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Original Article

Cyber Buddy is Better than No Buddy: A Test of the Köhler Motivation Effect in Exergames

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Abstract

Objective: Although exergames are popular, few people take advantage of the potential of group dynamics to motivate play (and achieve associated health benefits). One motivation gain phenomenon has shown promise for motivating greater effort in partnered exergames: The Köhler effect (working at a task with a more capable partner where one's performance is indispensable to the group). This article examines whether a Köhler effect can be demonstrated in an exergame by exercising with a moderately superior humanoid, software-generated partner.
Materials and Methods: Male and female ($n = 120$; mean age, 19.41 years) college students completed a series of plank exercises using ''CyBuddy Exercise,'' a program developed specifically for this study. In a lab in an academic building, participants completed the exercises individually and, after a rest, were randomly assigned to complete the same exercises again, but with a ''live'' human partner (HP) presented virtually, a nearly-human-like, humanoid partner (NHP), a hardly human-like, software-generated partner (HHP), or a no-partner control condition (IC), with equal numbers in each group (i.e., $n = 30$). Exercise persistence, perceived exertion, self-efficacy beliefs, enjoyment, and intentions to exercise were recorded and analyzed.
Results: A 4×2 analysis of variance on the (Block 2 – Block 1) difference scores showed that a significant Köhler motivation gain was observed in all partner conditions (compared with IC), but persistence was significantly greater with HPs than with either NHP or HHP humanoid partners ($P < 0.05$). By the conclusion of the study, there were no significant differences among the partnered conditions in perceived exertion, self-efficacy, enjoyment, or future intentions to exercise.
Conclusions: These results suggest that a software-generated partner can elicit the Kőhler motivation gain in exergames, but not as strongly as a partner who is thought to be human.

Introduction

Most U.S. adults are not getting enough exercise at the recommended levels to maintain health and reduce the risk of chronic disease.[1,2] Motivation is a key issue in the physical inactivity epidemic.[3] (Motivation is usually conceived as the process of initiating, guiding, and maintaining goal-directed behavior. Although all elements of this process are relevant to the goal of increasing physical activity, the primary focus in this investigation is on the maintenance element. So, hereafter, when we refer to motivation for physical activity, we are referring to maintaining a bout of physical activity [i.e., the persistence and intensity of such behavior, the level of effort].) Exergames have become increasingly popular and have been marketed as a fun way to increase people's motivation to exercise.[4] Several studies have found that people are better motivated to exercise with active games that are entertaining, engaging, and interactive.[5,6] However, even exergames can become boring if played in isolation.[7] Furthermore, few exergames take advantage of group dynamics principles that may help improve task motivation.[8] Research is relatively new in analyzing what interpersonal interactions would best motivate people to continue exercising within these games.[9]

Research also suggests that some social environments are more appropriate than others for fostering motivation and quality exercise experiences. For example, researchers have consistently found that group exercise leads to higher exercise adherence than individual exercise programs.[10] However, structured group exercise programs present problems for those with social physique anxiety[11] and those who lack the time and/or resources to schedule exercise with a partner or group. Moreover, prior models of group exercise have rarely, if ever, introduced any real interdependence between

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exercisers (e.g., by creating teams whose progress and/or outcomes are mutually determined), which can be a source of motivation gains.

One effective pattern of group interdependence produces the Köhler effect,[12–14] which has promise for improving effort and motivation in exercise.[9,15] In the Köhler effect, the least capable group member exhibits a motivation gain (relative to individual performance) when performing as part of a group on effort-based tasks. The effect is the result of two processes: unfavorable *social comparisons* with more able group members and being *indispensable* for the group's success.[16] These motivation gains are strongest with *conjunctive tasks*,[17] where the performance of the least capable group member is critical for group success.[18]

A series of recent studies has used the Köhler effect principles to demonstrate enhanced motivation to exercise in exergames. Results showed that exercising with a more capable, virtually present partner led to a 24 percent improvement in persistence at a series of isometric plank exercises and a 125 percent improvement in persistence in aerobic exercise on a stationary bike.[9,15] Other studies showed that exercising with a more capable partner who provided encouragement did not lead to higher motivation gains than a partner who did not communicate and that these motivation gains were unmoderated by age and weight discrepancies with the partner.[19,20]

These studies also have investigated whether participating in exergames with a more capable partner could detract from participants' enjoyment, interest in continuing the game, self-efficacy, and intention to exercise in the future. Additionally, ratings of perceived exertion were investigated because previous research has suggested that being immersed in an enjoyable exergame distracts one from the perceptions of greater effort.[21,22] These variables have been associated with exercise adherence,[23,24] and thus it is important to investigate the game's effect on them. Overall, our previous studies suggest that the Köhler effect can be effective in boosting motivation to exercise in the less able member of an exercise group without creating any aversion to the task.

Thus far, these experiments have used virtually presented human partners (HPs) (in reality, prerecorded confederates). However, for practical purposes, finding a matching live partner for any given person presents many difficulties (e.g., partner ability discrepancy should be moderate,[25] scheduling, and possible reduced motivation for the superior partner[26,27]). Additionally, there are limitations with using prerecorded confederates, such as the cost to produce them, the inflexibility of modifying what they say or do, the ethics of using deception (as participants believe they are exercising with another person), and the potential for suspicion. A software-generated (SG) partner—one that is anthropomorphic but clearly artificial and synthetic—would eliminate scheduling problems, minimize social physique anxiety, and allow for adjusting the partner's behaviors and abilities[25] to be maximally motivating to the player.

Although an SG partner clearly offers several advantages, it is unclear how the two psychological mechanisms that underlie the Kőhler effect might be altered if one's partner was not human. That is, (a) will one use a non-HP as a basis for social comparison, similar to using an HP for comparison, and (b) will one care as much about being indispensable to the group when one's partner is not human? The Media Equation[28] provides a basis for suggesting that SG partners can be as effective as real HPs at boosting exercise effort. According to the Media Equation, people respond socially to computer/software agents and apply social rules much as if they were human. There is research suggesting humans will establish significant social relationships (e.g., keep promises and perceive virtual characters as teammates) with SG partners.[28–30] To date, the motivating benefits of an SG versus a real HP have not been explored with tasks of physical exertion. This is important because the full promise of an SG partner in exergames hinges on this question.

Thus, the purpose of our research was to determine whether incorporating an SG partner into an exergame would result in a reliable Köhler motivation gain effect. We used the same plank exercises used in previous research.[9,25] In addition to having the usual individual control (IC) and human partner (HP) conditions, we included two conditions with a humanoid, computer-generated partner: one that was very human in appearance and behavior (the nearly human condition) and another that was much less so (the hardly human condition). Based on the Media Equation findings, we hypothesized that the duration of the player's exercise would be greater in all partnered conditions exercising under conjunctive task demands than when exercising alone.

Materials and Methods

Experimental design and participants

Participants ($n = 120$) were randomly assigned to four exercise conditions within a 4 (Condition: IC, HP, Nearly HP [NHP], Hardly HP [HHP]) × 2 (Participant Gender) factorial design with 30 participants in each condition. Participants were undergraduate students (60 females, 60 males; mean age, 19.41 years; standard deviation [SD] = 1.52) recruited from a large Midwestern university who completed the experiment for course credit.

Exergame and conditions

''CyBuddy Exercise'' (CyBud-X) was a game developed specifically for this experiment. CyBud-X was built using Autodesk® (San Rafael, CA) Maya® software and the Unity (San Francisco, CA) three-dimensional game engine and was based roughly on the ''PlayStation® 2 EyeToy: Kinetic'' exergame (Sony Computer Entertainment America LLC, San Mateo, CA). Similar to the latter, CyBud-X uses a Web camera to project the participant's image onto the screen. In the IC condition, participants saw only their own image as they performed the exercises. In the partnered conditions, participants viewed and interacted with one of three different same-sex partners (Fig. 1).

HP. The HP was either a male or female college-aged confederate whose video content had been prerecorded. During the crucial second block of exercises (see procedure below), the ostensibly live video of this partner doing the same exercises was displayed for the participant to see.

NHP. Male and female NHPs were created by applying a computerized effect to the video from the HP condition. The effect transformed the original video into a less realistic, almost animated cartoon appearance.

FIG. 1. Pictures of the three male partners (from left to right): human partner, nearly human partner, and hardly human partner. Color images available online at www.liebertonline.com/g4h

HHP. Male and female HHPs were modeled as three-dimensional graphical characters. These characters were then animated to perform the plank exercises. (In the Male condition, the female character was used as the trainer to demonstrate the exercises, and vice versa for the Female condition.)

As in prior Köhler research,[9,15,19,20] each partner was alleged to be moderately more capable than the participant at the exercise task. The continuous feedback participants received in the partnered conditions (i.e., the images of their partner always persisting longer as they exercised ''together'') was identical—the key difference was whether that image represented a human or non-human, SG partner.

Procedure

All outlined procedures were approved by the university's Institutional Review Board. Participants arrived at the lab individually, signed a consent form, and watched a short video that showed an opposite-sex SG trainer demonstrating five abdominal exercises (Fig. 2). Participants were instructed to hold each plank for as long as possible and were given short breaks between each exercise. Participants then completed Block 1 (each exercise once) individually. Afterward, participants in the IC condition were told the average time they held the planks and that they would complete the same set of exercises again (Block 2) after a 10-minute rest. (For all conditions, participants did not know that they would complete a second set of exercises until after they completed Block 1.)

After Block 1, participants in the partnered conditions were told they would complete the exercises again with a same-sex partner. In the HP condition, participants were told their partner was in another lab, connected via the Internet. Similar to previous experiments,[9,15,19,20] participants were led to believe they were interacting live with another person. However, their partner was actually a prerecorded confederate. In the NHP and HHP conditions, participants were told that their partner was not a real person but was instead computer-generated. Participants in all three partnered conditions were given an opportunity to meet their partner and exchange basic information (e.g., name, hometown, what you like to do for fun) through a Web camera-like connection, as prior research has shown that people treat a computer agent more like a human when there is an initial verbal interaction between them.[31,32]

After this brief interaction, the Köhler effect manipulation took place. Participants were informed that on the second block of exercises, they would work with their partner as a team and that the team's score would be defined as the score of the person who stopped holding the exercise first (thus making the task conjunctive). In all partnered conditions, participants were then truthfully given the average length they held the plank exercises but falsely told the average of how long their partner held them. The partner's plank average was always 40 percent better than the participant's, creating an unfavorable social comparison. A discrepancy of 40 percent is in line with previous research that suggests a moderate discrepancy leads to greater effects compared with small or large discrepancies.[12,25] In the NHP and HHP conditions, participants were told that although their partner was computer-generated and performed better on the first series of exercises, it was programmed to become fatigued over time, just like a real person. During Block 2, the partner always held each exercise longer than the participant (achieved via prerecorded looped videos in the HP and NHP conditions and via a fixed still image once the HHP moved into the correct position in the HHP condition). Upon completing Block 2, participants completed questionnaires, were thanked, and debriefed.

Measures

Persistence. Persistence was the total number of seconds a plank was held from when participants moved into position to the moment they quit, measured using a stopwatch. Block scores were calculated using total seconds held on all five exercises.

Ratings of perceived exertion. Perceived exertion was measured using the Borg ratings of perceived exertion scale.[33] The scale ranges from 6 to 20, where 6 is ''no exertion at all'' and 20 is ''maximal exertion.'' Immediately following each exercise, participants were asked their ratings of perceived exertion for the exercise. The Borg Scale has been shown to have adequate retest reliability (>0.80) as well as concurrent validity by way of strong correlations with

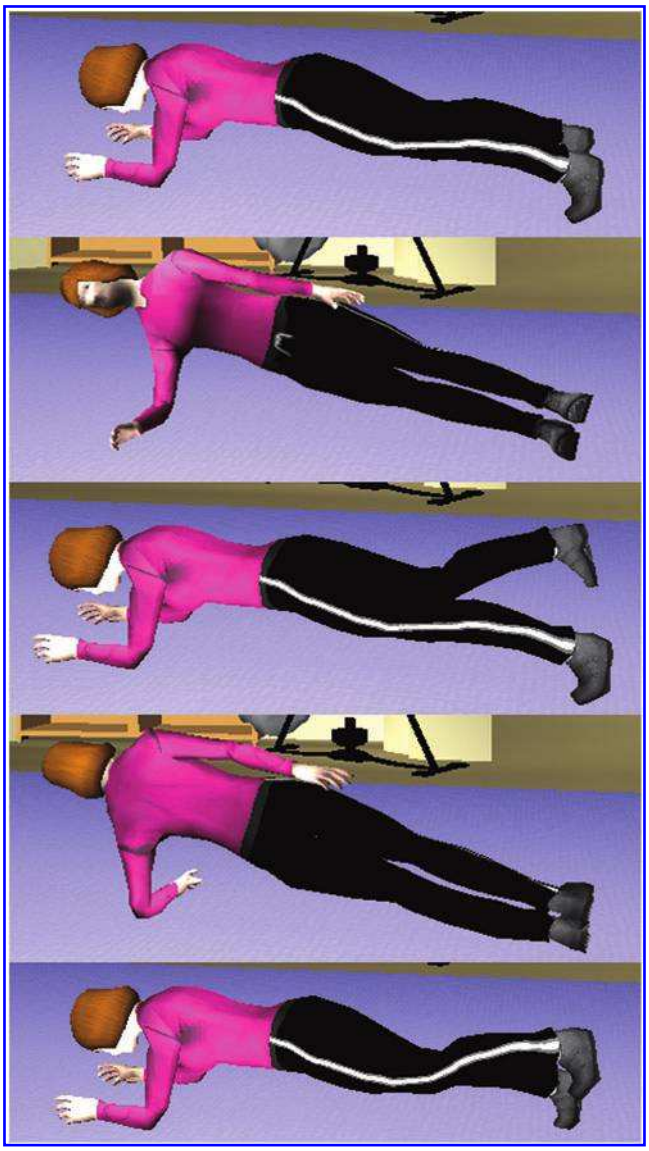

FIG. 2. Pictures of the female trainer demonstrating the five exercises (from top to bottom): front plank, right side plank, right one-legged plank, left side plank, and left one-legged plank. Color images available online at www.liebertonline.com/g4h

heart rate (>0.90).[33] Exertion scores were averaged across each Block.

Self-efficacy beliefs. Participants estimated how many seconds they believed they could hold each exercise at three points during the experiment: Before Block 1, before Block 2, and after Block 2 (e.g., what is the number of seconds which you are completely confident that you can hold the first exercise [front plank]?). The sum of the five estimates constituted an overall self-efficacy score.

Enjoyment and intention to exercise. Following Block 2, participants were asked about how much they enjoyed the task (e.g., from 1 = loved it to 7 = hated it) using the eight-item version of the Physical Activity Enjoyment Scale.[34,35] This eight-item version was found to have a strong correlation (0.94) with the full version, which itself demonstrated adequate internal consistency (Cronbach's $\alpha = 0.93$) and validity.[34,35] Responses on the Physical Activity Enjoyment Scale were averaged for an overall enjoyment score. Participants also rated on a 7-point scale their intention to "exercise tomorrow for at least 30 minutes."

Perceptions of the partner. Participants in the partnered conditions completed two questionnaires. The first was a five-item Team Perception index previously used in human–computer interaction research.[28] The second was a six-item group-identification measure based on a prior scale, modified for the exercise task.[36] Both questionnaires asked participants to rate a series of statements from Strongly Disagree to Strongly Agree (e.g., I felt I was part of a team; I considered this exercise group to be important) and were scored by averaging together the items. Both questionnaires have also displayed adequate internal consistency (Cronbach's $\alpha > 0.70$ for both).[28,36]

Additionally, as a manipulation check and to assess possible feelings of discomfort experienced when encountering a computer agent that is simultaneously human-like but not human (i.e., the Uncanny Valley),[37] participants completed the Alternative Godspeed Indices (19 items across three subscales: humanness, eeriness, attractiveness).[38] The questionnaire asked participants to rate a series of bipolar items from 1 to 5 (e.g., from 1 = artificial to 5 = natural, from 1 = unfriendly to 5 = friendly) to assess how human-like they perceived their partner. The items for each subscale were averaged. The Alternative Godspeed Indices have shown adequate internal consistency (Cronbach's $\alpha > 0.70$) and discriminant validity.[38]

Results

Manipulation check

The 4 (Condition) × 2 (Gender) multivariate analysis of variance on the three subscales of the Alternative Godspeed Indices (Humanness, Attractiveness, Eeriness) yielded significant effects for both Gender ($\Lambda_{Wilks} = 0.76$, $F_{1,71} = 7.53$, $P < 0.001$, $\eta_p^2 = 0.24$) and Condition ($\Lambda_{Wilks} = 0.76$, $F_{2,142} = 3.33$, $P < 0.01$, $\eta_p^2 = 0.12$). Males (mean, 3.57; SD, 1.64) rated the partners as more human than females (mean, 2.82; SD, 1.80) ($F_{1,71} = 7.43$, $P < 0.01$, $\eta_p^2 = 0.09$). For Condition, Tukey's Highly Significant Difference revealed that participants in the HP (mean, 3.86; SD, 2.08) and NHP (mean, 3.31; SD, 2.20) conditions (who did not differ significantly) rated their partner as more human compared with participants in the HHP (mean, 2.43; SD, 2.07) condition (P values < 0.05). Thus, these results show that our participants perceived the entirely SG partner (HHP) to be the least human-like.

Persistence

The primary dependent variable was the difference score between both blocks (Block 2 – Block 1), which would show any changes in persistence while controlling for individual differences in strength and fitness. This approach has generally produced the same pattern of results as using the Block 1 scores as a covariate in the analysis of Block 2 scores in previous research[20,39] and also did so here (see below). Because the difference score means are more directly interpretable than adjusted means produced by analysis of covariance, the difference score analysis is presented in the main text.

A preliminary 4 (Condition) × 2 (Gender) analysis of variance on Block 1 persistence scores resulted in only one significant effect—on average, males (326.3 seconds) were able to persist longer than females (250.6 seconds) ($F_{1,112} = 13.48$, $P < 0.001$, $\eta_p^2 = 0.107$). Random assignment succeeded in creating exercise conditions that did not differ in mean persistence at Block 1 ($F_{3,112} = 1.60$, difference not significant).

A parallel 4 × 2 analysis of variance on the (Block 2 – Block 1) difference scores showed a significant main effect for exercise condition ($F_{3,112} = 12.91$, $P < 0.001$, $\eta_p^2 = 0.257$) but no other effects. The condition means are plotted in Figure 3. Participants in the IC condition persisted 47.0 seconds less at Block 2 than at Block 1. This difference is nearly always obtained in prior Köhler studies,[13,15] especially those with brief intervals between blocks, and can confidently be attributed to fatigue and/or boredom. This condition provides a baseline against which the remaining conditions can be compared to detect motivation gains. Participants in the HP condition persisted 33.1 seconds more at Block 2 than at Block 1; the difference between the IC and HP conditions of 80.1 seconds was significant ($t_{112} = 6.13$, $P < 0.001$). Hence, the Köhler motivation gain routinely observed in several prior exergame studies with a virtually present HP was replicated here.

The interesting open questions are whether working with an explicitly non-HP can also produce a reliable Köhler effect and whether the verisimilitude of that partner's representation would matter. Our data suggest that the answer to the first question is yes. Persistence in the NHP condition was significantly greater (mean difference score, −9.8 seconds) than in the IC baseline (mean, −47.0 seconds) ($t_{112} = 2.86$, $P < 0.01$). Likewise, persistence in the HHP condition was also significantly greater (mean, −18.4 seconds) than in the IC baseline (mean, –47.0 seconds) ($t_{112} = 2.20$, $P < 0.05$). Newman–Keuls *post hoc* tests confirmed these differences and that the greater persistence (mean, 8.6 seconds) observed in the NHP condition relative to the HHP condition was not a significant difference ($P = 0.51$). Hence, at least for this participant population, a fairly extreme difference in the human likeness of the non-HP's representation did not materially affect the magnitude of the observed Köhler effect. Those same *post hoc* tests also confirmed what is evident in Figure 3—persistence was significantly greater with an HP than with non-HPs (NHP and HHP) ($P < 0.05$); the motivation gains in the latter conditions were less than half that observed in the former condition.

(As noted earlier, the analysis of block difference scores and analyses of covariance [with Block 1 used as a covariate in the analysis of Block 2 scores] have usually produced identical patterns of results in prior Köhler effect research. Here, the pattern of results for the latter analysis is nearly identical to that obtained with the former analysis, reported in the main text. Specifically, the exercise condition effect in the analysis of covariance was significant [$F_{3,111} = 13.39$, $P < 0.001$] with estimated exercise condition marginal means of IC = 247.3 seconds, HP = 321.7 seconds, NHP = 276.6 seconds, and HHP = 266.1 seconds. The HP and NHP conditions differed significantly [$P < 0.05$] from the IC condition, both in direct contrasts and in Newman–Keuls *post hoc* tests. However, in this analysis, the HHP condition did not differ significantly from the IC condition [$P = 0.13$ via direct contrast; $P = 0.124$ via *post hoc* test]. With the latter exception, the results of all the remaining between-condition comparisons were as reported for the difference score analyses.)

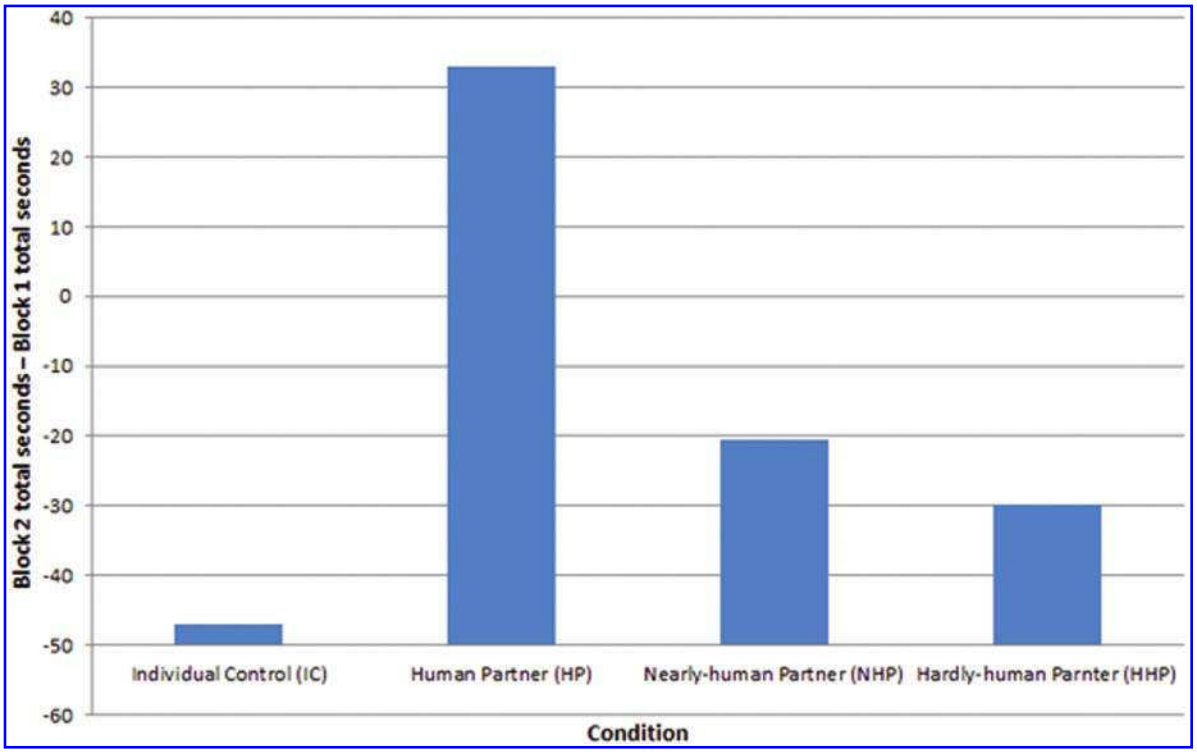

FIG. 3. (Block 2 – Block 1) difference scores for exercise persistence. Color images available online at www.liebertonline.com/g4h

Ancillary analyses

In prior work, significant motivation gains were generally not accompanied by differences in subjective effort, task self-efficacy, task enjoyment, or intention to exercise. Similarly, no significant main or interaction effects were observed for the 4 (Condition) × 2 (Gender) analyses of variance on perceived exertion (P values > 0.06), enjoyment (P values > 0.11), or intention to exercise (P values > 0.38). However, a significant main effect for Condition was observed on the 4 (Condition) × 2 (Gender) analysis of covariance (with self-efficacy prior to Block 1 as the covariate) on self-efficacy prior to and after Block 2 ($F_{6,208} = 3.02$, $P < 0.01$, $\eta_p^2 = 0.08$). As in prior research, individuals and those with an HP did not differ in task self-efficacy. However, those with non-HPs (NHP and HHP) reported lower task efficacy than individual controls, both before (IC = 235.64 seconds; NHP = 184.30 seconds, $P < 0.05$; HHP = 182.56 seconds, $P < 0.01$) and after (IC = 217.23 seconds; NHP = 152.74 seconds, $P < 0.05$; HHP = 156.68 seconds, $P < 0.05$) Block 2; after Block 2, the self-efficacy scores of the partnered conditions did not differ significantly (P values > 0.16). Prior to Block 2 (but not afterward), they also reported lower self-efficacy than those with an HP (HP = 244.48 seconds, P values < 0.01). Additionally, no significant condition differences were observed on measures of team perception and group identification (P values > 0.13).

Discussion

The primary objective of this study was to determine whether the Köhler effect, which we have demonstrated in several previous studies, could be achieved with non-human, computer-generated partners in exergame play. We found that performing plank exercises with a moderately more capable computer-generated exercise partner under conjunctive task demands boosted one's effort relative to performing those exercises individually. Even though participants were told that their partner was not a real person but was instead computer-generated, they still significantly increased their effort compared with participants exercising alone. There was still interdependence between exercisers even though one was computer-generated, and the participants, as the weaker members of the human–SG partner dyad, were indispensable to its success. This supports Media Equation arguments that people often will respond socially to computer/software agents as if they were human.[28] Nass et al.[29] have reported that people can perceive computers as teammates and experience common team interdependence dynamics similar to a strictly human team. However, our study is the first to demonstrate the motivating benefits of a computer-generated partner with tasks of physical exertion in a conjunctive game-like challenge.

Although our computer-generated partners were not as powerful in boosting one's effort as our (prerecorded) HP, as noted earlier, providing appropriate HPs within exergames is not as practical and is difficult to implement. A computer-generated partner can be programmed to adjust its abilities as the participant's ability changes over time to be maximally motivating to the exerciser.[25] The features of computer-generated partners also can be changed to the user's preference. Additionally, false feedback of partner ability was used in the HP condition, which may be impractical or even unethical in some exercise settings. No deception was necessary with the computer-generated partners. Participants were told that their computer-generated partner had been programmed to perform better on the first series of exercises but was also programmed to become fatigued over time, ''just like a real person.''

Both versions of the humanoid partner (NHP, HHP) produced significant increases in effort compared with ICs when using difference scores, and although they represented extreme differences in human likeness, this difference did not affect the magnitude of the observed Köhler effect. Even though participants viewed the nearly human version (NHP) as more human-like than the hardly human version (HHP), there were no differences in team perceptions (e.g., feeling part of a team) and identification (e.g., feelings of belonging to the group) among any of the partner conditions. The HHP version provided one test of just how life-like a humanoid partner needs to be to produce the Köhler effect. The HHP showed no expression, his or her mouth did not move, and cartoon-type word bubbles appeared along with the voice. It is important to note that the motivation gain observed here with the highly realistic NHP need not represent the upper bound for such an effect with an SG partner. The introductions between the participants and their partners were brief (a few sentences) and relatively superficial (e.g., name, hobbies). With an SG partner, a longer or more personal interaction could be built into the game (e.g., via a dialogue tree) that increases the perceived humanness of the partner and/or identification with the partner and, in turn, the magnitude of the effect. Moreover, the effect may be larger if the participant creates his or her own SG partner, or if that partner resembles someone significant to the participant (e.g., an admired celebrity, the participant's best/fittest self). Such questions deserve future study.

Despite significant differences in performance, no differences were observed among perceived exertion, enjoyment, and intention to exercise the following day, which mirrors previous research.[9,20] Although the experimental conditions did not lead to improvements on these measures, they also did not lead to declines. Participants in the experimental conditions of the present research held exercises for longer compared with the control group and, despite that, did not perceive themselves to be working harder, did not enjoy the task any less, and did not hinder their future exercise plans. These findings are encouraging as they show it may be plausible to extend exercise duration without leading to adverse consequences.

It is interesting that participants' self-efficacy beliefs did differ significantly. In particular, participants working with a NHP or HHP reported lower self-efficacy than participants working individually or with an HP prior to the second set of exercises. This measurement point occurred after participants were introduced to their partners. Additionally, participants working with non-HPs (NHP and HHP) also reported lower self-efficacy following Block 2 compared with individual controls. It is plausible that working with a non-HP led participants initially to feel that they could not compare in ability with an SG partner (versus working individually or with an HP), even though their subsequent performance showed otherwise. However, it is difficult to explain why that decrement persisted (compared with the control group) after the second set of exercises.

As with any study, the present one has limitations. The participants were healthy college student volunteers not in special need of improved fitness. This is probably a population that is more comfortable interacting with non-human, SG characters because they are more likely to play videogames and surf the Internet.[40,41] Our results may not hold for an older less ''wired'' population or for a population that does not interact regularly with non-human, SG characters (such as through playing videogames). Furthermore, our study focused on a single type of isometric strength and a one-time exercise experience. These findings may not generalize to other exergames that are more dynamic in nature or repeated over several sessions.[39,42] Future studies should examine other types of exercise (e.g., intermittent, high intensity, or aerobic exercise) over multiple sessions.

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Author Disclosure Statement

No competing financial interests exist.

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