and adults in feelings of presence (Baumgartner et al., 2008); it is possible that how presence relates to other variables may also differ in children.

It should also be noted that the direction of the relationships in this model are unclear. It is possible that intrinsic motivation could lead to presence, or that unmeasured variables may moderate some of the included relationships. Larger studies, in both scope and sample, are needed to further investigate how psychological reactions to video games affect both physiological reactions and one another.

Conclusion. Greater levels of presence, perceived competence, and intrinsic motivation are associated with greater energy expenditure during play of an active video game. The more a player enjoys an active video game, the more energy he or she is likely to expend playing the game. Play of active games that successfully produce these psychological reactions may lead to more intense and frequent physical activity over time. Future active games that include more presence-inducing aspects, such as an involved storyline, high-quality graphics, and a highly interactive environment, may be more successful both at maintaining interest over time as well as in encouraging higher intensity activity. Researchers and practitioners should keep the importance of motivation and related variables in mind when selecting games for intervention or recommendation.

CHAPTER 6

SUMMARY OF FINDINGS, RECOMMENDATIONS, AND RESEARCH NEEDS

Summary of Findings

Overall, the findings of this study suggest that active gaming may be a viable method for increasing physical activity and reducing sedentary behavior in young adults. However, currently available options for active gaming may not be sufficiently active or motivating to produce sustained increases in physical activity. The following sections summarize results and implications by specific aim.

Aim One. The primary purpose of Aim One was to investigate the potential of motion control as a method for increasing energy expended during play of popular action/adventure games. Because these games are more popular than explicitly active or exercise-themed games, they may be a more feasible alternative to sedentary time spent watching television. In the past, action/adventure games have been played with traditional gamepad controllers, which use buttons as inputs. The implementation of motion control into this genre of game presents an opportunity to integrate physical activity into a behavior that is highly reinforcing.

Six pairs of games were tested, with three played using motion controllers and three played using traditional gamepad controllers. The game pairs differed in player perspective: in one pair, perspective was first person. In another, perspective was over-the-shoulder, which combined first person with a visible avatar. In the final pair, both perspective and controller were varied such that one game was hypothesized to have the most presence-inducing combination of the two characteristics (labeled the "maximized" game), and the other game the least presence-inducing combination (labeled the "minimized" game). It was hypothesized that the motion controlled games would produce greater energy expenditure than the traditionally controlled games, and that the over-the-shoulder perspective would produce greater feelings of presence than first person perspective. It was also hypothesized that differences in game pairs would be greatest in the third pair that compared different perspectives and controllers.

None of the motion controlled shooter games tested in this study produced MET levels that would be considered moderate intensity activity. Energy expenditure produced was in the sedentary range (< 1.5 METs). Only one of the motion controlled games, the maximized game, produced energy expenditure that was significantly higher than a comparison traditionally controlled game. The traditional and motion controlled games studied here produced average energy expenditures of 0.89 and 0.93 kcal/hr/kg, respectively (increases of 22 and 25 percent over rest). These estimates more closely resembled energy expenditure of traditional sedentary games (Borusiak et al., 2008; Lanningham-Foster et al., 2006) than of other motion controlled games that have been studied (Graf et al., 2009; Graves et al., 2007).

These results suggest that the simple addition of motion control to perform the same actions required by traditional shooter games was not sufficient to produce light or moderate intensity physical activity. They do, however, represent approximately 15% greater energy expenditure than would be expended while watching TV (Lanningham-Foster et al., 2009;

Lanningham-Foster et al., 2006). Such small increases may, when combined with other small changes in lifestyle, contribute to energy balance. It has been estimated that the average daily energy surplus is 100 kilocalories (Hill et al., 2003); replacement of TV watching (at an average of 3 hours per day) with motion controlled video game play could burn an additional 30 calories per day in an 80kg individual.

BMI was found to negatively predict body mass adjusted estimates of energy expenditure regardless of controller or game. Both BMI and gender influenced intrinsic motivation. Males and heavier participants rated the games as more motivating than females and lighter participants. That men liked shooter games more than did females was not surprising; this genre is primarily marketed towards a male audience, and shooter games often include content found aversive by some women (Burgess, Stermer, & Burgess, 2007; Hartmann & Klimmt, 2006). The reasons behind heavier participants finding these games more motivating than lighter participants are less clear and require further study.

The maximized game produced greater energy expenditure than the minimized game, but it also produced greater energy expenditure than the over-the-shoulder motion controlled game. Though it was not hypothesized that differences in perspective would affect energy expenditure directly, it was believed that perspective might affect feelings of presence, which has been found to be associated with energy expenditure (Ijsselsteijn et al., 2006). However, the pattern of presence findings in this study suggests that presence was likely not the driving factor behind differences in energy expenditure. In fact, presence ratings were nearly identical in the maximized and over-the-shoulder motion controlled games.

No difference in presence was found between the two first person games, and the difference in the over-the-shoulder pair was in the opposite of the hypothesized direction.

Presence differences did exist, however, in comparisons of the minimized game to the other two traditionally controlled games in both presence and motivation. It may be that a third-person perspective truly is less presence and motivation inducing than first person or over-the-shoulder perspectives; it is also possible that other unanticipated aspects of the minimized game, such as difficulty level, contributed to these differences.

Aim Two. The second aim compared several games along a continuum of hypothesized activity intensity and motivation. It was hypothesized that energy expenditure would be greatest in the dance simulation game, followed by the fitness game and that shooter games would produce higher presence and intrinsic motivation than the other games. The final hypothesis was that the games that used specific, unique controllers (i.e., not traditional button-based gamepad controllers) would produce higher energy expenditure than the traditionally controlled shooter games.

Both the dance simulation and fitness games produced significantly greater energy expenditure than the other game types, but they did not differ from one another (a trend towards higher energy expenditure in fitness games existed). All but the traditional shooter games increased energy expenditure over rest, with the band simulation games increasing expenditure 73%, the dance simulation game 298%, and the fitness game 322%. Contrary to the second hypothesis, shooter games did not produce the highest presence or intrinsic motivation. The band simulation games were rated as significantly more motivating than the other three game types, and presence was similar in all games but for the dance simulation game, in which presence was significantly lower. In agreement with the third hypothesis, the games using unique controllers produced greater energy expenditure than shooter games.

Band simulation games received the highest motivation scores from both genders, but did not produce MET levels that were considered moderate intensity physical activity. Though not appropriate as an intervention strategy to promote moderate to vigorous physical activity, these games may be a viable option for decreasing sedentary behavior, particularly because they appear to be highly reinforcing. If these games can produce greater energy expenditure (for example, by including songs that require faster drumming and/or drum sets that are sturdier and quieter to encourage more vigorous playing), they have great potential for replacing sedentary screen time with more active screen time because they were more motivating than other game types and might be played with greater frequency.

Women rated the fitness game as less motivating than the dance simulation game. Both women and men rated the fitness game as less motivating than band simulation games. The implications for fitness or activity themed games are concerning, though not unexpected. The purpose of combining video games and exercise has generally been to utilize the motivating and/or distracting power of video games to encourage activity. Because many find physical activity insufficiently motivating or perhaps even aversive, a reinforcing activity has been harnessed to increase motivation to be active. Games that disguise physically strenuous motions by providing a purpose for those actions (such as encouraging jumping by integrating it into dance-like moves set to a music beat) may ultimately promote greater amounts of activity than games that present explicitly exercise-themed motions, due to differences in motivating power.

Differences were found by weight status (overweight/non-overweight) in energy expenditure and by gender and weight status in intrinsic motivation. Overweight participants expended less energy during play of the dance simulation and fitness games than normal weight participants. In fact, moderate-intensity physical activity did not occur in overweight participants during play of any of the games included in this study, though both dance and fitness games were played at moderate intensity levels for normal weight individuals. Energy expenditure estimates were corrected for body mass, so these findings were not influenced by differences in mass. Despite expending less energy during play, overweight participants found the games more motivating than their non-overweight counterparts, however, which may mean that they would play the games more often and potentially accumulate similar or greater amounts of physical activity over time.

As with analyses in Aim One, it was found that participant and game characteristics were important in predicting outcomes. In addition, participant and game characteristics often interacted to produce different patterns across groups. Games that are motivating and active to one person may be uninteresting and sedentary for another. These moderating variables will greatly complicate any efforts at intervention using active games, and thus a better understanding of these differences will improve both research and implementation.

Aim Three. In the third aim, relationships found in the first two aims were explored in greater detail. Specifically, a mediation model was tested to determine whether presence, perceived competence, and perceived control predicted energy expenditure via intrinsic motivation.

Significant direct effects of intrinsic motivation and BMI existed on energy expenditure. Presence and perceived competence predicted intrinsic motivation and had significant indirect effects on energy expenditure. Neither variable directly affected energy expenditure. Perceived competence did not have a significant effect on motivation or energy expenditure. A sub-analysis of gender effects supported the hypothesis that gender was associated with motivation.

These results partially supported the application of Cognitive Evaluation Theory to video game play as well as its expansion to active gaming. They also supported the extension of this theory to include presence as a predictor of intrinsic motivation. However, they also raise a number of questions about the relative importance of components of this theory, and how their importance may differ across games or other activities. In this dance simulation game, presence and perceived competence predicted intrinsic motivation, but perceived control did not (though its effect trended towards significance). It is possible that the instrument used to measure perceived control in this study lacked precision to find a truly significant effect; it is also possible that perceived control within a video game (i.e., control over characters and the game environment) differs from control over whether and when to play a video game.

As in the previous two aims, BMI was negatively associated with energy expenditure. It appears that over a wide variety of games, more overweight players expend less energy than less overweight players. BMI was only related to energy expenditure, not to any of the theoretical predictors. Thus, participants with higher BMI did not appear to expend less energy than lower BMI participants due to differences in perceptions of control or competence. The causes of this consistent lower energy expenditure in overweight players are not known, but for this game they do not appear to be related to the theoretical predictors tested here.

Active gaming studies published to date have not been theory-based. This analysis suggests that theoretical covariates, mediators, and outcomes will add to the explanatory power of future models and provide insight into the success or failure of interventions. Health researchers should become familiar with theoretical work on video games and virtual reality-related exercise studies from other disciplines. It is likely that other theoretical constructs not presented here may also strengthen active gaming research by their inclusion.

Based on these models, it appears that games that are more motivating (i.e., fun) not only may be more likely to be played, but they also may produce higher intensity activity within discrete periods of time. Because there is a large literature outlining predictors of intrinsic motivation and presence, the results also point to specific methods that could be used to potentially increase the effectiveness of active video games by increasing their motivating potential. Some of these methods are discussed in the recommendations section below.

Comparisons with Previous Studies

Though this research was novel, its results can be compared to similar studies from several disciplines. Many of the studies were quite different from this project, and thus comparisons may be biased by a number of potential confounders. Nevertheless, placing this project in the context of other work may provide valuable information on necessary directions for future research.

Energy expenditure estimates for the traditional games in this study were similar to those found previously in the active gaming literature, near 1.0 METs (Borusiak et al., 2008; Graves et al., 2007; Lanningham-Foster et al., 2006; Maddison et al., 2007; Straker & Abbott, 2007; Wang & Perry, 2006). Our estimate of energy expended during play of Wii Fit (3.10 METs) was also similar to previous estimates of balance and aerobic Wii Fit minigames (2.0 METs and 3.4 METs, respectively) (Miyachi et al., in press). Dance Dance Revolution, however, produced lower energy expenditure here (2.91 METs) than in other studies (3.74 – 7.20 METs) (Graf et al., 2009; Lanningham-Foster et al., 2006; Maddison et al., 2007; Sell et al., 2008; Tan et al., 2002; Unnithan et al., 2006). Our estimates may be lower due to age differences. Almost all of these studies sampled children, who have been found to expend more energy than adults during video game play (Lanningham-Foster et al., 2009). Even corrected for body mass, children expend more energy than older individuals both at rest and during exercise, making comparisons of results across age groups difficult to interpret (Harrell et al., 2005). When published estimates were adjusted for resting energy expenditure to make them more comparable to adult populations, they were closer to our estimates (2.41 - 6.46 METs; see Table 1.1). To our knowledge, no published studies of the energy expended during play of band simulation games exist.

Though active gaming studies have not thus far measured intrinsic motivation, studies in several other areas provide estimates of similar games and virtual devices. A study of motivation to play Half-Life 2, a popular first person shooter, found motivation scores of 3.66 in males and 3.04 in females (Przybylski et al., 2009). Only four questions from the seven-question inventory were used, but the 1 – 7 Likert scale was the same as in this study. Motivation scores in the shooter games studied here were higher than those estimates (4.67 for males and 3.45 for females). Study samples were similar in age (young adults), and the games were very similar. The exact questions used were not reported, so it was not possible to directly compare these results; differences may be an artifact of measurement due to slight differences in the inventory used.

Motivation scores for the other games were somewhat similar to those found in studies of virtual reality exercise games. A study of the effects of manipulating immersion levels in a virtual reality stationary cycling game found scores of 3.55 in a low immersion and 4.88 in a high immersion game (Ijsselsteijn et al., 2006). Motivation scores for games studied here were 4.10 for the fitness game, 4.70 for the dance simulation game, and 5.87 for the band simulation games. The two active games produced motivation levels comparable to that produced by the virtual reality exercise game, while motivation to play band simulation games was much higher. As these comparisons show, video games can differ in their power to motivate individuals. Though active games may be more motivating than other competing activities, they are not the most motivating type of video game.

Presence ratings in this study are difficult to compare to others due to differences in scoring of the measurement instrument. The SUS presence scale was intended to measure differences in presence only over a minimum threshold; however, very few participants in this study reached that threshold. The results of Aim Three suggest that higher presence levels, even when they do not approach the minimum threshold for measurement in virtual reality studies, do have a positive effect on motivation to play a video game.

Conversion of presence means to scores, to match the previous literature, produced presence scores that were lower in these games (ranging between 0.46 and 1.06) than in several published estimates, which ranged between 1.4 and 3.0 (Banos et al., 2008; Lok, Naik, Whitton, & Brooks, 2003). However, these studies used sophisticated virtual reality equipment, which would be expected to create greater feelings of presence.

A previous study has compared both presence scores and averaged responses to SUS scale items. When item responses to this measure have been averaged across the scale, presence ratings were very similar to those found here (3.8 in a virtual office setting, as compared to 2.60 – 3.39 in these games) (Usoh et al., 2000). The theoretical implications of differences between measuring gradations in presence only over a minimum threshold as opposed to overall gradations are not clear. Results of this study appear to suggest that, in video games, variation below the commonly-used threshold does hold explanatory power. Though the video game types studied here appear to have produced presence levels lower than those produced by virtual reality apparatus, this difference may not impact typical video game users who do not have the opportunity to experience highly presence-inducing virtual reality. It is not known how these video games would compare to other potentially presence-inducing media such as novels, television shows, or movies.

Implications of Findings

Historically, active gaming has been conceptualized as a way to increase physical activity by making it more motivating than traditional activity. However, this comparison may not be the most important one; making physical activity more motivating does not necessarily make it motivating enough to become a habitual behavior. To have the greatest public health impact, active video games must be motivating enough to be chosen over TV watching. At approximately three hours per day, Americans spend more time watching TV than doing anything else other than sleep and work (U.S. Department of Labor, 2009). Even small decreases in this uniquely harmful time (Dunstan et al., 2010in press) could have large effects.

The motivating power of alternatives to TV is extremely important and should be a clear priority for future research. Predictors of TV watching appear to be primarily cognitive and attitudinal; in other words, watching TV is a planned behavior (Rhodes & Dean, 2009). Even controlling for intention to be physically active, intention to watch TV is predictive of physical activity (Rhodes & Blanchard, 2008). Intervening to alter cognitions and behaviors related to TV watching may have a positive effect on physical activity as well as an effect on sedentary behavior.

The purpose of this study was, ultimately, to set the stage for future public health interventions to increase physical activity and decrease sedentary behavior using video games. Preliminary interventions using active video games have been less successful than anticipated, likely due to declines in play over time. Greater insight is needed into why these games may have been insufficiently reinforcing to encourage sustained play.

Theoretically, integrating physical activity into an enjoyable sedentary behavior such as video gaming should make physical activity more reinforcing. However, many games that promote physical activity differ from highly reinforcing sedentary games. Here, we found that dance simulation and fitness games, though the most active of the games studied, were not the most motivating. As has been seen in several interventions thus far, moderately active video games do not necessarily produce physical activity increases over time, probably because they are not played often enough (Madsen et al., 2007; Maloney et al., 2008; Ni Mhurchu et al., 2008). Dance simulation and fitness games were most active in the laboratory, but it remains to be seen if they are better able to produce sustained increases in physical activity in real-world settings.

The results of these studies suggest that a behavior that can reduce sedentary TV watching while simultaneously increase physical activity could have a large public health impact. However, the replacement must be sufficiently reinforcing to be chosen over TV.

Clearly, many individuals find TV preferable to physical activity and plan to watch it. Enjoyment, or motivation, is predictive of both physical activity and sedentary behavior (Salmon et al., 2003). Alternatives to TV must be equally or more reinforcing to be successful replacements (Epstein et al., 2004).

Unfortunately, little attention has been paid in this literature to the reasons behind television watching and video game playing – in other words, what makes these behaviors motivating. Television appears to function primarily as entertainment and as a way to relax and pass time (Lee & Lee, 1995; Sherry, 2001). Similarly, common reasons given for playing video games are for fantasy, diversion, and arousal (Sherry et al., 2006). Distraction from the real world, i.e. presence, is an explicit purpose of screen-based leisure time for many people. Virtual worlds in which players perform mundane exercise tasks such as jogging, particularly if those tasks are unappealing or aversive, may not be motivating enough to compete with the engaging fantasy worlds of television and traditional video gaming.

Aim One of this study showed that simply altering controllers to potentially encourage physical activity during traditional action/adventure games, while keeping game requirements essentially unchanged, was not sufficient to increase activity levels. What is done with those inputs in the game is vitally important not only to production of physical activity during play but also to enjoyment of the game. Increasing presence and motivation inducing aspects of games is in the interests of developers, publishers, researchers, and consumers alike. Greater presence and motivation can increase energy expenditure in the short term (by increasing intensity of activity during play) and the long term (by increasing the frequency and duration of activity during play). Games that fulfill needs for distraction and entertainment will also likely be more reinforcing alternatives to television watching.

Motion controlled action/adventure games and band simulation games are two genres that hold potential to incorporate additional activity requiring inputs to boost energy burned during play. These game types are popular and motivating, and their style of gameplay could easily be adapted to encourage more strenuous motions. For example, motions that have been found to be moderately or vigorously active include punching, jumping, running, and dancing. These motions could easily be integrated into many traditional game genres, such as fighting games (punching), platformers (jumping across chasms and running), and shooters (running, jumping behind cover, and fighting with melee weapons).

If motion controls are implemented successfully, motion controlled versions of games should be more presence-inducing and motivating than traditionally controlled versions. The motion controlled shooter games studied here represented some of the first attempts at integrating such controls with the shooter genre. These results indicate that the integration of motion control does not necessarily negatively affect presence or motivation. Thus, modifying traditional action/adventure games to be less sedentary appears to be a feasible strategy for public health intervention, capable of increasing energy expenditure without decreasing motivation.

Overweight and more sedentary individuals find exercise more aversive than lighter, less sedentary individuals (Ekkekakis & Lind, 2006). Overweight is also related to amount of TV watched (Hu et al., 2003). Interestingly, participants with a higher BMI enjoyed the games played in this study more than those with a lower BMI. Overweight and sedentary individuals, a population in great need of intervention to increase physical activity, may be the population most likely to benefit from game-based activity interventions. Though overweight participants expended less energy in the more active games, they also found them (and other games) more motivating than leaner participants. Over time, they may accumulate greater amounts of physical activity due to higher frequency and/or duration of play. Even though these games did not produce moderate intensity physical activity in this subgroup and may not be able to produce health benefits related to physical fitness, dance simulation or fitness games would represent a large improvement over time spent watching television in terms of overall energy expenditure. Particularly at a population level, small individual decreases in sedentary behavior could produce large public health benefits.

The implications of these results are potentially wide-reaching. Active game development, implementation, and research may benefit from recommendations made a result of this study. Several of these recommendations are discussed below.

Recommendations

Recommendations for development. As mentioned above, the results of this research point to many concrete steps that could be taken to potentially improve the efficacy of active video games. These steps should ideally be both theory and evidence-based, integrating concepts related to motivation.

The distinction between intrinsic and extrinsic motivation, especially, may be important for games with explicit exercise themes. Extrinsic motivation can affect behavior, but intrinsic motivation is a much more powerful predictor. This pattern has been shown in many behaviors and specifically in physical activity behavior (Ingledew & Markland, 2008; Sebire, Standage, & Vansteenkiste, 2009; Thogersen-Ntoumani & Ntoumanis, 2006). Someone who exercises because the exercise activity is inherently enjoyable will likely exercise more often than someone who views exercise as a chore that must be done for external rewards. Though many fitness games attempt to motivate players with in-game rewards and explicit monitoring of exercise and weight loss goals, these gameplay elements may reinforce extrinsic rather than intrinsic motivation. These games often do not play like video games at all, but rather exist as hybrid interactive workout videos. Clearly, this strategy is effective in encouraging purchase of such games, as the success of Wii Fit has shown. However, this strategy may be sub-optimal for encouraging sustained increases in physical activity.

For example, the jogging portion of Wii Fit consisted of the player jogging in place while the player avatar ran through a virtual environment. For individuals who do not enjoy running, it is unlikely that pretending to run will be a particularly compelling activity. In Gold’s Gym Cardio Workout, however, the player runs on a trail similar to that found in the other games, but occasionally a bear jumps out of the woods. Players must punch the bears as they run. The bear-punching provides some distraction from the exercise itself as well as a goal, turning an interactive workout into a game. Even such a small inclusion of gameplay elements may have a substantial effect on play intensity or duration via motivation and/or presence.

As fitness games may benefit from the inclusion of traditional gameplay mechanics, so too might traditional action/adventure games benefit from the inclusion of more vigorous movement. Integration of motion controls to more typical button-based controls was not found to reduce feelings of motivation in this project, and their effect on presence was unclear. In theory, realistic and meaningful movements should increase feelings of presence, motivation, and energy expenditure; they have been found to do so in several studies (Bianchi-Berthouze et al., 2007; Lindley et al., 2008). Developers, publishers, health professionals, and consumers all stand to benefit from the integration of high-quality motion control to traditional video games.

The findings from this study suggest that, as hypothesized, many traditional games are not producing levels of activity out of the sedentary range, and more active games are not currently very motivating or engaging. Finding ways to integrate compelling aspects of highly motivating games (e.g., Guitar Hero) with activity-promoting aspects of fitness games should be a major goal of active game developers in the future. Ultimately, individuals have varying tastes that will influence their game preferences. Many will likely enjoy fitness games that are explicitly workout-themed; these recommendations are not to say that there is no place for such games. Rather, inclusion of more gamelike elements into such games would likely improve not only their staying power but also the intensity of the workouts produced during play.

Recommendations for implementation. Caution should be taken when implementing or recommending video games as physical activity. Characteristics of the game, controller, situation, or player may all affect the amount of energy expended in any given play period; what is exercise for one may be a sedentary behavior for another. Generally, however, the outcomes of this as well as other similar research do point to several tentative recommendations that could be made.

Active gaming may contribute to a healthy lifestyle in several ways, but its impact depends on the behavior it replaces. Were individuals to replace, for example, an aerobic workout at the gym with play of aerobic exercise games in Wii Fit for an equivalent period of time, their energy expenditure would likely decrease. However, were individuals to replace time spent watching TV or being otherwise sedentary with play of those aerobic games, energy expenditure would be increased substantially. Benefits may also exist related to decreases in television watching unrelated to physical activity, such as decreases in sedentary behavior and snacking.

Games such as DDR, Wii Sports, and Wii Fit have consistently been found to result in at least moderate intensity physical activity (Graves et al., 2007; Lanningham-Foster et al., 2006; Tan et al., 2002). However, it was found here that DDR and Wii Fit were rated as less motivating than several other games, indicating that in practice these games may not be played as often as less active, more motivating ones. These games may be more motivating than other types of exercise, but they may not be more motivating than competing sedentary behaviors. Dance simulation and fitness games may be more successful as methods of encouraging physical activity by making exercise more motivating, rather than as a replacement for sedentary screen time.

Research Needs

Laboratory and observational studies. Because so little is known about the many possible predictors of reactions to active gaming, there is a real need for laboratory studies. Particularly because these studies offer the possibility of rigorous control of extraneous variables, they will be helpful in providing a better understanding of the relative importance of various personal and game characteristics. Such studies could be used to test and expand theoretical constructs as well as to integrate previous empirical findings into existing theory. Without such a firm theoretical foundation to suggest potential intermediary variables, it will be difficult to evaluate intervention studies.

Behavioral choice experiments in particular would be helpful and should be pursued if possible. These experiments offer the ability to draw tentative conclusions as to relative reinforcing value without the cost and difficulty of a long-term longitudinal study. In particular, further investigation into the relative reinforcing value of TV watching, various types of gaming, and traditional methods of exercise is needed. Though this study has investigated relative amounts of motivation among game types, it is not known how games compare to TV, exercise, or other leisure activities.

Longitudinal non-experimental studies could also provide useful information about behavior over time without the cost of a randomized controlled trial. There is a need for better understanding of how active gaming affects other aspects of players' lives; specifically, whether active gaming may replace time spent watching TV, playing sedentary video games, or participating in more traditional exercise or sports. It will also be important to understand how play of all games, not just active ones, changes over time. It is possible that the pattern of play dropping off after several weeks is a typical pattern across all types of video games, or perhaps across many types of hobbies and that new games that introduce novelty will be required to sustain engagement and play over time.

Intervention studies. The nascent discipline of active gaming research is moving towards large-scale and long-term randomized controlled trials of active game implementation. Without a larger literature of laboratory and observational studies, however, such trials are likely premature. Smaller-scale intervention studies could help move the literature forward for a relatively small investment of time and resources. For example, published pilot tests have suggested that providing children or families with DDR mats and games does not produce sustained physical activity (Chin A Paw et al., 2008; Maloney et al., 2008). Additional pilot testing of different games and protocol (i.e., gaming groups, online multiplayer, in-person multiplayer with friends/family) along with the measurement of motivational variables could suggest fruitful directions for future intervention or development work.

Beyond testing whether certain games or game-based programs work, there is also a need for better insight into how games might work to produce health benefits. Body composition, blood pressure, fasting plasma glucose, waist circumference, cholesterol, and triglyceride measurement could be used as indicators of changes in metabolic risk over a relatively short time period, without the need for explicit health-related outcome measurement (such as morbidity and mortality). Objective measurement of physical activity at different levels (sedentary, light, moderate, and vigorous), such as is used in epidemiologic sedentary behavior research, could be matched to these health indicators to determine how different games affect behavior, and how those behavior changes affect health.

The RE-AIM (Reach, Efficacy, Adoption, Implementation, Maintenance) framework is useful in this context (Glasgow, Vogt, & Boles, 1999). Fitness games may be quite efficacious, but maintenance in particular is a concern. Playing drums on a higher difficulty level in a band simulation game may produce light to moderate intensity physical activity, meaning lower efficacy than fitness games, but the reach and maintenance may be much higher. Randomized controlled trials should implement the RE-AIM framework in interpretation of results, to provide context for their evaluation.

Conclusion

The purpose of this research project was to investigate whether video gaming was a fruitful avenue for future physical activity and sedentary behavior intervention. Taken together, the results of the three studies suggest that, indeed, active gaming can increase energy expended during screen time. However, characteristics of games and individuals interact in complex ways to influence how much energy is expended during play. These characteristics likely also influence how often and for how long a game is played. Though these studies provide a solid foundation for future research and present compelling evidence of active gaming's utility, they also raise a number of additional questions.

Video games can be successful tools for increasing energy expended during screen time that would otherwise be sedentary. However, not all games will be motivating enough to successfully compete against sedentary screen behaviors such as TV watching. There is a need for more theory-based research on both games and player reactions as well as for greater collaboration between developers, practitioners, and researchers. Active games hold promise for making a large public health impact – promise which will be greatly enhanced as a wider variety of games and a larger base of evidence become available in the future.

REFERENCES

Ahearn, N. (2007). Dance Dance Revolution Ultramix 2 review. Retrieved February 23, 2008, from http://xbox360.ign.com/articles/841/841991p1.html

Alexander, C. M., Landsman, P. B., & Grundy, S. M. (2008). The influence of age and body mass index on the metabolic syndrome and its components. *Diabetes, Obesity and Metabolism, 10*(3), 246-250.

Annesi, J. J., & Mazas, J. (1997). Effects of virtual reality-enhanced exercise equipment on adherence and exercise-induced feeling states. *Perceptual and Motor Skills, 85*(3), 835-844.

Bailey, R., Wise, K., & Bolls, P. (2009). How avatar customizability affects children's arousal and subjective presence during junk food-sponsored online video games. *Cyberpsychology & Behavior, 12*(3), 277-283.

Banos, R. M., Botella, C., Rubio, I., Quero, S., Garcia-Palacios, A., & Alcaniz, M. (2008). Presence and emotions in virtual environments: the influence of stereoscopy. *Cyberpsychology & Behavior, 11*(1), 1-8.

Baron, R. M., & Kenny, D. A. (1986). The Moderator Mediator Variable Distinction in Social Psychological-Research - Conceptual, Strategic, and Statistical Considerations. *Journal of Personality and Social Psychology, 51*(6), 1173-1182.

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin, 117*(3), 497-529.

Baumgartner, T., Speck, D., Wettstein, D., Masnari, O., Beeli, G., & Jaencke, L. (2008). Feeling present in arousing virtual reality worlds: prefrontal brain regions differentially orchestrate presence experience in adults and children. *Frontiers in Human Neuroscience, 2*(8).

Baumgartner, T., Valko, L., Esslen, M., & Jancke, L. (2006). Neural correlate of spatial presence in an arousing and noninteractive virtual reality: An EEG and psychophysiology study. *Cyberpsychology & Behavior, 9*(1), 30-45.

Bellissimo, N., Pencharz, P. B., Thomas, S. G., & Anderson, G. H. (2007). Effect of television viewing at mealtime on food intake after a glucose preload in boys. *Pediatric Research, 61*(6), 745-749.

Bertrais, S., Beyeme-Ondoua, J. P., Czernichow, S., Galan, P., Hercberg, S., & Oppert, J. M. (2005). Sedentary behaviors, physical activity, and metabolic syndrome in middle-aged French subjects. *Obesity Research, 13*(5), 936-944.

Bey, L., & Hamilton, M. T. (2003). Suppression of skeletal muscle lipoprotein lipase activity during physical inactivity: a molecular reason to maintain daily low-intensity activity. *Journal of Physiology, 551*(Pt 2), 673-682.

Bianchi-Berthouze, N. (2009). *Body movement as a means to modulate engagement in computer games*. Paper presented at the Whole Body Interaction 2009: A SIGCHI 2009 Workshop. Retrieved January 14, 2010, from http://lister.cms.livjm.ac.uk/homepage/staff/cmsdengl/WBI2009/

Bianchi-Berthouze, N., Kim, W. W., & Patel, D. (2007). Does body movement engage you more in digital game play? And why? *Affective Computing and Intelligent Interaction, 4738*, 102-113.

Blass, E. M., Anderson, D. R., Kirkorian, H. L., Pempek, T. A., Price, I., & Koleini, M. F. (2006). On the road to obesity: Television viewing increases intake of high-density foods. *Physiology & Behavior, 88*(4-5), 597-604.

Borg, G. (1998). *Borg's perceived exertion and pain scales*. Stockholm: Human Kinetics Publishers.

Borusiak, P., Bouikidis, A., Liersch, R., & Russell, J. B. (2008). Cardiovascular effects in adolescents while they are playing video games: A potential health risk factor? *Psychophysiology, 45*(2), 327-332.

Bowman, S. A. (2006). Television-viewing characteristics of adults: correlations to eating practices and overweight and health status. *Preventing Chronic Disease, 3*(2), A38.

Burgess, M. C. R., Stermer, S. P., & Burgess, S. R. (2007). Sex, lies, and video games: The portrayal of male and female characters on video game covers. *Sex Roles, 57*(5-6), 419-433.

Byrne, N. M., Hills, A. P., Hunter, G. R., Weinsier, R. L., & Schutz, Y. (2005). Metabolic equivalent: one size does not fit all. *Journal of Applied Physiology, 99*(3), 1112-1119.

Calle, E. E., Rodriguez, C., Walker-Thurmond, K., & Thun, M. J. (2003). Overweight, obesity, and mortality from cancer in a prospectively studied cohort of U.S. adults. *New England Journal of Medicine, 348*(17), 1625-1638.

Carnagey, N. L. (2007). *Is it competitiveness or violent content? the effects of violent sports video games on aggression.* ProQuest Information & Learning, US.

Catenacci, V. A., Ogden, L. G., Stuht, J., Phelan, S., Wing, R. R., Hill, J. O., et al. (2008). Physical activity patterns in the National Weight Control Registry. *Obesity (Silver Spring), 16*(1), 153-161.

Cavazza, M., Lugrin, J. L., & Buehner, M. (2007). Causal perception in virtual reality and its implications for presence factors. *Presence-Teleoperators and Virtual Environments, 16*(6), 623-642.

Chatting, D. J., Galpin, J. S., & Donath, J. S. (2006). *Presence and portrayal: video for casual home dialogues.* Paper presented at the the 14th annual ACM International Conference on Multimedia, Santa Barbara, CA.

Chen, M. J., Fan, X., & Moe, S. T. (2002). Criterion-related validity of the Borg ratings of perceived exertion scale in healthy individuals: a meta-analysis. *Journal of Sports Sciences, 20*(11), 873-899.

Chin A Paw, M. J., Jacobs, W. M., Vaessen, E. P., Titze, S., & van Mechelen, W. (2008). The motivation of children to play an active video game. *Journal of Science and Medicine in Sport, 11*, 163-166.

Chuang, T. Y., Chen, C. H., Chang, H. A., Lee, H. C., Chou, C. L., & Doong, J. L. (2003). Virtual reality serves as a support technology in cardiopulmonary exercise testing. *Presence-Teleoperators and Virtual Environments, 12*(3), 326-331.

Chuang, T. Y., Sung, W. H., & Lin, C. Y. (2005). Application of a virtual reality-enhanced exercise protocol in patients after coronary bypass. *Archives of Physical Medicine and Rehabilitation, 86*(10), 1929-1932.

Cooper, J. A., Watras, A. C., O'Brien, M. J., Luke, A., Dobratz, J. R., Earthman, C. P., et al. (2009). Assessing validity and reliability of resting metabolic rate in six gas analysis systems. *Journal of the American Dietetic Association, 109*(1), 128-132.

Croal, N. (2007). The problem (and danger) of the continued infantilization of video games, part II. Retrieved February 13, 2008, from http://blog.newsweek.com/blogs/levelup/archive/2007/10/10/the-problem-and-the-danger-of-the-continued-infantilization-of-videogames-part-ii.aspx

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York: Plenum.

Deci, E. L., & Ryan, R. M. (1991). A motivational approach to self - integration in personality. *Nebraska Symposium on Motivation, 38*, 237-288.

Duh, H. B. L., Lin, J. J. W., Kenyon, R. V., Parker, D. E., & Furness, T. A. (2002). Effects of characteristics of image quality in an immersive environment. *Presence-Teleoperators and Virtual Environments, 11*(3), 324-332.

Dunstan, D. W., Barr, E. L., Healy, G. N., Salmon, J., Shaw, J. E., Balkau, B., et al. (2010). Television Viewing Time and Mortality. The Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Circulation, 121*(3), 384-391.

Dunstan, D. W., Salmon, J., Healy, G. N., Shaw, J. E., Jolley, D., Zimmet, P. Z., et al. (2007). Association of television viewing with fasting and 2-h postchallenge plasma glucose levels in adults without diagnosed diabetes. *Diabetes Care, 30*(3), 516-522.

Dunstan, D. W., Salmon, J., Owen, N., Armstrong, T., Zimmet, P. Z., Welborn, T. A., et al. (2005). Associations of TV viewing and physical activity with the metabolic syndrome in Australian adults. *Diabetologia, 48*(11), 2254-2261.

Eastin, M. S. (2006). Video game violence and the female game player: Self- and opponent gender effects on presence and aggressive thoughts. *Human Communication Research, 32*(3), 351-372.

Eastin, M. S., & Griffiths, R. P. (2006). Beyond the shooter game - Examining presence and hostile outcomes among male game players. *Communication Research, 33*(6), 448-466.

Ekelund, U., Brage, S., Froberg, K., Harro, M., Anderssen, S. A., Sardinha, L. B., et al. (2006). TV viewing and physical activity are independently associated with metabolic risk in children: the European Youth Heart Study. *PLoS Medicine, 3*(12), e488.

Ekkekakis, P., & Lind, E. (2006). Exercise does not feel the same when you are overweight: the impact of self-selected and imposed intensity on affect and exertion. *International Journal of Obesity, 30*(4), 652-660.

Entertainment Software Association. (2009). Essential facts about the computer and video game industry. Retrieved August 12, 2009, from http://www.theesa.com/facts/pdfs/ESA_EF_2009.pdf

Epstein, L. H., Beecher, M. D., Graf, J. L., & Roemmich, J. N. (2007). Choice of interactive dance and bicycle games in overweight and nonoverweight youth. *Annals of Behavioral Medicine, 33*(2), 124-131.

Epstein, L. H., Kilanowski, C. K., Consalvi, A. R., & Paluch, R. A. (1999). Reinforcing value of physical activity as a determinant of child activity level. *Health Psychology, 18*(6), 599-603.

Epstein, L. H., Paluch, R. A., Consalvi, A., Riordan, K., & Scholl, T. (2002). Effects of manipulating sedentary behavior on physical activity and food intake. *Journal of Pediatrics, 140*(3), 334-339.

Epstein, L. H., Roemmich, J. N., Robinson, J. L., Paluch, R. A., Winiewicz, D. D., Fuerch, J. H., et al. (2008). A randomized trial of the effects of reducing television viewing and computer use on body mass index in young children. *Archives of Pediatric & Adolescent Medicine, 162*(3), 239-245.

Epstein, L. H., Roemmich, J. N., Saad, F. G., & Handley, E. A. (2004). The value of sedentary alternatives influences child physical activity choice. *International Journal of Behavioral Medicine, 11*(4), 236-242.

Evenson, K. R., & McGinn, A. P. (2005). Test-retest reliability of adult surveillance measures for physical activity and inactivity. *American Journal of Preventive Medicine, 28*(5), 470-478.

Faith, M. S., Berman, N., Heo, M., Pietrobelli, A., Gallagher, D., Epstein, L. H., et al. (2001). Effects of contingent television on physical activity and television viewing in obese children. *Pediatrics, 107*(5), 1043-1048.

Farrar, K. M., Krcmar, M., & Nowak, K. L. (2006). Contextual features of violent video games, mental models, and aggression. *Journal of Communication, 56*(2), 387-405.

Flegal, K. M., Graubard, B. I., Williamson, D. F., & Gail, M. H. (2007). Cause-specific excess deaths associated with underweight, overweight, and obesity. *Journal of the American Medical Association, 298*(17), 2028-2037.

Ford, E. S., Kohl, H. W., 3rd, Mokdad, A. H., & Ajani, U. A. (2005). Sedentary behavior, physical activity, and the metabolic syndrome among U.S. adults. *Obesity Research, 13*(3), 608-614.

Foster, J. A., Gore, S. A., & West, D. S. (2006). Altering TV viewing habits: an unexplored strategy for adult obesity intervention? *American Journal of Health Behavior, 30*(1), 3-14.

Fox, J. (1991). *Regression diagnostics* (Vol. 79). Thousand Oaks, CA: Sage Publications.

Freeman, J., Avons, S. E., Pearson, D. E., & Ijsselsteijn, W. (1999). Effects of sensory information and prior experience on direct subjective ratings of presence. *Presence-Teleoperators and Virtual Environments, 8*(1), 1-13.

Garau, M., Slater, M., Pertaub, D. P., & Razzaque, S. (2005). The responses of people to virtual humans in an immersive virtual environment. *Presence-Teleoperators and Virtual Environments, 14*(1), 104-116.

Gerstmann, J. (2007). Dance Dance Revolution Universe for Xbox360 review. Retrieved February 23, 2008, from http://www.gamespot.com/xbox360/puzzle/ddrevolutionuniverse/review.html?sid=6166564

Glasgow, R. E., Vogt, T. M., & Boles, S. M. (1999). Evaluating the public health impact of health promotion interventions: the RE-AIM framework. *American Journal of Public Health, 89*(9), 1322-1327.

Gold, J. I., Belmont, K. A., & Thomas, D. A. (2007). The neurobiology of virtual reality pain attenuation. *Cyberpsychology & Behavior, 10*(4), 536-544.

Gordon-Larsen, P., Nelson, M. C., & Popkin, B. M. (2004). Longitudinal physical activity and sedentary behavior trends: adolescence to adulthood. *American Journal of Preventive Medicine, 27*(4), 277-283.

Graf, D. L., Pratt, L. V., Hester, C. N., & Short, K. R. (2009). Playing Active Video Games Increases Energy Expenditure in Children. *Pediatrics, 124*(2), 534-540.

Graves, L., Ridgers, N. D., & Stratton, G. (2008). The contribution of upper limb and total body movement to adolescents' energy expenditure whilst playing Nintendo Wii. *European Journal of Applied Physiology, 104*(4), 617-623.

Graves, L., Stratton, G., Ridgers, N. D., & Cable, N. T. (2007). Comparison of energy expenditure in adolescents when playing new generation and sedentary computer games: cross sectional study. *British Medical Journal, 335*, 1282-1284.

Gustat, J., Srinivasan, S. R., Elkasabany, A., & Berenson, G. S. (2002). Relation of self-rated measures of physical activity to multiple risk factors of insulin resistance syndrome in young adults: the Bogalusa Heart Study. *Journal of Clinical Epidemiology, 55*(10), 997-1006.

Hamilton, M. T., Hamilton, D. G., & Zderic, T. W. (2004). Exercise physiology versus inactivity physiology: an essential concept for understanding lipoprotein lipase regulation. *Exercise and Sport Sciences Reviews, 32*(4), 161-166.

Hamilton, M. T., Hamilton, D. G., & Zderic, T. W. (2007). Role of low energy expenditure and sitting in obesity, metabolic syndrome, type 2 diabetes, and cardiovascular disease. *Diabetes, 56*(11), 2655-2667.

Harrell, J. S., McMurray, R. G., Baggett, C. D., Pennell, M. L., Pearce, P. F., & Bangdiwala, S. I. (2005). Energy costs of physical activities in children and adolescents. *Medicine & Science in Sports & Exercise, 37*(2), 329-336.

Hartmann, T., & Klimmt, C. (2006). Gender and computer games: Exploring females' dislikes. *Journal of Computer-Mediated Communication, 11*(4).

Hayes, A. (2009). Beyond Baron and Kenny: statistical mediation analysis in the new millennium. *Communication Monographs, 76*, 408-420.

Healy, G. N., Dunstan, D. W., Salmon, J., Cerin, E., Shaw, J. E., Zimmet, P. Z., et al. (2007). Objectively measured light-intensity physical activity is independently associated with 2-h plasma glucose. *Diabetes Care, 30*(6), 1384-1389.

Healy, G. N., Dunstan, D. W., Salmon, J., Cerin, E., Shaw, J. E., Zimmet, P. Z., et al. (2008). Breaks in sedentary time: beneficial associations with metabolic risk. *Diabetes Care, 31*(4), 661-666.

Healy, G. N., Dunstan, D. W., Salmon, J., Shaw, J. E., Zimmet, P. Z., & Owen, N. (2008). Television time and continuous metabolic risk in physically active adults. *Medicine & Science in Sports & Exercise, 40*(4), 639-645.

Healy, G. N., Wijndaele, K., Dunstan, D. W., Shaw, J. E., Salmon, J., Zimmet, P. Z., et al. (2008). Objectively measured sedentary time, physical activity, and metabolic risk: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Diabetes Care, 31*(2), 369-371.

Hebert, S., Beland, R., Dionne-Fournelle, O., Crete, M., & Lupien, S. J. (2005). Physiological stress response to video-game playing: the contribution of built-in music. *Life Sciences, 76*(20), 2371-2380.

Hill, J. O., Wyatt, H. R., Reed, G. W., & Peters, J. C. (2003). Obesity and the environment: where do we go from here? *Science, 299*(5608), 853-855.

Hoffman, H. G., Seibel, E. J., Richards, T. L., Furness, T. A., Patterson, D. R., & Sharar, S. R. (2006). Virtual reality helmet display quality influences the magnitude of virtual reality analgesia. *Journal of Pain, 7*(11), 843-850.

Hoffman, H. G., Sharar, S. R., Coda, B., Everett, J. J., Ciol, M., Richards, T., et al. (2004). Manipulating presence influences the magnitude of virtual reality analgesia. *Pain, 111*(1-2), 162-168.

Hu, F. B., Li, T. Y., Colditz, G. A., Willett, W. C., & Manson, J. E. (2003). Television watching and other sedentary behaviors in relation to risk of obesity and type 2 diabetes mellitus in women. *Journal of the American Medical Association, 289*(14), 1785-1791.

Ijsselsteijn, W. A., de Kort, Y. A. W., Westerink, J., & de Jager, M. (2006). Virtual fitness: Stimulating exercise behavior through media technology. *Presence-Teleoperators and Virtual Environments, 15*(6), 688-698.

Ingledew, D. K., & Markland, D. (2008). The role of motives in exercise participation. *Psychology & Health, 23*(7), 807-828.

International Society for Presence Research. (2000). The concept of presence: explication statement. Retrieved February 25, 2008, from http://ispr.info/

Ivory, J. D., & Kalyanaraman, S. (2007). The effects of technological advancement and violent content in video games on players' feelings of presence, involvement, physiological arousal, and aggression. *Journal of Communication, 57*(3), 532-555.

Jakes, R. W., Day, N. E., Khaw, K. T., Luben, R., Oakes, S., Welch, A., et al. (2003). Television viewing and low participation in vigorous recreation are independently associated with obesity and markers of cardiovascular disease risk: EPIC-Norfolk population-based study. *European Journal of Clinical Nutrition, 57*(9), 1089-1096.

Karnehed, N. E., Rasmussen, F., Hemmingsson, T., & Tynelius, P. (2008). Obesity in Young Adulthood Is Related to Social Mobility Among Swedish Men. *Obesity (Silver Spring), 16*(3), 654-658.

Kim, Y. Y., Kim, H. J., Kim, E. N., Ko, H. D., & Kim, H. T. (2005). Characteristic changes in the physiological components of cybersickness. *Psychophysiology, 42*(5), 616-625.

Klimmt, C., Hartmann, T., & Frey, A. (2007). Effectance and control as determinants of video game enjoyment. *Cyberpsychology & Behavior, 10*(6), 845-848.

Kronenberg, F., Pereira, M. A., Schmitz, M. K., Arnett, D. K., Evenson, K. R., Crapo, R. O., et al. (2000). Influence of leisure time physical activity and television watching on atherosclerosis risk factors in the NHLBI Family Heart Study. *Atherosclerosis, 153*(2), 433-443.

Kruk, J. (2007). Physical activity in the prevention of the most frequent chronic diseases: an analysis of the recent evidence. *Asian Pacific Journal of Cancer Prevention, 8*(3), 325-338.

La Guardia, J. G., Ryan, R. M., Couchman, C. E., & Deci, E. L. (2000). Within-person variation in security of attachment: a self-determination theory perspective on attachment, need fulfillment, and well-being. *Journal of Personality and Social Psychology, 79*(3), 367-384.

Lanningham-Foster, L., Foster, R. C., McCrady, S. K., Jensen, T. B., Mitre, N., & Levine, J. A. (2009). Activity-Promoting Video Games and Increased Energy Expenditure. *Journal of Pediatrics, 154*(6), 819-823.

Lanningham-Foster, L., Jensen, T. B., Foster, R. C., Redmond, A. B., Walker, B. A., Heinz, D., et al. (2006). Energy expenditure of sedentary screen time compared with active screen time for children. *Pediatrics, 118*(6), e1831-1835.

Lee, B., & Lee, R. S. (1995). How and why people watch TV: implications for the future of interactive television. *Journal of Advertising Research, 35*(6), 9-18.

Levine, J. A. (2004). Non-exercise activity thermogenesis (NEAT). *Nutrition Reviews, 62*(7 Pt 2), S82-97.

Levine, J. A., Lanningham-Foster, L. M., McCrady, S. K., Krizan, A. C., Olson, L. R., Kane, P. H., et al. (2005). Interindividual variation in posture allocation: possible role in human obesity. *Science, 307*(5709), 584-586.

Li, C., Ford, E. S., McGuire, L. C., & Mokdad, A. H. (2007). Increasing trends in waist circumference and abdominal obesity among US adults. *Obesity (Silver Spring), 15*(1), 216-224.

Li, C., Lin, J., Lee, S. E., & Tseng, R. (2007). Associations between the metabolic syndrome and its components, watching television and physical activity. *Public Health, 121*, 83-91.

Lindley, S., Le Couteur, J., & Bianchi-Berthouze, N. (2008). *Stirring up experience through movement in game play: effects on engagement and social behaviour*. Paper presented at CHI 2008. Retrieved January 10, 2010, from http://portal.acm.org/citation.cfm?id=1357136

Lipscomb, S. D., & Zehnder, S. M. (2004). Immersion in the virtual environment: the effect of a musical score on the video gaming experience. *Journal of Physiological Anthropology and Applied Human Science, 23*(6), 337-343.

Lok, B., Naik, S., Whitton, M., & Brooks, F. P. (2003). Effects of handling real objects and self-avatar fidelity on cognitive task performance and sense of presence in virtual environments. *Presence-Teleoperators and Virtual Environments, 12*(6), 615-628.

Lombard, M., & Ditton, T. (1997). At the heart of it all: the concept of presence. *Journal of Computer-Mediated Communication, 3*(2), 1-22.

Lombard, M., & Ditton, T. (2004). A literature-based presence measurement instrument: the Temple Presence Inventory (TPI) (Beta). Retrieved October 14, 2008, from http://astro.temple.edu/~lombard/research/P2scales_11-04.doc

Lombard, M., Ditton, T., Crane, D., Davis, B., Gil-Egui, G., Horvath, K., et al. (2000). *Measuring presence: a literature-based approach to the development of a standardized paper-and-pencil instrument*. Paper presented at Presence 2000: The Third International Workshop on Presence. Retrieved March 26, 2008, from http://astro.temple.edu/~lombard/research/p2_P2000.html

Lucas, K., & Sherry, J. L. (2004). Sex differences in video game play: A communication-based explanation. *Communication Research, 31*(5), 499-523.

Macfarlane, D. J., Taylor, L. H., & Cuddihy, T. F. (2006). Very short intermittent vs continuous bouts of activity in sedentary adults. *Preventive Medicine, 43*(4), 332-336.

Mackinnon, D. P. (2008). *Introduction to Statistical Mediation Analysis*. New York, NY: Psychology Press.

Maddison, R., Ni Mhurchu, C., Jull, A., Jiang, Y., Prapavessis, H., & Rodgers, A. (2007). Energy expended playing video console games: an opportunity to increase children's physical activity? *Pediatric Exercise Science, 19*, 9.

Madsen, K. A., Yen, S., Wlasiuk, L., Newman, T. B., & Lustig, R. (2007). Feasibility of a dance videogame to promote weight loss among overweight children and adolescents. *Archives of Pediatric and Adolescent Medicine, 161*(1), 105-107.

Maloney, A. E., Bethea, T. C., Kelsey, K. S., Marks, J. T., Paez, S., Rosenberg, A. M., et al. (2008). A pilot of a video game (DDR) to promote physical activity and decrease sedentary screen time. *Obesity, 16*(9), 2074-2080.

Mark, A. E., & Janssen, I. (2008). Relationship between screen time and metabolic syndrome in adolescents. *Journal of Public Health, 30*(2), 153-160.

Markland, D., & Hardy, L. (1997). On the factorial and construct validity of the intrinsic motivation inventory: Conceptual and operational concerns. *Research Quarterly for Exercise and Sport, 68*(1), 20-32.

Martinez-Gomez, D., Tucker, J., Heelan, K. A., Welk, G. J., & Eisenmann, J. C. (2009). Associations between sedentary behavior and blood pressure in young children. *Archives of Pediatric & Adolescent Medicine, 163*(8), 724-730.

McAuley, E., Duncan, T., & Tammen, V. V. (1989). Psychometric properties of the Intrinsic Motivation Inventory in a competitive sport setting: a confirmatory factor analysis. *Research Quarterly for Exercise and Sport, 60*, 11.

McDonough, M. H., & Crocker, P. R. (2007). Testing self-determined motivation as a mediator of the relationship between psychological needs and affective and behavioral outcomes. *Journal of Sport & Exercise Psychology, 29*(5), 645-663.

Mellecker, R. R., & McManus, A. M. (2008). Energy expenditure and cardiovascular responses to seated and active gaming in children. *Archives of Pediatric & Adolescent Medicine, 162*(9), 886-891.

Mikropoulos, T. A., & Strouboulis, V. (2004). Factors that influence presence in educational virtual environments. *Cyberpsychology & Behavior, 7*(5), 582-591.

Miyachi, M., Yamamoto, K., Ohkawara, K., & Tanaka, S. (in press). METs In Adults While Playing Active Video Games: A Metabolic Chamber Study. *Medicine & Science in Sports & Exercise*.

Moller, A. C., Deci, E. L., & Ryan, R. M. (2006). Choice and ego-depletion: the moderating role of autonomy. *Personality and Social Psychology Bulletin, 32*(8), 1024-1036.

Moller, A. C., Ryan, R. M., & Deci, E. L. (2006). Self-determination theory and public policy: Improving the quality of consumer decisions without using coercion. *Journal of Public Policy & Marketing, 25*(1), 104-116.

Murray, C. D., Fox, J., & Pettifer, S. (2007). Absorption, dissociation, locus of control and presence in virtual reality. *Computers in Human Behavior, 23*(3), 1347-1354.

Nash, E. B., Edwards, G. W., Thompson, J. A., & Barfield, W. (2000). A review of presence and performance in virtual environments. *International Journal of Human-Computer Interaction, 12*(1), 1-41.

Nevitt, J., & Hancock, G. R. (2004). Evaluating small sample approaches for model test statistics in structural equation modeling. *Multivariate Behavioral Research, 39*(3), 439-478.

Ni Mhurchu, C., Maddison, R., Jiang, Y., Jull, A., Prapavessis, H., & Rodgers, A. (2008). Couch potatoes to jumping beans: A pilot study of the effect of active video games on physical activity in children. *International Journal of Behavioral Nutrition and Physical Activity, 5*, 8.

Nowak, K. L., & Blocca, F. (2003). The effect of agency and anthropomorphism on users' sense of telepresence, copresence, and social presence in virtual environments. *Presence-Teleoperators and Virtual Environments, 12*(5), 481-494.

Nunez, D., & Blake, E. (2003). The thematic baseline technique as a means of improving the sensitivity of presence self-report scales. Retrieved February 25, 2008, from http://presence-research.org/papers/nunez.html

O'Connor, T. J., Fitzgerald, S. G., Cooper, R. A., Thorman, T. A., & Boninger, M. L. (2001). Does computer game play aid in motivation of exercise and increase metabolic activity during wheelchair ergometry? *Medical Engineering & Physics, 23*(4), 267-273.

O'Rahilly, S. (2007). Human obesity and insulin resistance: lessons from experiments of nature. *Novartis Foundation Symposium, 286*, 13-20; discussion 20-13, 162-163, 196-203.

Ogden, C. L., Carroll, M. D., Curtin, L. R., McDowell, M. A., Tabak, C. J., & Flegal, K. M. (2006). Prevalence of overweight and obesity in the United States, 1999-2004. *Journal of the American Medical Association, 295*(13), 1549-1555.

Paffenbarger, R. S., Jr., Wing, A. L., & Hyde, R. T. (1978). Physical activity as an index of heart attack risk in college alumni. *American Journal of Epidemiology, 108*(3), 161-175.

Pate, R. R., O'Neill, J. R., & Lobelo, F. (2008). The evolving definition of "sedentary". *Exercise & Sport Science Reviews, 36*(4), 173-178.

Perez Perez, A., Ybarra Munoz, J., Blay Cortes, V., & de Pablos Velasco, P. (2007). Obesity and cardiovascular disease. *Public Health Nutrition, 10*(10A), 1156-1163.

Pietilainen, K. H., Kaprio, J., Borg, P., Plasqui, G., Yki-Jarvinen, H., Kujala, U. M., et al. (2008). Physical Inactivity and Obesity: A Vicious Circle. *Obesity (Silver Spring), 16*(2), 409-414.

Plante, T. G., Aldridge, A., Bogden, R., & Hanelin, C. (2003a). Might virtual reality promote the mood benefits of exercise? *Computers in Human Behavior, 19*(4), 495-509.

Price, M., & Anderson, P. (2007). The role of presence in virtual reality exposure therapy. *Journal of Anxiety Disorders, 21*(5), 742-751.

Przybylski, A. K., Ryan, R. M., & Rigby, C. S. (2009). The motivating role of violence in video games. *Personality and Social Psychology Bulletin, 35*(2), 243-259.

Raudenbush, B., Esgro, W., Cessna, T., McCombs, K., & Yahn, R. (2006). Effects of video game play types on pain threshold and tolerance. *Journal of Sport & Exercise Psychology, 28*, S149-S150.

Raudenbush, B., Koon, J., Cessna, T., & McCombs, K. (2009). Effects of playing video games on pain response during a cold pressor task. *Perceptual and Motor Skills, 108*(2), 439-448.

Ravaja, N., Saari, T., Turpeinen, M., Laarni, J., Salminen, M., & Kivikangas, M. (2006). Spatial presence and emotions during video game playing: Does it matter with whom you play? *Presence-Teleoperators and Virtual Environments, 15*(4), 381-392.

Raynor, D. A., Phelan, S., Hill, J. O., & Wing, R. R. (2006). Television viewing and long-term weight maintenance: results from the National Weight Control Registry. *Obesity (Silver Spring), 14*(10), 1816-1824.

Reeve, J., & Deci, E. L. (1996). Elements of the competitive situation that affect intrinsic motivation. *Personality and Social Psychology Bulletin, 22*(1), 10.

Reeves, G. K., Pirie, K., Beral, V., Green, J., Spencer, E., & Bull, D. (2007). Cancer incidence and mortality in relation to body mass index in the Million Women Study: cohort study. *British Medical Journal, 335*(7630), 1134.

Regenbrecht, H. T., Schubert, T. W., & Friedmann, F. (1998). Measuring the sense of presence and its relations to fear of heights in virtual environments. *International Journal of Human-Computer Interaction, 10*(3), 233-249.

Reis, H. T., Sheldon, K. M., Gable, S. L., Roscoe, J., & Ryan, R. M. (2000). Daily well-being: the role of autonomy, competence, and relatedness. *Personality and Social Psychology Bulletin, 26*, 419-435.

Rhodes, R. E., & Blanchard, C. M. (2008). Do sedentary motives adversely affect physical activity? Adding cross-behavioural cognitions to the theory of planned behaviour. *Psychology & Health, 23*(7), 789-805.

Rhodes, R. E., & Dean, R. N. (2009). Understanding Physical Inactivity: Prediction of Four Sedentary Leisure Behaviors. *Leisure Sciences, 31*(2), 124-135.

Riva, G., Mantovani, F., Capideville, C. S., Preziosa, A., Morganti, F., Villani, D., et al. (2007). Affective interactions using virtual reality: The link between presence and emotions. *Cyberpsychology & Behavior, 10*(1), 45-56.

Ryan, R. M., & Deci, E. L. (2000a). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25*(1), 54-67.

Ryan, R. M., & Deci, E. L. (2000b). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68-78.

Ryan, R. M., & Deci, E. L. (2000c). The darker and brighter sides of human existence: Basic psychological needs as a unifying concept. *Psychological Inquiry, 11*(4), 319-338.

Ryan, R. M., Rigby, C. S., & Przybylski, A. (2006). The motivational pull of video games: A self-determination theory approach. *Motivation and Emotion, 30*(4), 347-363.

Sachs-Ericsson, N., Burns, A. B., Gordon, K. H., Eckel, L. A., Wonderlich, S. A., Crosby, R. D., et al. (2007). Body mass index and depressive symptoms in older adults: the moderating roles of race, sex, and socioeconomic status. *American Journal of Geriatric Psychiatry, 15*(9), 815-825.

Saelens, B. E., & Epstein, L. H. (1999). The rate of sedentary activities determines the reinforcing value of physical activity. *Health Psychology, 18*(6), 655-659.

Salamin, P., Thalmann, D., & Vexo, F. (2006). *The benefits of third-person perspective in virtual and augmented reality?* Paper presented at VRST '06. Retrieved January 10, 2010, from http://vrlab.epfl.ch/~psalamin/publications/vrst06.pdf

Salmon, J., Owen, N., Crawford, D., Bauman, A., & Sallis, J. F. (2003). Physical activity and sedentary behavior: A population-based study of barriers, enjoyment, and preference. *Health Psychology, 22*(2), 178-188.

Schneider, E. F., Lang, A., Shin, M., & Bradley, S. D. (2004). Death with a story - How story impacts emotional, motivational, and physiological responses to first-person shooter video games. *Human Communication Research, 30*(3), 361-375.

Schneider, S. M., & Hood, L. E. (2007). Virtual reality: A distraction intervention for chemotherapy. *Oncology Nursing Forum, 34*(1), 39-46.

Sebire, S. J., Standage, M., & Vansteenkiste, M. (2009). Examining intrinsic versus extrinsic exercise goals: cognitive, affective, and behavioral outcomes. *Journal of Sport & Exercise Psychology, 31*(2), 189-210.

Sell, K., Lillie, T., & Taylor, J. (2008). Energy expenditure during physically interactive video game playing in male college students with different playing experience. *Journal of American College Health, 56*(5), 505-511.

Sesso, H. D., Paffenbarger, R. S., Jr., & Lee, I. M. (2000). Physical activity and coronary heart disease in men: The Harvard Alumni Health Study. *Circulation, 102*(9), 975-980.

Sharar, S. R., Carrougher, G. J., Nakamura, D., Hoffman, H. G., Blough, D. K., & Patterson, D. R. (2007). Factors influencing the efficacy of virtual reality distraction analgesia during postburn physical therapy: Preliminary results from 3 ongoing studies. *Archives of Physical Medicine and Rehabilitation, 88*(12), S43-S49.

Sheldon, K. M., Elliot, A. J., Kim, Y., & Kasser, T. (2001). What is satisfying about satisfying events? Testing 10 candidate psychological needs. *Journal of Personality and Social Psychology, 80*(2), 325-339.

Sherry, J. L. (2001). Toward an etiology of media use motivations: The role of temperament in media use. *Communication Monographs, 68*(3), 274-288.

Sherry, J. L., Greenberg, B. S., Lucas, K., & Lachlan, K. (2006). Video game uses and gratifications as predictors of use and game preference. In P. Vorderer & J. Bryant (Eds.), *Playing video games: motives, responses, and consequences*. Mahwah, NJ: Lawrence Erlbaum Associates.

Skalski, P., Lange, R., & Tamborini, R. (2006). *Mapping the way to fun: the effect of video game interfaces on presence and enjoyment*. Paper presented at PRESENCE 06. Retrieved January 10, 2010, from http://www.temple.edu/ispr/prev_conferences/proceedings/2006/Skalski, Lange, Tamborini.pdf

Slater, C., Steed, A., McCarthy, J., & Maringelli, F. (1998). The influence of body movement on subjective presence in virtual environments. *Human Factors, 40*(3), 9.

Slater, M. (1999). Measuring presence: a response to the Witmer and Singer Presence Questionnaire. *Presence-Teleoperators and Virtual Environments, 8*(5), 560-565.

Smith, B. P. (2006). The (computer) games people play: an overview of popular game content. In P. Vorderer & J. Bryant (Eds.), *Playing video games: motives, responses, and consequences* (pp. 43-56). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Spanier, P. A., Marshall, S. J., & Faulkner, G. E. (2006). Tackling the obesity pandemic: a call for sedentary behaviour research. *Canadian Journal of Public Health, 97*(3), 255-257.

Stanney, K., Salvendy, G., Deisinger, J., DiZio, P., Ellis, S., Ellison, J., et al. (1998). Aftereffects and sense of presence in virtual environments: Formulation of a research and development agenda. *International Journal of Human-Computer Interaction, 10*(2), 135-187.

Steuer, J. (1992). Defining virtual reality: dimensions determining telepresence. *Journal of Communication, 4*(2), 73-93.

Straker, L. G., & Abbott, R. (2007). Effect of screen-based media on energy expenditure and heart rate in 9- to 12-year-old children. *Pediatric Exercise Science, 19*, 12.

Sugiyama, T., Healy, G. N., Dunstan, D. W., Salmon, J., & Owen, N. (2008). Joint associations of multiple leisure-time sedentary behaviours and physical activity with obesity in Australian adults. *International Journal of Behavioral Nutrition and Physical Activity, 5*, 35.

Swinburn, B., & Shelly, A. (2008). Effects of TV time and other sedentary pursuits. *International Journal of Obesity (London), 32 Suppl 7*, S132-136.

Takatalo, J. (2002). *Presence and flow in virtual environments: an explorative study.* Unpublished Masters thesis, University of Helsinki, Helsinki.

Takatalo, J., Nyman, G., & Laaksonen, L. (2008). Components of human experience in virtual environments. *Computers in Human Behavior, 24*(1), 1-15.

Tamborini, R., & Skalski, P. (2006). The role of presence in the experience of electronic games. In P. Vorderer & J. Bryant (Eds.), *Playing video games: motives, responses, and consequences* (pp. 225-240). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Tan, B., Aziz, A. R., Chua, K., & Teh, K. C. (2002). Aerobic demands of the dance simulation game. *International Journal of Sports Medicine, 23*, 125-129.

Thogersen-Ntoumani, C., & Ntoumanis, N. (2006). The role of self-determined motivation in the understanding of exercise-related behaviours, cognitions and physical self-evaluations. *Journal of Sports Sciences, 24*(4), 393-404.

Thornton, M., Marshall, S., McComas, J., Finestone, H., McCormick, A., & Sveistrup, H. (2005). Benefits of activity and virtual reality based balance exercise programmes for adults with traumatic brain injury: Perceptions of participants and their caregivers. *Brain Injury, 19*(12), 989-1000.

Tortell, R., & Morie, J. F. (2006). *Videogame play and the effectiveness of virtual environments for training*. Paper presented at the Interserving/Industry Training, Simulation, and Education Conference 2006.

Trost, S. G., Way, R., & Okely, A. D. (2006). Predictive validity of three ActiGraph energy expenditure equations for children. *Medicine & Science in Sports & Exercise, 38*(2), 380-387.

Truesdale, K. P., Stevens, J., Lewis, C. E., Schreiner, P. J., Loria, C. M., & Cai, J. (2006). Changes in risk factors for cardiovascular disease by baseline weight status in young adults who maintain or gain weight over 15 years: the CARDIA study. *International Journal of Obesity (London), 30*(9), 1397-1407.

U.S. Department of Labor. (2009). American Time Use Survey - 2008 Results. Retrieved October 1, 2009, from http://www.bls.gov/news.release/pdf/atus.pdf

Unnithan, V. B., Houser, W., & Fernhall, B. (2006). Evaluation of the energy cost of playing a dance simulation video game in overweight and non-overweight children and adolescents. *Int J Sports Med, 27*(10), 804-809.

Usoh, M., Catena, E., Arman, S., & Slater, M. (2000). Using presence questionnaires in reality. *Presence-Teleoperators and Virtual Environments, 9*(5), 497-503.

Utter, J., Scragg, R., & Schaaf, D. (2006). Associations between television viewing and consumption of commonly advertised foods among New Zealand children and young adolescents. *Public Health Nutrition, 9*(5), 606-612.

Van Schaik, P., Blake, J., Pernet, F., Spears, I., & Fencott, C. (2008). Virtual augmented exercise gaming for older adults. *Cyberpsychology & Behavior, 11*(1), 103-106.

Vandelanotte, C., Sugiyama, T., Gardiner, P., & Owen, N. (2009). Associations of leisure-time internet and computer use with overweight and obesity, physical activity and sedentary behaviors: cross-sectional study. *Journal of Medical Internet Research, 11*(3), e28.

Vansteenkiste, M., & Deci, E. L. (2003). Competitively contingent rewards and intrinsic motivation: Can losers remain motivated? *Motivation and Emotion, 27*(4), 273-299.

Wang, X., & Perry, A. C. (2006). Metabolic and physiologic responses to video game play in 7- to 10-year-old boys. *Archives of Pediatric & Adolescent Medicine, 160*(4), 411-415.

Warburton, D. E., Bredin, S. S., Horita, L. T., Zbogar, D., Scott, J. M., Esch, B. T., et al. (2007). The health benefits of interactive video game exercise. *Applied Physiology, Nutrition, and Metabolism, 32*(4), 655-663.

Warburton, D. E., Sarkany, D., Johnson, M., Rhodes, R. E., Whitford, W., Esch, B. T., et al. (2009). Metabolic requirements of interactive video game cycling. *Medicine & Science in Sports & Exercise, 41*(4), 920-926.

Washburn, R. A., Smith, K. W., Goldfield, S. R., & McKinlay, J. B. (1991). Reliability and physiologic correlates of the Harvard Alumni Activity Survey in a general population. *Journal of Clinical Epidemiology, 44*(12), 1319-1326.

Weinstein, S. E., Quigley, K. S., & Mordkoff, J. T. (2002). Influence of control and physical effort on cardiovascular reactivity to a video game task. *Psychophysiology, 39*(5), 591-598.

Witmer, B., & Singer, M. (1998). Measuring presence in virtual environments: a presence questionnaire. *Presence-Teleoperators and Virtual Environments, 7*(3), 15.

Yang, H., & Olson, G. M. (2002). *Exploring collaborative navigation: the effect of perspectives on group performance*. Paper presented at CVE '02. Retrieved January 10, 2010, from http://portal.acm.org/citation.cfm?id=571899

Zderic, T. W., & Hamilton, M. T. (2006). Physical inactivity amplifies the sensitivity of skeletal muscle to the lipid-induced downregulation of lipoprotein lipase activity. *Journal of Applied Physiology, 100*(1), 249-257.

Zhou, Z. Y., Cheok, A. D., Qiu, Y., & Yang, X. B. (2007). The role of 3-D sound in human reaction and performance in augmented reality environments. *Ieee Transactions on Systems Man and Cybernetics Part a-Systems and Humans, 37*(2), 262-272.

APPENDIX 1. PRE-EXPERIMENTAL QUESTIONNAIRE

Free-time activities

Below is a series of questions about things you may do at home in your free time. Please check the box that comes closest to the correct answer for you. Please answer considering the length of time you spend doing the particular activity, even if you are doing something else at the same time. For example, if you listen to music while using the computer, please count that time in both the computer and music questions.

1. In a usual week, how many hours or minutes do you spend per day using a computer outside of work?

Less than 1 hour	☐
1 hour	☐
2 hours	☐
3 hours	☐
4 hours	☐
5 hours or more	☐
none	☐

2. In a usual week, how many hours or minutes do you spend per day sitting or lying down and watching TV or videos?

Less than 1 hour	☐
1 hour	☐
2 hours	☐
3 hours	☐
4 hours	☐
5 hours or more	☐
none	☐

3. In a usual week, how many hours or minutes do you spend per day sitting or lying down and playing video games?

Less than 1 hour	☐

1 hour	☐
2 hours	☐
3 hours	☐
4 hours	☐
5 hours or more	☐
none	☐

4. In a usual week, how many hours or minutes do you spend per day sitting or lying down and reading?

Less than 1 hour	☐
1 hour	☐
2 hours	☐
3 hours	☐
4 hours	☐
5 hours or more	☐
none	☐

5. In a usual week, how many hours or minutes do you spend per day sitting or lying down and listening to music?

Less than 1 hour	☐
1 hour	☐
2 hours	☐
3 hours	☐
4 hours	☐
5 hours or more	☐
none	☐

6. In a usual week, how many hours or minutes do you spend per day sitting or lying down and talking on the phone?

Less than 1 hour	☐

1 hour	☐
2 hours	☐
3 hours	☐
4 hours	☐
5 hours or more	☐
none	☐

7. In a usual week, how many hours or minutes do you spend per day sitting or lying down and relaxing, thinking, or resting?

Less than 1 hour	☐
1 hour	☐
2 hours	☐
3 hours	☐
4 hours	☐
5 hours or more	☐
none	☐

8. In a usual week, how many hours or minutes do you spend per day sitting or lying down and doing other hobbies?

Less than 1 hour	☐
1 hour	☐
2 hours	☐
3 hours	☐
4 hours	☐
5 hours or more	☐
none	☐

Physical activity

Please answer the following questions based on your average daily physical activity habits for the past year.

1. How many stairs did you climb up on an average day during the past year?

__________ stairs per day (1 flight or floor = 10 stairs)

2. How many city blocks or their equivalent did you walk on an average day during the past year?

__________ blocks per day (12 blocks = 1 mile)

3. List any sports, leisure, or recreational activities you have participated in on a regular basis during the past year. Enter the average number of times per week you took part in these activities and the average duration of these sessions. Include only time you were physically active (that is, actual playing or activity time).

Sport or recreation	Times per week	Time per episode	
		Hours	Minutes
________________	___________	________	________
________________	___________	________	________
________________	___________	________	________
________________	___________	________	________
________________	___________	________	________
________________	___________	________	________

Immersive tendencies

Below is a series of statements and questions asking about your normal experiences with different types of media. Please circle the number that comes closest to how you feel. Use the anchor words for each question to decide on the best number.

1. **Do you easily become deeply involved in movies or TV dramas?**

1	2	3	4	5	6	7
Never			Occasionally			Often

2. **Do you ever become so involved in a television program or book that people have problems getting your attention?**

1	2	3	4	5	6	7
Never			Occasionally			Often

3. **Do you ever become so involved in a movie that you are not aware of things happening around you?**

1	2	3	4	5	6	7
Never			Occasionally			Often

4. **How frequently do you find yourself closely identifying with the characters in a story line?**

1	2	3	4	5	6	7
Never			Occasionally			Often

5. **Do you ever become so involved in a video game that it is as if you are inside the game rather that moving a joystick and watching the screen?**

1	2	3	4	5	6	7
Never			Occasionally			Often

6. **How good are you at blocking out external distractions when you are involved in something?**

1	2	3	4	5	6	7
Never			Occasionally			Often

7. **When watching sports, do you ever become so involved in the game that you react as if you were one of the players?**

1	2	3	4	5	6	7
Never			Occasionally			Often

8. Do you ever become so involved in a daydream that you are not aware of things happening around you?

1	2	3	4	5	6	7
Never			Occasionally			Often

9. Do you ever have dreams that are so real that you feel disorientated when you awake?

1	2	3	4	5	6	7
Never			Occasionally			Often

10. When playing sports, do you become so involved in the game that you lose track of time?

1	2	3	4	5	6	7
Never			Occasionally			Often

11. How well do you concentrate on enjoyable activities?

1	2	3	4	5	6	7
Never			Occasionally			Often

12. How often do you play arcade or video games? (Often should be taken to mean every day or every two days, on average)

1	2	3	4	5	6	7
Never			Occasionally			Often

13. Have you ever gotten excited during a chase or fight scene on TV or in the movies?

1	2	3	4	5	6	7
Never			Occasionally			Often

14. Have you ever gotten scared by something happening on a TV show or in a movie?

1	2	3	4	5	6	7
Never			Occasionally			Often

15. Have you ever remained apprehensive or fearful long after watching a scary movie?

1	2	3	4	5	6	7
Never			Occasionally			Often

16. Do you ever become so involved in doing something that you lose all track of time?

1	2	3	4	5	6	7
Never			Occasionally			Often

Video game experiences and preferences

These questions ask about your experience playing games and how you prefer to play them. Please circle the number or mark the box that is closest to your answer.

1. How much experience do you have playing video games?

1	2	3	4	5	6	7
Not a lot			Some			A lot

2. How much do you like the following game genres?

	Strongly dislike			Neither like nor dislike			Strongly like
	1	2	3	4	5	6	7
Action							
Adventure							
Driving/racing							
Shooter							
Fantasy/role-playing							
Fighting							
Music/rhythm							
Platform							
Puzzle							
Simulation							
Sports							
Survival horror							

3. In a typical month, how much money do you spend on video games (buying and/or renting)?

_______________ dollars per month

4. What is the longest number of hours you've ever spent playing a single video game in one sitting (at one time)?

Less than 1 hour	☐
1 hour	☐
2 hours	☐
3 hours	☐
4 hours	☐
5 hours	☐
6 hours	☐
7 hours	☐
More than 7 hours	☐

5. What is the longest number of hours you've ever spent playing a single video game not in one sitting (total over the entire time you played the game)?

Less than 1 hour	☐
1 – 10 hours	☐
11 – 20 hours	☐
21 – 30 hours	☐
31 – 40 hours	☐
41 – 50 hours	☐
51 – 60 hours	☐
61 – 70 hours	☐
More than 70 hours	☐

If more than 70 hours, how long? ____________

6. Which of the following video game consoles do you have in your home?

Playstation 3	☐	DS	☐
Wii	☐	PSP	☐
Xbox360	☐	Gameboy Advance	☐
GameCube	☐	Other handheld	☐
Playstation 2	☐	Other older system	☐
Xbox	☐		

<u>Reasons for playing video games</u>

Below is a series of statements and questions asking about your normal experiences with different types of media. Please circle the number that comes closest to how you feel. Use the anchor words for each question to decide on the best number.

1. I play video games because they let me do things I can't do in real life.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

2. I find that playing video games raises my level of adrenaline.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

3. I feel proud when I master an aspect of the game.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

4. I play video games when I have other things to do.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

5. Video games keep me on the edge of my seat.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

6. I like to play to prove to my friends that I am the best.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

7. My friends and I use video games as a reason to get together.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

8. I find it very rewarding to get to the next level.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

9. Video games allow me to pretend I am someone/somewhere else.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

10. I play video games instead of other things I should be doing.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

11. I play video games because they stimulate my emotions.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

12. When I lose to someone, I immediately want to play again in an attempt to beat him/her.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

13. I play until I complete a level or win a game.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

14. I like to do something that I could not normally do in real life through a video game.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

15. Often, a group of friends and I will spend time playing video games.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

16. It is important to me to be the fastest and most skilled person playing the game.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

17. I enjoy finding new and creative ways to work through video games.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

18. I enjoy the excitement of assuming an alter ego in a game.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

19. I play video games because they excite me.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

20. I get upset when I lose to my friends.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

Emotional response
This scale consists of a number of words that describe different feelings and emotions. Read each item and then circle the appropriate answer next to that word. Indicate to what extent you felt this way during the past week.

	Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
1. Interested	1	2	3	4	5
2. Distressed	1	2	3	4	5
3. Excited	1	2	3	4	5
4. Upset	1	2	3	4	5
5. Strong	1	2	3	4	5
6. Guilty	1	2	3	4	5
7. Scared	1	2	3	4	5
8. Hostile	1	2	3	4	5
9. Enthusiastic	1	2	3	4	5
10. Proud	1	2	3	4	5
11. Irritable	1	2	3	4	5
12. Alert	1	2	3	4	5
13. Ashamed	1	2	3	4	5
14. Inspired	1	2	3	4	5
15. Nervous	1	2	3	4	5
16. Determined	1	2	3	4	5
17. Attentive	1	2	3	4	5
18. Jittery	1	2	3	4	5
19. Active	1	2	3	4	5
20. Afraid	1	2	3	4	5

Eating habits

1. Place an x in the box to indicate the number of snacks (food or drinks) you typically eat on weekdays and weekends/vacation days.

	Weekdays					Weekends/vacation days				
Snacks	None	1	2	3	4+	None	1	2	3	4+
Between breakfast and lunch										
After lunch, before dinner										
After dinner										

2. Think about your usual snacks. How often do you eat each type of snack food? Place an x in the appropriate box.

	Never/less than 1 per month	1-3 per month	One per week	2-6 per week	1 or more per day
Potato chips (1 small bag)					
Corn chips/Doritos (small bag)					
Nachos with cheese (1 serving)					
Popcorn (1 small bag)					
Pretzels (1 small bag)					
Peanuts, nuts (1 small bag)					
Fun fruit or fruit rollups (1 pack)					
Graham crackers					
Crackers, like saltines or wheat thins					
Poptarts (1)					
Cake (1 slice)					
Snack cakes, twinkies (1 package)					

	Never/less than 1 per month	1-3 per month	One per week	2-6 per week	1 or more per day
Danish, sweetrolls, pastry (1)					
Donuts (1)					
Cookies (1)					
Brownies (1)					
Pie (1 slice)					
Chocolate (1 bar or packet), like Hershey's or M&Ms					
Other candy bars (Milky Way, Snickers)					
Other candy without chocolate (Skittles) (1 pack)					
Jello					
Pudding					
Frozen yogurt					
Ice cream					
Milkshake or frappe (1)					
Popsicles					

Background questions

Please write in your answer or check the box that describes you best.

1. What is your age?

____________________ years old

2. What is your date of birth?

______/_______/______

3. Are you

☐ Male ☐ Female

4. Are you Hispanic or Latino?

☐ Yes ☐ No

5. Which one or more of the following would you say is your race?

American Indian or Alaska Native	☐
Asian	☐
Black or African American	☐
Native Hawaiian or Other Pacific Islander	☐
White	☐
Other race	☐

6. What is the highest grade of school you have completed?

Some high school	☐
High school graduate or GED	☐
Some college or technical school	☐
College graduate	☐
Graduate or professional school	☐

APPENDIX 2: BETWEEN GAMES QUESTIONNAIRE

Exertion

Look at the rating scale on the wall. It ranges from 6 to 20, where 6 means "no exertion at all" and 20 means "maximal exertion." Choose the number from the wall that best describes your level of exertion during the game. Try to appraise your feeling of exertion as honestly as possible, without thinking about what the actual physical load is. Your own feeling of effort and exertion is important, not how it compares to other people's. Look at the scales and the expressions and then give a number.

____

Next is a series of statements and questions asking you to think about your experience of playing the game. Please check the box of the number from 1 to 7 that comes closest to how you felt *while you were playing the game*. Use the anchor words for each item to help decide which number is best.

Presence

1. Please rate your sense of being in the game environment, on the following scale from 1 to 7, where 7 represents your normal experience of being in a place.
   I had a sense of "being there" in the game:

1	2	3	4	5	6	7
Not at all						Very much

2. To what extent were there times during the experience when the game environment was the reality for you?
   There were times during the experience when the game environment was the reality for me…

1	2	3	4	5	6	7
At no time						Almost all the time

3. When you think back about your experience, do you think of the game more as images that you saw, or more as somewhere that you visited?
   The game environment seemed to me to be more like…

1	2	3	4	5	6	7
Images that I saw						Somewhere that I visited

4. During the time of the experience, which was strongest on the whole, your sense of being in the game, or of being elsewhere?
   I had a stronger sense of…

1	2	3	4	5	6	7
Being elsewhere						Being in the game

5. Consider your memory of playing the game. How similar in terms of the structure of the memory is this to the structure of the memory of other places you have been today? By "structure of the memory," consider things like the extent to which you have a visual memory of the game environment, whether that memory is in color, the extent to which the memory seems vivid or realistic, its size, location in your imagination, the extent to which it is panoramic in your imagination, and other structural elements.
   I think of the game environment as a place in a way similar to the other places that I've been today:

1	2	3	4	5	6	7
Not at all						Very much so

6. During the time of the experience, did you often think to yourself that you were actually in the game environment?
   During the experience I often thought that I was really in the game…

1	2	3	4	5	6	7
Not very often						Very much so

Engagement

1. To what extent did you feel mentally immersed in the experience?

1	2	3	4	5	6	7
Not at all						Very much

2. How involving was the experience?

1	2	3	4	5	6	7
Not at all						Very much

3. How completely were your senses engaged?

1	2	3	4	5	6	7
Not at all						Very much

4. To what extent did you experience a sensation of reality?

1	2	3	4	5	6	7
Not at all						Very much

5. How relaxing or exciting was the experience?

1	2	3	4	5	6	7
Very relaxing						Very exciting

6. How engaging was the story?

1	2	3	4	5	6	7
Not at all						Very much

Spatial Presence

1. How much did it seem as if the objects and people you saw/heard had come to the place where you were?

1	2	3	4	5	6	7
Not at all						Very much

2. How much did it seem as if you could reach out and touch the objects you saw/heard?

1	2	3	4	5	6	7
Not at all						Very much

3. How often when an object seemed to be headed toward you did you want to move to get out of its way?

1	2	3	4	5	6	7
Never						Always

4. To what extent did you experience a sense of being there inside the environment you saw/heard?

1	2	3	4	5	6	7
Not at all						Very much

Emotional response

This scale consists of a number of words that describe different feelings and emotions. Read each item and then circle the appropriate answer next to that word. Indicate to what extent you felt this way while playing the game.

	Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
1. Interested	1	2	3	4	5
2. Distressed	1	2	3	4	5
3. Excited	1	2	3	4	5
4. Upset	1	2	3	4	5
5. Strong	1	2	3	4	5
6. Guilty	1	2	3	4	5
7. Scared	1	2	3	4	5
8. Hostile	1	2	3	4	5
9. Enthusiastic	1	2	3	4	5
10. Proud	1	2	3	4	5
11. Irritable	1	2	3	4	5
12. Alert	1	2	3	4	5
13. Ashamed	1	2	3	4	5
14. Inspired	1	2	3	4	5
15. Nervous	1	2	3	4	5
16. Determined	1	2	3	4	5
17. Attentive	1	2	3	4	5
18. Jittery	1	2	3	4	5
19. Active	1	2	3	4	5
20. Afraid	1	2	3	4	5

Experiences with game characters

1. How often did you have the sensation that people you saw/heard could also see/hear you?

1	2	3	4	5	6	7
Never						Always

2. To what extent did you feel you could interact with the person or people you saw/heard?

1	2	3	4	5	6	7
None						Very much

3. How much did it seem as if you and the people you saw/heard were together in the same place?

1	2	3	4	5	6	7
Not at all						Very much

4. How often did it feel as if someone you saw/heard in the environment was talking directly to you?

1	2	3	4	5	6	7
Never						Always

Control over the game

1. How much were you able to control events?

1	2	3	4	5	6	7
Not at all			Somewhat			Completely

2. How responsive was the environment to actions that you initiated (or performed)?

1	2	3	4	5	6	7
Not responsive			Moderately responsive			Completely responsive

3. Were you able to anticipate what would happen next in response to the actions that you performed?

1	2	3	4	5	6	7
Not at all			Somewhat			Completely

4. How much delay did you experience between your actions and expected outcomes?

1	2	3	4	5	6	7
Long delays			Moderate delays			No delays

5. How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?

1	2	3	4	5	6	7
Not proficient			Reasonably proficient			Very proficient

<u>Competence</u>

1. I think I am pretty good at this game.

1	2	3	4	5	6	7
Not at all true			Somewhat true			Very true

2. I think I did pretty well at this game, compared to others.

1	2	3	4	5	6	7
Not at all true			Somewhat true			Very true

3. After working at this game for awhile, I felt pretty competent.

1	2	3	4	5	6	7
Not at all true			Somewhat true			Very true

4. I am satisfied with my performance in this game.

1	2	3	4	5	6	7
Not at all true			Somewhat true			Very true

5. I was pretty skilled at this game.

1	2	3	4	5	6	7
Not at all true			Somewhat true			Very true

6. This was a game that I couldn't do very well.

1	2	3	4	5	6	7
Not at all true			Somewhat true			Very true

Game Enjoyment

1. I enjoyed playing this game very much.

1	2	3	4	5	6	7
Not at all true			Somewhat true			Very true

2. This game was fun to play.

1	2	3	4	5	6	7
Not at all true			Somewhat true			Very true

3. I thought this was a boring game.

1	2	3	4	5	6	7
Not at all true			Somewhat true			Very true

4. This game did not hold my attention at all.

1	2	3	4	5	6	7
Not at all true			Somewhat true			Very true

5. I would describe this game as very interesting.

1	2	3	4	5	6	7
Not at all true			Somewhat true			Very true

6. I thought this game was quite enjoyable.

1	2	3	4	5	6	7
Not at all true			Somewhat true			Very true

7. While I was playing this game, I was thinking about how much I enjoyed it.

1	2	3	4	5	6	7
Not at all true			Somewhat true			Very true

Game familiarity and reactions

1. Have you ever played this game before?

No, I haven't played it at all	☐
Yes, I've played it a little bit	☐
Yes, I've played it some	☐
Yes, I've played it a lot, but haven't beaten it	☐
Yes, I've beaten it	☐
Yes, I've beaten it multiple times	☐

2. How often have you played games similar to this one?

1	2	3	4	5	6	7
Not very often			Somewhat often			Very often

3. How much did this game frustrate you?

1	2	3	4	5	6	7
Not much			Some			A lot

4. How likely would you be to play this game again in the future, if you were given the chance?

1	2	3	4	5	6	7
Not likely			Somewhat likely			Very likely

5. Why?

____

APPENDIX 3: FINAL QUESTIONNAIRE

The following questions ask for your opinions on the games you played today and how you played them. When you answer these questions, please think about your experience over the entire study period, including all of the games and all of the controllers.

1. Which of the controllers you used today was the easiest to use? Please rank them in order from 1 to 5, with 1 meaning the easiest to use and 5 meaning the hardest to use.

   Balance board ____________

   Dance mat ____________

   Drum set ____________

   Guitar ____________

   Wiimote and Nunchuk ____________

2. Which of the controllers you used today was the most fun to use? Please rank them in order from 1 to 5, with 1 meaning the most fun to use and 5 meaning the least fun to use.

   Balance board ____________

   Dance mat ____________

   Drum set ____________

   Guitar ____________

   Wiimote and Nunchuk ____________

3. Please rank the games you played today in order in terms of how much you liked them, with 1 being your favorite and 7 being your least favorite.

Dance Dance Revolution: Hottest Party	____________
Guitar Hero III	____________
Medal of Honor: Heroes 2	____________
Resident Evil 4: Wii Edition	____________
Resident Evil: The Umbrella Chronicles	____________
Rock Band	____________
Wii Fit	____________

4. Thinking about your favorite game that you played today, how likely would you be to play it again if given the chance?

1	2	3	4	5	6	7
Not likely						Very likely