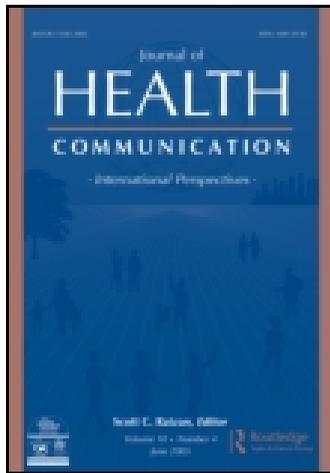


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Can Exergames Impart Health Messages? Game Play, Framing, and Drivers of Physical Activity Among Children

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This study examines the effectiveness of incorporating exergaming into physical education lessons as a platform for imparting health education messages and influencing children's beliefs about and attitudes toward physical activity. The authors launched a 6-week intervention program using Nintendo Wii games coupled with protection motivation theory-based health messaging among 5th-grade school children in Singapore. Results indicated that when children who were exposed to threat-framed messages played Wii exergames during physical education lessons, they reported more positive physical activity attitude, self-efficacy, and perceived behavioral control than did those who underwent regular physical education lessons and were exposed to the same message. In addition, among children playing Wii, the threat and coping frames had similar effects on the degree of message influence on physical activity attitudes and beliefs. The implications for schools, parents, and health policy are discussed.

Changing lifestyles have contributed to physical inactivity in both developed and developing nations (World Health Organization, 2010). Although it is recommended that children engage in 1 or more hours of physical activity each day (Centers for Disease Control and Prevention, 2010; World Health Organization, 2010), 13-year-old children in the United States are likely to exercise less than that amount and even less as they grow older (Nader, Bradley, Houts, McRitchie, & O'Brien, 2008). Similarly, adolescents in Asian countries such as Singapore have been found to be insufficiently active (Lee & Trost, 2006). This decline in physical activity among young people has been found to play a role in the prevalence of obesity in many nations (Steinbeck, 2001). In Asia, for example, at least 2 out of 10 school-aged youth were predicted to be overweight by 2010 (Wang & Lobstein, 2006).

In efforts to battle obesity, intervention programs to encourage physical activity in school, family, and community settings have been tested (Salmon, Booth, Phongsavan, Murphy, & Timperio, 2007). Some schools in the United States have incorporated exergaming into physical education (PE) classes in an attempt to encourage sedentary children to be more physically active (Davis, 2008; Henning, 2007). The American Heart Association has also endorsed exergames in its campaign against

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obesity (Lenzer, 2010). Exergaming integrates video game play and physical exercise into one medium (Sall & Grinter, 2007), and individuals engage in physical movement when playing such exergames as *Wii Sports* and *Dance Dance Revolution*. Exergames' potential to enhance physical activity appears promising, as they have been related to increased enjoyment levels and higher levels of energy expenditure than sedentary activities (White, Kilding, & Schofield, 2009).

Another direction for combating obesity-related behavior includes the use of communication messages in campaigns or individually. Messages that use framing have been found particularly influential in encouraging antiobesity behavior. The prospect theory, for example, which uses gain- and loss-framed messages, has been applied in the exercise domain (Jones, Sinclair, & Courneya, 2003; Jones, Sinclair, Rhodes, & Courneya, 2004). Research shows that messages can be more effective in influencing beliefs, motivation, and behavior when they are anchored in health communication theories (Fishbein & Cappella, 2006; Graham, Prapavessis, & Cameron, 2006).

Obesity-prevention campaigns that rely solely on media campaigns have seen limited success (Wardle, Rapoport, Miles, Afuape, & Duman, 2001). Multifaceted interventions that include other elements in addition to their media component are likely to be more effective in changing beliefs. For example, Flynn and colleagues (1994) reported a combined media- and school-based antismoking intervention to be effective. An approach that combines an implementation intention plan with the mobile short text-message system has also been found more effective in boosting exercise levels than any one intervention alone (Prestwich, Perugini, & Hurling, 2009).

Most of the existing research examining the effects of message framing and exergaming in the promotion of physical activity has looked only at their solo effects in enhancing behavior and motivation. In this study, we aimed to investigate the combined effects of two types of intervention, exergaming and the provision of health education messages, in influencing beliefs about physical activity among children. This research makes a number of important contributions. First, it is one of the initial studies (a) to integrate exergaming and message interventions and (b) to examine their influence on physical activity beliefs. Simulated exercises through exergaming allow for an experiential type of intervention, while health promotion messages represent a more cognitive-based intervention. Combining these two interventions allow for the examination of the efficacy of a mixed experiential- and cognitive-based intervention versus a cognitive-based intervention only in influencing physical activity beliefs. Second, although there is a growing body of research assessing the efficacy of exergaming in boosting physical activity levels, to our knowledge, most of the studies in this arena focus on physiological measures and lack theoretical framework. To address this gap in the research, the present study draws upon the theory of planned behavior (TPB) to guide our assessment of the efficacy of exergaming and message interventions in enhancing physical activity, particularly in terms of attitudes and beliefs. Third, we aimed to examine the effectiveness of theory-based health messages among children. Few studies have used protection motivation theory-based messages targeted at children (Floyd, Prentice-Dunn, & Rogers, 2000), and none has applied the theory in the context of physical activity.

Literature Review

Persuasive Health Messages

Health campaigns have made use of such theories as social cognitive theory, the TPB, and the elaboration likelihood model (Noar, 2006), as they have been shown to guide

the behavioral determinants that messages should target (Brawley & Latimer, 2007). For example, messages that emphasize immediate or short-term benefits have been reported to influence attitudes among younger people (e.g., Ouellette, Hessling, Gibbons, Reis-Bergan, & Gerrard, 2005).

The protection motivation theory (PMT; Rogers & Prentice-Dunn, 1997), which posits that protection motivation—or the intention to protect oneself from negative health conditions—is determined by an individual's threat and coping appraisals, is particularly useful in guiding the construction of health messages. Threat appraisal consists of the individual's assessment of his or her vulnerability to health threats and the severity of those threats, whereas coping appraisal reflects his or her belief in the efficacy of the recommended health behavior in reducing those threats and ability to adopt that behavior. A review of PMT applications revealed coping appraisal to be more closely associated with protection motivation than threat appraisal (Milne, Sheeran, & Orbell, 2000). In the physical activity context, intention has been found to be affected by self-efficacy (Fruin, Pratt, & Owen, 1992) as well as perceived response efficacy (Stanley & Maddux, 1986). Among the threat appraisal variables, perceived vulnerability to heart disease and stroke has been found to influence participation in aerobic exercise (Wurtele & Maddux, 1987). Similarly, persuasive communication interventions grounded in PMT can be an effective tool in health promotion programs (Milne, Orbell, & Sheeran, 2002). For example, exposure to a video embedded with PMT component-related messages proved effective in influencing participants' coping appraisal, particularly their response efficacy and intention to exercise more (Graham et al., 2006). Reading persuasive communication material arguing that exercise can help to reduce the risk of contracting the disease has been shown to lead to a greater intention to exercise (Courneya & Hellsten, 2001).

Exergaming

Since exergames were launched in the 2000s, researchers have begun to investigate the effects of exergaming on the physical and psychological state of players. Exergame players have been found to expend twice as much energy as their counterparts playing sedentary video games (Lanningham-Foster et al., 2009). Playing even the beginner's level of Dance Dance Revolution can result in an energy expenditure level that meets the daily cardiorespiratory requirement recommended by the American College of Sports Medicine (Tan, Aziz, Chua, & Teh, 2002). Furthermore, a pilot study showed that exergames can have favorable effects on weight loss and glucose levels (Smith, 2005).

Exergame systems such as the Wii have attracted particular attention from researchers interested in assessing exergaming's motion-movement effects on health. Researchers have shown the level of energy expenditure from playing Wii exergames to be significantly higher than that from watching television or from playing sedentary or seated video games (Graf, Pratt, Hester, & Short, 2009; Graves, Stratton, Ridgers, & Cable, 2008). The Wii boxing game, in particular, can significantly increase energy expenditure (Lanningham-Foster et al., 2009; Miyachi, Yamamoto, Ohkawara, & Tanaka, 2010) and generate physiological (e.g., heart rate) and metabolic (e.g., energy expenditure) response values equivalent to brisk treadmill walking (Willems & Bond, 2009). Critics have argued, however, that although playing Wii Sports produces greater energy expenditure than playing sedentary games, the amount is likely to be less than that produced from playing actual sports (Graves et al., 2008; White et al., 2009).

The potential of exergames to encourage more physical activity could also be derived from their psychological benefits. Overweight children who played Dance Dance Revolution at least five times per week were more likely to have higher levels of self-esteem and to start exercising regularly (Brubaker, 2006). Among girls, the perceived social support structure afforded by exergames' ease of access and multiplayer function has been cited as a factor in boosting physical activity levels (Motl et al., 2001). Children consistently rank Wii exergames, such as Wii boxing, Wii tennis, Wii bowling, and Wii Fit, as more enjoyable than running, walking, or even watching television (White, Kilding, & Schofield, 2009). Similarly, participants who played the Wii boxing game were shown to experience greater enjoyment and exhibit better ability to improve a negative mood than those who played a computer boxing game or watched a boxing match on DVD (Chen & Raney, 2009). Penko and Barkley (2010) found lean children to exhibit greater motivation to play Wii than traditional sedentary video games, whereas their overweight/obese counterparts felt equally motivated by the two. Exergaming has also been shown to appeal to sedentary adolescents and to those with weak exercise self-efficacy, and hence the confidence instilled through successful exergame plays may motivate these groups to pursue real sports (Klein & Simmers, 2009). Klein and Simmers (2009) found Nintendo Wii to be perceived more as a form of entertainment than exercise.

Conceptual Framework

Fishbein and Capella (2006) argued that a better understanding of behavioral determinants is useful in developing effective intervention strategies to influence behavioral change. Among the various behavioral prediction theories, the TPB (Ajzen, 1988, 1991) has gained wide support in predicting health behavior (e.g., Armitage & Conner, 2000). TPB posits behavioral intention, which reflects a person's plans and motivation to engage in a certain type of behavior, as the most proximal determinant of behavior. In turn, behavioral intention is influenced by attitude, subjective norm, and perceived behavioral control (PBC). Attitude reflects an individual's positive or negative evaluation of a particular behavior, whereas subjective norm refers to the perceived social pressure from significant others to engage (or fail to engage) in that behavior. PBC represents the perceived level of control a person has over engagement in a particular type of behavior (Sheeran, Trafimow, & Armitage, 2003). In addition to the three main constructs used to predict behavioral intention, scholars have proposed the incorporation of several others (e.g., Conner & Armitage, 1998). For example, group norm, which is drawn from social identity/self-categorization theory has been proposed to be added to TPB, as the perceived norms concerning related behavior among referent groups can influence behavioral intention (Johnston & White, 2003). The inclusion of self-efficacy in TPB has also been recommended, as it has been reported to be distinct from PBC. Self-efficacy is concerned with perceived internal control or control over "one's own personal resources," whereas PBC refers to "factors beyond one's personal control that may either facilitate or inhibit behavior" (Bandura, 1997, as cited in Armitage & Conner, 2001, p. 1433).

The aim of this study was to examine the effect of exergaming, specifically playing Wii exergames, and PMT-based health message interventions on the antecedents of physical activity intention and behavior. Given that TPB has been widely applied to the physical activity domain (Armitage, 2005), it provides us with a suitable analytical framework by which to understand which social cognitive constructs are affected

by the combined health message and exergaming intervention. As Figure 1 shows, we propose that exergaming and health education messages can together influence children's physical attitudes, perceived norms (subjective and group norms), self-efficacy, PBC, and intention. Intention appears on the right-hand side of the framework, with the arrows from attitudes, perceived norms, and perceived control pointing toward it, which is in line with the essence of TPB. In this research, we focus on examining the direct influence of both interventions on behavioral intention in addition to the other TPB variables, as opposed to testing TPB by assessing the relationship between intention and its determinants.

Lieberman (2001) and other scholars have suggested that the medium by which messages are communicated can have differential effects on young audiences. She argued that messages delivered to youth through pamphlets may be perceived as less relevant than those delivered through video games. Video games may be seen by this population as "their" medium, and hence they may deem the messages delivered through this medium to be targeted at them (Lieberman, 2001). For example, preadolescents who played an action-adventure video game infused with an antismoking message were found to have a higher level of awareness about the negative consequences of smoking, stronger attitudes against smoking, and greater intentions not to smoke (Tingen, Grimling, Bennett, Gibson, & Renew, 1997). Moreover, as the literature suggests that exergaming has positive effects on energy expenditure and physical activity motivation (e.g., Graves et al., 2008), we hypothesize the following.

Hypothesis 1: Among children exposed to health messages with coping frames, playing Wii exergames during PE lessons will elicit more favorable (a) attitudes, (b) self-efficacy, (c) PBC, (d) subjective norm, (e) group norm, and (f) intention toward physical activity than participating in regular PE lessons.

Hypothesis 2: Among children exposed to health messages with threat frames, playing Wii exergames during PE lessons will elicit more favorable (a) attitudes, (b) self-efficacy, (c) PBC,

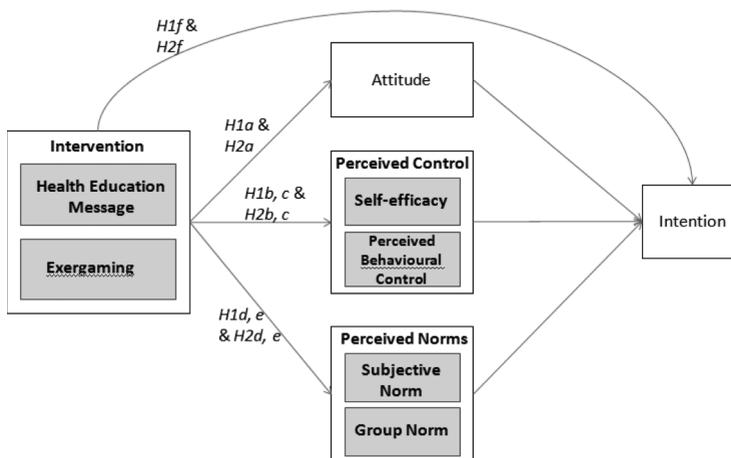


Figure 1. Conceptual model to assess the effect of a 6-week intervention program incorporating exergaming and health messages on physical activity beliefs.

(d) subjective norm, (e) group norm, and (f) intention toward physical activity than participating in regular PE lessons.

Health promotion research has revealed that coping-framed messages can have a positive influence on beliefs about physical activity (Courneya & Hellsten, 2001; Graham et al., 2006). The coping appraisal component of PMT is generally considered to be more closely related to physical activity measures than the theory's threat appraisal component (Plotnikoff & Higginbottom, 2002), although there is a line of research showing that messages imbued with threat or fear appeals can produce favorable outcomes when coping responses that individuals can easily undertake are also proposed (Self & Rogers, 1990; Witte & Allen, 2000). Most of the studies in this arena have been conducted using adult samples, however, and, to the best of our knowledge, there is little evidence concerning the effect of coping- and threat-framed health messages on physical activity levels among children. Hence, assessing the comparative effects of these two message frames in two different contexts, i.e., when coupled with an exergaming intervention and when coupled with regular PE lessons (normative context for school-going children) is of considerable research interest. Accordingly, we posed the following research questions.

Research Question 1: Among children who play Wii, how do health messages with coping frames versus threat frames fare in eliciting favorable (a) attitudes, (b) self-efficacy, (c) PBC, (d) subjective norm, (e) group norm, and (f) intention toward physical activity?

Research Question 2: Among children who participate in the regular PE lessons, how do health messages with coping frames versus threat frames fare in eliciting favorable (a) attitudes, (b) self-efficacy, (c) PBC, (d) subjective norm, (e) group norm, and (f) intention toward physical activity?

Method

Participants and Procedures

The present study was carried out in Singapore, a city state in which the trend toward obesity and excess weight is a huge concern (Soon, Koh, Wong, & Lam, 2008), with their prevalence rates having increased steadily from 5.1% and 21.1%, respectively, in 1992 to 6.9% and 25.6% in 2004. At the same time, Singapore's population is highly technologically savvy. In 2009, 81% of Singaporean households had access to the Internet (Info-Communications Development Authority of Singapore, 2010), and Wii sales regularly exceed those for Xbox 360 and PlayStation 3 (Wikipedia, 2010). For these reasons, Singapore is a particularly suitable setting for this research.

We gained approval from Singapore's Ministry of Education to administer a 6-week intervention program in three elementary schools. Written parental consent was obtained prior to the study. Four classes were selected within each of the three participating schools, with each class randomly assigned to one experimental condition. We used a 2×2 factorial design, as shown in Figure 2, with subjects being exposed to either

Type of PE lesson \ Health message	PE lesson with Wii	Regular PE lesson without Wii
Coping	Condition 1	Condition 2
Threat	Condition 3	Condition 4

Figure 2. 2×2 (Type of Physical Education Lesson \times Health Education Message Framing) factorial design.

a threat- or coping-framed health education message and participating in either a regular PE lesson or a PE lesson incorporating an exergaming (Wii) component.

Three Wii game consoles were set up in each school, and no more than two players at a time were assigned to one console. Participants in the PE lesson with Wii condition played Wii exergames during one of their weekly 45-minute PE lessons over a consecutive 6-week period. Three Wii exergames were chosen for a period of two weeks each, starting with Dance Dance Revolution, followed by Wii tennis and Wii boxing in rotation. These games were chosen because the two Wii Sports games have been found to generate energy expenditure levels that were at least equivalent to moderate physical activity intensity (Miyachi et al., 2010) and that engaging in the beginner level of Dance Dance Revolution met the minimal cardio respiratory requirement (Tan, Aziz, Chua, & Teh, 2002). Participants in the regular PE lesson condition were given no opportunity to play Wii, but took part only in the regular PE curriculum outlined by each school.

All participants in the health communication intervention condition were provided with one-page, A4-sized color brochures containing health education messages. These brochures, which used simple language suitable for elementary students, were distributed before the PE lessons in Weeks 1, 3, and 6 of the 6-week intervention period, and the participating students were asked to read them in their own time and retain them. Their teachers were asked to explain any vocabulary that participants did not understand. Participants in both conditions were given health education messages relating to physical activity, framed accordingly in either PMT's coping or threat appraisals. Participants in the coping appraisal condition, for example, were provided with practical tips on how to develop physical activity habits, whereas those in the threat appraisal condition received messages highlighting the negative health outcomes associated with obesity, such as heart disease, stroke, and diabetes. The content of both brochures was based on existing health communication materials obtained from Singapore's Health Promotion Board. Before administering the health message intervention, we showed the brochures to a few elementary school students as a pretest to determine whether the messages were understandable to this population.

After taking part in the 6-week program, a self-completion paper-and-pen survey was administered to all participants. Research assistants assisted in administering the survey and answering queries.

Measures

We measured attitude using seven items adapted from Lowe, Eves, and Carroll's (2002) affective and instrumental attitude scale. Participants were asked to indicate

their responses to the statement, "For me, exercising in my leisure time over the next 6 months would be ..." on seven 5-point semantic-differential scales, such as *harmful-beneficial* and *enjoyable-unenjoyable*. All items were averaged to form a composite scale, with higher scores indicating a more positive attitude (Cronbach's $\alpha = .80$ for pretest and $.84$ for posttest).

We measured self-efficacy using three items adapted from Armitage and Conner (2001) and Lwin (2009). Participants were asked to indicate their level of agreement with items such as "If it were entirely up to me, I am confident that I would be able to exercise regularly in my leisure time in the next 6 months." on a 5-point scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). All items were averaged to form a composite scale, with higher scores indicating higher levels of efficacy (Cronbach's $\alpha = .66$ for pretest and $.63$ for posttest).

We measured perceived behavioral control (PBC) using a single item adapted from Armitage and Conner (2001). We asked participants to respond, on a 5-point scale ranging from 1 (*very little control*) to 5 (*complete control*), to the question, "How much personal control do you feel you have over exercising regularly in your leisure time in the next 6 months?"

We measured subjective norm on a 5-point scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*) using four items to assess the injunctive norm and two items to assess the descriptive norm, adapted from Rhodes and Courneya (2003). Injunctive norm refers to the belief that important others approve or disapprove of one's behavior, whereas descriptive norm refers to the pressure derived from the behavior other people commonly do in specific situations (Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007). To assess the former, participants were asked to respond to items such as "My friends would approve if I exercised regularly in the next 6 months" and for the latter to respond to items such as "Most of my family members exercise regularly." All six items were averaged to form a composite scale, with higher scores indicating higher levels of subjective norm (Cronbach's $\alpha = .79$ for pretest and $.80$ for posttest).

We assessed group norm using four items adapted from Terry and Hogg (1996), with participants asked to respond on a 5-point scale ranging from 1 (*none*) to 5 (*all*) to such items as "How many of your friends at school would exercise on a regular basis in their leisure time in the next 6 months?" All items were averaged to form a composite scale, with higher scores indicating higher levels of group norm (Cronbach's $\alpha = .70$ for pretest and $.79$ for posttest).

We assessed intention using three items adapted from Armitage and Conner (2001) and Lwin (2009). Participants were asked to indicate their level of agreement on a 5-point scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*) with such items as "I intend to exercise regularly in my leisure time in the next 6 months." All items were averaged to form a composite scale, with higher scores indicating higher levels of behavioral intention (Cronbach's $\alpha = .76$ for pretest and $.76$ for posttest).

A set of questions related to participants' demographic profile, including sex, age, and race were also included in the questionnaire.

Results

We reduced the initial sample size of 454 fifth-grade students to 398 after excluding cases with problematic or incomplete responses in the pre- and posttest survey data, among whom 58.5% were boys, and the mean age was 10.2 years. The sample consisted of 59.5% Chinese, 21.9% Malays, 11.6% Indians, and 7.0% other races.

To check whether the initial attitudes toward and beliefs about physical activity differed among participants in different intervention groups, we performed two-way analysis of variance on the pretest (baseline) data on these attitudes and beliefs. The results showed none of the main effects or the interaction effects for each of the six dependent variables to be significant. A one-way analysis of variance of the baseline data comparing the four conditions was also conducted for all dependent variables. No significant differences were found.

To test our hypotheses, we carried out a series of two-way analyses of covariance to determine whether playing Wii and health education message frames influence children's physical activity beliefs. The respective baseline data for each physical activity attitude and belief variable were included as covariates to control for any initial differences among the intervention groups even though the previous analysis of variance tests using these data produced no significant findings. The analysis of covariance results revealed significant interaction effects between Wii playing and health education messages on attitude, $F(1, 392) = 4.92, p < .05$; and self-efficacy, $F(1, 392) = 5.41, p < .05$; whereas the interaction effect on PBC was marginally significant, $F(1, 393) = 3.23, p = .07$. No significant interaction effects were found for subjective norm, group norm or intention. The adjusted mean scores from analysis of covariance for all dependent variables in each experimental condition are shown in Table 1.

Hypothesis 1 posited that among children exposed to health messages with coping frames, playing Wii exergames during PE lessons would elicit more favorable

Table 1. Adjusted mean and standard error scores of all outcome variables

	Physical education lesson with Wii		Physical education lesson without Wii	
	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>
Attitude				
Threat	4.35	.06	3.94	.06
Coping	4.31	.06	4.16	.06
Self-efficacy				
Threat	3.93	.07	3.61	.07
Coping	3.80	.07	3.81	.07
Perceived behavioral control				
Threat	3.85	.09	3.59	.09
Coping	3.79	.09	3.86	.09
Subjective norm				
Threat	3.62	.07	3.38	.07
Coping	3.47	.07	3.42	.07
Group norm				
Threat	3.80	.07	3.64	.07
Coping	3.72	.07	3.67	.07
Intention				
Threat	4.08	.07	3.91	.07
Coping	3.98	.07	3.99	.07

(a) attitudes, (b) self-efficacy, (c) PBC, (d) subjective norm, (e) group norm, and (f) intention toward physical activity than participating in regular PE lessons (comparison of conditions 1 and 2, as shown in Figure 2). The analysis of covariance results showed that the combined effects of health message and Wii were not significant on subjective norm, group norm, or physical activity intention, thus failing to support Hypothesis 1d, 1e, and 1f. For the dependent variables in which the interaction effects were significant, namely, attitude, self-efficacy, and PBC, pairwise comparison of the adjusted means using Bonferroni test was performed. The results revealed that among children who were exposed to coping-framed health education messages, the difference in their attitude was marginally significant, with those playing Wii displaying a better attitude than those taking part in regular PE lessons: with Wii, $M = 4.31$; without Wii, $M = 4.16$; $F(1, 392) = 3.33$, $p = .07$. In contrast, no significant differences in self-efficacy or PBC levels were found between those who played Wii exergames and those who participated in regular PE lessons. These findings provide marginal support for Hypothesis 1a, but none for Hypothesis 1b and 1c.

Hypothesis 2 proposed that among children exposed to health messages with threat frames, playing Wii exergames during PE lessons would elicit more favorable (a) attitudes, (b) self-efficacy, (c) PBC, (d) subjective norm, (e) group norm, and (f) intention toward physical activity than participating in regular PE lessons (comparison of conditions 3 and 4). As previously mentioned, no interaction effects were found for subjective norms, group norms, or intention, and thus Hypothesis 2d, 2e, and 2f are supported. The results of pairwise comparison using Bonferroni for attitude, self-efficacy, and PBC showed significant differences, in that those who played Wii exergames were more likely to espouse positive beliefs about physical activity than their counterparts participating in regular PE lessons. More specifically, attitude [with Wii, $M = 4.35$; without Wii, $M = 3.94$; $F(1, 392) = 24.27$, $p < .001$], self-efficacy [with Wii, $M = 3.93$; without Wii, $M = 3.61$; $F(1, 392) = 10.58$, $p < .01$], and PBC [with Wii, $M = 3.85$; without Wii, $M = 3.59$; $F(1, 392) = 4.06$, $p < .05$] were significant, thus lending support to Hypothesis 2a, 2b, and 2c. The plots in Figure 3 indicate that among those exposed to threat-framed health education messages, the Wii players displayed higher attitude, self-efficacy, and PBC levels than those who were not given the opportunity to play Wii during PE lessons.

Research Question 1 aimed to assess the comparative effects of health message framing in eliciting physical activity beliefs among children playing Wii exergames (comparison of conditions 1 and 3). Pairwise comparison using Bonferroni was performed on the dependent variables for which interaction effects between Wii and health education message frames were detected—attitude, self-efficacy, and PBC—but no significant differences were found.

Research Question 2 aimed to examine which type of health message framing was more effective in eliciting physical activity beliefs among children taking part in regular PE lessons (comparison of conditions 2 and 4). Pairwise comparison using Bonferroni carried out on the dependent variables with significant interactions revealed more positive beliefs about physical activity among children exposed to the coping- rather than threat-framed health messages, particularly in terms of attitude [coping $M = 4.16$ versus threat $M = 3.94$; $F(1, 392) = 7.26$, $p < .01$], self-efficacy [coping $M = 3.81$ versus threat $M = 3.61$; $F(1, 392) = 4.18$, $p < .05$], and PBC [coping $M = 3.86$ versus threat $M = 3.59$; $F(1, 392) = 4.33$, $p < .05$].

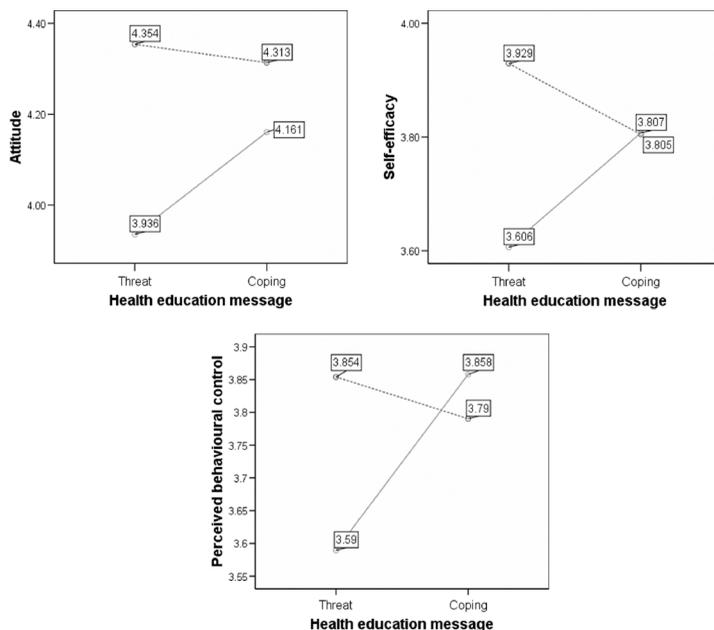


Figure 3. The effect of playing Wii and health education message on attitude, self-efficacy, and perceived behavioral control toward physical activity: , physical education lesson with Wii; ———, physical education lesson without Wii.

Discussion

This study aimed to examine the effect of a 6-week intervention program combining exergaming and theory-based health education messages on beliefs about and attitudes toward physical activity among children. Our findings revealed significant effects of the combined intervention on children's attitudes, self-efficacy, and PBC, thus suggesting the efficacy of using more than one intervention component. More specifically, we found significant differences in attitudes, self-efficacy, and PBC between children in the Wii and non-Wii conditions, but only among those exposed to health messages with threat frames. Similar comparisons among children provided with coping-framed messages revealed only a marginally significant result for attitude, and no significant differences for the other outcome variables.

These research findings allude to the potential role of exergaming in influencing beliefs about physical activity and that the effect is more pronounced when threat-framed messages were deployed over coping-framed messages. Exergaming does not add much additional influence to coping-framed messages, possibly because messages framed in this manner are generally more effective in influencing children's physical activity beliefs than are threat-framed messages. However, the inclusion of exergaming activities such as Wii in PE lessons may level out the effect of differently framed health messages in influencing beliefs about physical activity, particularly in enhancing the physical activity beliefs of those in the threat-framed condition. This supposition is evidenced by our finding that the level of beliefs and attitudes among the children in the combined Wii/threat-framed message intervention became on par with those in the Wii/coping-framed message intervention. In other words, incorporating exergames

into the PE curriculum may promote children's physical activity beliefs to equal levels regardless of which health message framing they were exposed to.

These findings imply that playing exergames during PE lessons can help to boost children's confidence in performing physical activities, and in turn lead to more positive physical activity-related self-efficacy, attitudes, and PBC. According to Erikson's (1963, 1968) stages of psychosocial development, children 7 to 11 years of age are at the *competence: industry versus inferiority* stage, during which they should be complimented on their performance of various activities to ensure they develop competence, self-confidence, and industry by practicing diligence and perseverance and prioritizing work over pleasure.

In the present study, when children were exposed to coping-framed health messages, the inclusion of exergaming into their PE lesson was equally effective as the activities in the regular PE curriculum in influencing children's physical activity beliefs. These messages were also more effective than threat-framed messages were among children who took part in regular PE lessons in terms of physical activity-related attitude, self-efficacy, and PBC. Although these findings confirm previous findings on the effectiveness of coping-framed messages in influencing physical activity beliefs (Courneya & Hellsten, 2001; Graham et al., 2006), our study is the first to demonstrate their efficacy in children. Overall, the results of this study support the potential of health messages grounded in health communication theory to improve children's physical activity beliefs, specifically those framed on the basis of the PMT's coping appraisals. Messages with threat appeals may be similarly effective as long as they are accompanied by proposed actions to overcome impending threats. In this study, among the participants who were provided with threat-framed health messages, those who played Wii exhibited more positive physical activity attitudes and beliefs, which implies that exergames provide a viable solution to coping with the threats posed by inactivity. Corresponding to past research (Self & Rogers, 1990; Witte & Allen, 2000), threat-framed messages appear to be effective when the individuals concerned feel empowered to overcome the health threats. However, when such solution is unavailable, exposing individuals with threat-framed messages may prove to have detrimental effects. Our research supports this notion by demonstrating that threat-framed messages, when coupled with exergames, can improve children's physical activity attitudes and beliefs to a level roughly matching that of their counterparts who are exposed to coping-framed messages.

We did not find the combined Wii/health message intervention under study to exert a significant influence on subjective or group norms or physical activity intention. In retrospect, it is unsurprising that the intervention did not influence subjective norm, as the interventions were performed solely on the participants, and not on their friends or family members, while the measures used to assess these norms concerned the exercise habits and expectations of the latter two groups. Although participants' classmates could have been considered in the "friends" category, the 6-week intervention period may have been too short to produce any visible change in physical activity behavior. Similarly, the limited intervention period may also explain the nonsignificant finding for group norm. It may be that a longer period is needed to develop a new exercise-related norm among participants' classmates. Last, the intervention's effect on intention may have been less pronounced due to the relatively brief exposure to the intervention components, with participants playing Wii only once a week and exposed to the health messages only three times during the program period. It is also possible that although the combined exergaming/health message intervention was effective in improving physical activity beliefs, its influence was insufficiently strong to effect a real change in intention.

Future research in this area could consider several additional aspects. First, the PBC measure could include additional items instead of the existing one item used here. Second, we used three combinations of Wii exergames in this study, but were unable to determine the effects of each game genre. Future studies could explore whether different game genres exert different influences on physical activity beliefs and intentions. Third, the intervention period and amount of time allotted to Wii game playing could be increased to afford children more time to master the games, because greater proficiency may result in more positive beliefs about physical activity. Fourth, it would be interesting to find out which types of intervention are more effective in changing and sustaining positive beliefs over the long run. Given that it is more difficult to change beliefs on the basis of direct experience than those on the basis of information provided by others (Fishbein, von Haefen, & Appleyard, 2001), it is possible that beliefs derived from playing Wii, once changed, might last longer than those arising from message intervention. Last, a panel study design to examine the role played by the intervention under study in influencing physical activity behavior would contribute important knowledge to the field and guide schools, parents, and health authorities in setting up an effective curriculum and policy to encourage higher levels of physical activity.

Conclusion and Implications

Our findings suggest that the combined exergaming and health message interventions significantly influenced physical activity beliefs, particularly in terms of attitudes, self-efficacy, and PBC. The effect of exergaming is especially pronounced among those who have been exposed to threat-framed health messages. Schools in Singapore and elsewhere could adopt a similar approach to that used in a number of innovative schools in the United States and Japan, which incorporate exergaming into their PE programs. Schools could also be creative in their exergame-incorporated PE programs, such as holding exergaming competitions. PE teachers could link the types of sports played to the curriculum by capitalizing on students' interest in different Wii games, such as boxing, tennis, and baseball.

At home, parents may wish to consider substituting exergames for sedentary family activities such as watching television or playing computer games. Exergames also offer an alternative in-door physical activity in countries in which extremely hot or cold weather makes outdoor exercise unpleasant and in homes in which there is limited space. However, parents should be careful to select active games rather than passive games.

The role of coping-framed health messages cannot be underestimated. Regardless of whether exergaming is incorporated into schools' PE curricula, our findings suggest that, overall, coping-framed messages are more effective than threat-framed messages in influencing physical activity beliefs. In addition, when designing their coping-framed health education contents, it is recommended that schools and health authorities emphasize beliefs that were not previously held by the children.

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