EXPLORING EXERCISE MOTIVATION THROUGH HUMAN AND VIRTUAL PARTNERED EXERGAMES

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PUBLIC ABSTRACT

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This work explored the motivational benefits of exercising with partners in exercise video games (exergames) who are either virtually presented or are computer-generated, but who nevertheless are moderately superior to the exerciser. The motivation effect is such that the team performance outcome is dependent upon the least capable (weaker ability) member's performance. This team structure results in increased levels of motivation that stem from feeling indispensable to the group, making a comparison to one's moderately better partner, and striving to match or over take the better partner.

Three experiments examined performance in two-person exercise teams (utilizing the motivation effect) in an effort to support a practical application that may increase time engaged in moderate-vigorous physical activity and move closer to the recommended guideline levels for physical activity. The studies adapt this motivation effect to teams with either human and software-generated (SGP) exercise partners to influence persistence in the team exercise.

Experiment 1 questioned whether the weight characteristics (i.e., body mass index) of a human partner moderate the motivation effect with adult obese participants. The answer to this question is important because obese individuals have reported feelings of being too overweight, feeling self-conscious, and experiencing high levels of distress when exercising among others. Experiment 1 demonstrated that the motivation effect increased persistence with abdominal plank exercises in obese adults but relative weight (same or lighter than participant) of one's partner did not affect the result.

Experiment 2 participants were exclusively partnered with a same-sex SGP to explore whether exercise participants would willingly team up with an SGP, or view the SGP as an incomparable *other* with the effect of weakening the motivation to persist with exercise. A simple introductory exchange of spoken information via an interactive dialogue tree was tested against a non-interactive method to potentially enhance perceptions of the SGP-human social relationship. SGP partnered participants persisted with exercise longer than non-partnered controls but the difference was not significant. Differences between introductory dialogue methods were also not significant but tended to favor the dialogue tree technique.

Experiment 3 extended prior motivation gain research to a field study, outside the lab, for the first time using a mobile phone application. This experiment tested the use of SGPs on a walking task in a community setting over 3 weeks. A novel sound feature was added to one of the conditions to potentially enhance the human-SGP partner social bond. Experiment 3 successfully implemented an SGP mobile exercise application to examine motivation to persist with walking. Results demonstrated a non-significant trend for average minutes of walking per week, taken across all 3 weeks, such that participants in the *synchronized* motivation condition walked the most compared with those in the no partner control condition.

These experiments support this specific motivation effect in adult, community-based samples. A discussion of the findings and limitations is included, as well as avenues of future research for partnered exercise.

ABSTRACT

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This work explored the group process benefits of dyadic interaction and interdependence that may be harnessed in exergames (physical activity games) to achieve motivation to persist with physical activity. The Köhler motivation gain effect is a conjunctive task paradigm in which the team outcome is dependent upon the least capable member's performance. This performance gain is thought to be the result of feeling indispensable to the group and making an upward comparison to one's moderately higher-ability partner.

There is evidence that exercising in groups may be a popular modality for maintaining individual exercise. However, pairing people together to boost persistence with exercise is somewhat risky, as group dynamics may have a negative effect on motivation. The Köhler paradigm offers a method of minimizing performance group losses (e.g., social loafing, free-riding). By instilling task interdependence and a moderate ability discrepancy, the weaker member is nonconsciously encouraged to increase performance above what she/he may have achieved individually. Exergames can provide a tailored exercise partner to operationalize the Köhler group dynamics processes.

Experiment 1 questioned whether or not partner weight characteristics moderate the Köhler effect with adult obese participants. Community adults completed the first block of three isometric abdominal exercises alone and the second block either alone (Control), with a lighter weight (LW), or with a same weight partner (SW). Partners were actually confederates recorded earlier and presented as live, from another lab. Experiment 1 demonstrated that the Köhler

motivation effect increased persistence with abdominal isometric exercises in obese adults but this effect was not moderated by the relative weight of one's partner.

Experiment 2 participants were exclusively partnered with a same-sex software-generated partner (SGP) to explore whether exercise participants would willingly team up with an SGP. Adults completed a series of abdominal plank exercises similar to Experiment 1. A simple interactive introductory exchange of spoken information via a dialogue tree was tested against a non-interactive method to potentially enhance perceptions of the SGP-human social relationship. SGP partnered participant persisted with exercise longer than non-partnered controls but the difference was not significant. Differences between introductory dialogue methods were also not significant but tended to favor the dialogue tree technique.

Experiment 3 extended prior Köhler motivation gain research to a field study for the first time using a mobile phone application. This experiment tested the use of SGPs on a walking task in free-living conditions over 3 weeks. Community adults were randomized to use an app without a SGP, with a SGP, or with a SGP and synchrony tone (a novel interpersonal synchronization feature). Experiment 3 successfully demonstrated implementation of a free-living SGP mobile application using the Köhler paradigm. Results demonstrated a non-significant trend for mean minutes of walking per week, taken across all three weeks, such that participants in the *synchronized* conjunctive condition walked the most compared to no partner controls.

These experiments support this specific motivation effect in adult, community-based samples. A discussion of the findings and limitations is included, as well as avenues of future research for partnered exercise.

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CHAPTER 1

INTRODUCTION

Increasing the amount of time spent in moderate-vigorous physical activity (MVPA) is recognized as a key intervention strategy to improve physical and cognitive well-being and limit the associated health risk of sedentary behavior. The 2008 Physical Activity Guidelines for Americans (PAG) provide physical activity recommendations to reduce many adverse health risks (Services, 2008). The PAG recommended minimum of 150 minutes per week of MVPA is associated with lower rates of cardiovascular disease, and improvements in glucose intolerance, insulin resistance, dyslipidemia, and inflammatory markers (Garber et al., 2011; Services, 2008). Activity above minimum levels may have even more health and risk reduction benefits (Services, 2008). Low levels of MVPA are strongly associated with obesity and metabolic risk (Bell et al., 2014; Peterson, Al Snih, Stoddard, Mcclain, & Lee, 2014). Therefore, the consensus recommendation from the PAG panel of experts, as well as those of other organizations (i.e. the American College of Sports Medicine) is for adults to engage in at least 150-minutes of moderate-vigorous physical activity each week to improve health and reduce the risk of some illnesses. Unfortunately, objective activity recorded from accelerometry (versus self-report) for adult physical activity that satisfies the guideline has been estimated to be less than 10% (Tucker, Welk, & Beyler, 2011). In light of known benefits of physical activity and levels necessary to achieve those benefits, work toward understanding and positively affecting physical activity motivation is important to improving public health.

There is strong evidence that exercise companions increase time engaged in regular physical activity (Gellert, Ziegelmann, Warner, & Schwarzer, 2011; Kahn et al., 2002; Kassavou, Turner, & French, 2013). Social factors in and around group exercise activity (e.g., social support; exercise partners/buddies; task cohesion; partner and family attitudes) may also exert a significant influence on physical activity behavior (Carron, Hausenblas, & Mack, 1996; Dishman and Buckworth, 1996; Heath et al., 2012; Jago et al., 2011; Lombard, Lombard, & Winett, 1995; Maturo & Cunningham, 2013). Furthermore, Burke and colleagues reviewed evidence that participants exercising in groups, in which efforts were made to enhance feelings of cohesiveness, demonstrated a significant positive difference in adherence versus those participants engaged in coactive or collective groups (Burke, Carron, Eys, Ntoumanis, & Estabrooks, 2006). Coactive and collective groups are those in which the group members exercise in each other's presence and may socially interact but the exercise doesn't share any interdependence or connection to a common shared goal. Participating in group physical activity, although not for everyone, seems to be consistent with a consensus agreement that humans are social animals and the fundamental need to belong is, in itself, motivating (Baumeister & Leary, 1985). With evidence that exercising in groups may be popular and also capable of facilitating and maintaining exercise, it behooves researchers to explore dynamics within these groups that may be responsible for increasing physical activity motivation.

In small group research, a dyad (two people) is also considered a group and is capable of exhibiting many of the dynamics noted in larger groups (Williams, 2010). In light of this perspective on the definition of groups, motivation research with exercise group dynamics might consider forms of physical activity well-suited for dyads and amenable to the study and application of group dynamics. For example, walking, as a popular form of group physical activity, may be such an activity. Walking is easy to do, is low cost, and requires no special training, equipment, or facilities. Walking also holds mass appeal and has a huge potential to help people reach the PAG (Lee & Buchner, 2008) as it is the most common adult physical activity, with an estimated 41.5% of adults walking for leisure, as of 2005 (Kruger, Ham, Berrigan, & Ballard-Barbash, 2008). The Centers for Disease Control and Prevention (CDC) suggests walking as a way to meet the PAG, because there is some evidence that walkers are much more likely to meet the PAG than non-walkers (CDC, 2012). Yet, simply suggesting people walk or walk with a companion may not be enough to affect behavior and common challenges to adequate physical activity levels (coordinating time and partners; distraction; motivation) may remain. Less than 40% of walkers reach the recommended 150-minute per week (Rafferty, Reeves, McGee, & Pivarnik, 2002), so it is reasonable to conclude that motivation to walk (or walk to adequate levels) is lacking.

Motivation, defined as a broad category of factors that guide the direction and intensity of behavior, is often inferred from the observation of one's action or response. So, the *motivation to persist* may be operationalized as maintaining physical activity with persistence of effort and is different than a cognitive working definition of motivation that might be measured as attitude or intentions. Examining the factors responsible for motivation in dyads, or the influences on the maintenance (versus initiation) of targeted goal-directed individual behavior, may be an effective strategy to increasing overall physical activity. This behavior, directed at a goal, is naturally reliant upon the fact that one's action is connected to the outcome of that action (Dickinson & Balleine, 1994) and can be self-regulated. The capacity to self-regulate one's action and reaction toward goals is thought to be one mechanism of motivation (Bandura, 1997). Put another way, the theoretical processes involved with engaging motivational factors to influence behavior entail affecting one's conscious or nonconscious self-regulation and decision-making related to attaining a desired goal. When participating in a shared *group* activity, such as exercise, social and task-related aspects of dynamics within the group may also influence the persistence or intensity motivation so that it exceeds that of individual effort in the same activity (Baron & Kerr, 2003; Weber & Hertel, 2007). Therefore, examining motivation in a group setting must include the consideration of these group dynamics, as well as those factors that might function on an individual basis. Integral to the influence of group dynamics on motivation is the perception of how instrumental one is to the accepted and valued group goal. For example, the choice of whether to engage in positive or negative performance-related behavior is linked to perceptions of how one might be able to contribute and affect an important shared group goal or outcome. Behavior is more likely to benefit the group goal if the team member perceives value in the group outcome and meaningfulness in their contribution to this outcome (Karau & Williams, 1993; Vroom, 1964).

At the most basic level, understanding group dynamics in a physical activity setting may afford opportunities to employ motivation gain mechanisms inherent in cooperation and competition. However, group dynamics also have the potential to negatively affect individual motivation and goals (e.g., loafing), and ultimately group and individual performance. Specific features of the social and task small group dynamics are thought to be key to avoiding potential coordination and motivation losses (Steiner, 1972). Such group dynamics features include: the demands of the physical activity task on group members, the abilities or resources required to successfully perform the activity, and the relationship processes based on the individuals' abilities and how these influence group member interaction. In other words, exploring motivation gains in small groups may be approached by attending to the specific activity to be performed, the abilities of the members, and the level and type of *interdependence* each group member shares with the other.

This dissertation built on evidence of the group process benefits of dyadic interaction and interdependence that may be harnessed to achieve motivation to persist with physical activity. Specifically, the studies employed Köhler effect group dynamics with both human and virtual (software-generated, non-human) exercise partners in an exergame context to influence persistence motivation. The Köhler effect is thought to be one of the few group dynamics paradigms capable of realizing performance gains. Group, or partnered, activity interventions have demonstrated effectiveness in increasing the initiation and maintenance of physical activity and provide an attractive alternative to individual exercise modalities in helping Americans meet the PAG. Yet, group physical activity, in and of itself, is not sufficient. Understanding group dynamics that may be manipulated to increase motivation, as well as the mechanisms of these group dynamics, is an important step in designing effective group-based physical activity interventions.

Exergames (interactive games that require physical exertion in order to play) can provide a tailored exercise partner to operationalize the Köhler group dynamics processes. Group or partnered exercise can enhance motivation and offer social support, but not without potential problems: finding a partner, coordinating time to walk, negotiating different exercise goals, and meeting a partner’s slow or fast pace. Unless partners are compatible, personal and group factors may undermine the willingness to engage or persist with exercise. For example, social physique anxiety (anxiety about one’s body shape being evaluated) and self-presentational concerns may decrease participation, persistence, and pleasure with exercise (Focht, & Hausenblas, 2004; Kruger, Lee, Ainsworth, & Macera, 2008; Song, Kim, & Lee, 2014; Spink, 1992; Treasure, Lox, & Lawton, 1998). Walking with a software-generated partner offers several unique advantages (e.g., availability, adaptability, autonomy, reduced social concerns) and a way to adjust abilities or characteristics automatically over time to those the walker always finds motivating.

The first two projects sought to extend prior research and explore potential moderators of the Köhler effect, as well as work toward a proof of concept for this group dynamics approach as a way of ultimately increasing physical activity and improving public health. The final project built on the previous Köhler research to move outside the lab and into free-living environments with a practical application of this paradigm. The overall goal for this line of research was to provide evidence for the Köhler effect group dynamic as a means of enhancing the motivation to persist with exercise and potentially come closer to recommended levels of physical activity known to decrease health risk. What follows is a review of the conceptual theories of motivation in groups relevant to the three projects presented in this dissertation, as well as an outline summary of previous research. An overview of three experiments is provided before presenting each in its entirety. Finally, a discussion chapter concludes this dissertation that integrates key findings across all three of the studies.

Review of Conceptual Theories

The review of conceptual theories describes group motivation concepts relevant to the three experiments in this dissertation. The focus of this section is on factors thought to produce motivation gains in group settings. After an explanation of group tasks and task structure, as well as a model for understanding motivation within those task structures, group motivation processes (gains and losses) are discussed. Motivation group processes include social facilitation, compensation, comparison, the Köhler effect, cohesion, and social support. Some moderators of these processes are also reviewed, while others (group roles, norms, identity) are subsumed in the group processes. Concepts related to the use of software-generated exercise partners are presented at the end of this section.

Group dynamics. If the motivation to persist is enhanced by engaging in physical activity with another person, what factors may be responsible for the effect? Context is a fundamental consideration in the examination of group dynamics in physical activity contexts and includes analyzing the activity task to be performed and the group structure and processes. How members act and react may be influenced significantly by the activity they wish to accomplish and the level of interdependence created by member abilities and responsibilities. Steiner (1966, 1972) developed a classification of group tasks to help explain how the productivity of a group might relate and be distinguished by the level of member contribution and interdependence. Steiner's model of group productivity points to potential problems with member coordination and motivation when explaining why actual performance does not match the potential performance of the member contributions. In relation to the demands of the group task and the member abilities, one can look to motivation and coordination (i.e. working together) processes for vulnerabilities in achieving the group's *potential* productivity. Individuals might not just maintain their typical performance when working toward a group task (avoiding performance losses) but actually perform better (realizing performance gains) in a group versus when alone as a result of group motivation and coordination processes (Kerr & Hertel, 2011). Faber, Hausser, and Kerr (2015) have suggested that actual group productivity is indeed a function of group potential, process losses, *and* process gains. This perspective on optimal group productivity includes the possibility that performance gains can occur within group activity, not just the minimization of performance losses. Determining an appropriate typical individual performance, to utilize as a baseline, and comparing it to a similar group performance may be inherently easier with some physical activity than doing so with other tasks (e.g., creative tasks). Controlling the complexity of the group goal, as well as the knowledge, intelligence, training, and skill required to perform the activity should provide appropriate performance measurements by which to evaluate group-related losses and gains (Hackman & Morris, 1975; Hertel, Kerr, & Messé, 2000)

As stated previously, it is vital to consider the context of the group dynamics that might ultimately have an effect on the behavior of members. The activity task to be performed and the task structure of the group will be contextual determinants of interdependence, abilities and resources required, and the social-psychological responses of the group members. Group task structure will be reviewed next, along with how this context may affect motivation gains and losses.

Group task structure. Although the group may be engaged in multiple tasks or operations, when the group performance is focused on one unitary outcome, Steiner's task structures are useful in predicting which structure might best suit members and goals. Task structure might also allow for an explanation of the group productivity losses. Steiner proposed three primary task structures: disjunctive, additive, and conjunctive. With *disjunctive group structures,* the overall group potential productivity is determined by the ability of the most competent member. Each group member may be working toward a unitary outcome, but except for the most competent member, an individual's effort does not determine the outcome. For example, a disjunctive group structure would exist if the winner of a multi-school track event, that allows two runners to represent each school team, was determined by the fastest of all runners. In *additive group structures,* the potential productivity is simply determined by the sum of all group members' performance. If several schools were competing in a track event and the winning school is determined by the sum of each running team's event finishing times, the task structure would resemble Steiner's additive group. *Conjunctive group structures* are such that the group performance relies on the least competent member. A conjunctive task running group would be one for which a team victory relies on the slowest runner in the event or relay. Aside from Steiner's description of the three group task structures, two or more people may be *coactive* as they work along side each other and independently at the same task. Motivation processes may occur as a result of this coaction but the lack of coordination and cooperation distinguish this setting from the other three that are considered true group task structures.

Group motivation gains and losses. Steiner's task structure definitions describe how member contributions are combined to complete the group task, as well as direct how the group outcome will be determined (McGrath, 1984). Steiner's tasks provide an effective productivity-focused model by which group coordination and motivation processes can elicit losses or gains in productivity or performance. However, Steiner's model does not go so far as to indicate how psychosocial factors within the group might alter the group task coordination and motivation processes. An expectancy-instrumentality-value model (Karau & Williams, 1993; Kerr, 1983; Vroom, 1964) fits well with Steiner's task structures and aids in identifying psychosocial factors and further clarifying motivation processes. According to the model, motivation is dependent upon whether a group member perceives his/her contribution to be instrumental in the group performing at a high level and if they perceive value in the group effort outcome. For example, one type of group motivation loss, the *free-rider effect* (Kerr & Bruun, 1983), may occur when a group member's motivation decreases due to the perception that his/her efforts are not instrumental to a high group performance. If so, the group member may feel as if his/her contribution is dispensable, or not important, and "free-ride", allowing other members to do the work required to achieve the group goal. Additive and disjunctive task structures are ripe for this potential process loss, as group performance does not necessarily rely on contributions of weaker members or maximum contributions of all the individuals. Similarly, motivation losses in these task structures may result from *social loafing*, as an individual's contribution may be difficult to identify within the group and the member suffers from poor expectancy, instrumentality, or valuation perceptions (Latane, Williams, Harkins, 1979). While the free-rider effect may occur even when his/her contributions can be identified by others, social loafing is more likely to occur when the member's contribution are not readily apparent to the others. In contrast, the *sucker effect* may also occur, in which motivation may decrease in additive or disjunctive task groups when one perceives others are not putting forth effort towards group success and therefore decrease his/her performance as a consequence of that perception (Kerr, 1983). Steiner's task structures provide a frame in which one can understand how the structure of the group and interdependence of the members either permits (additive, disjunctive) or inhibits (conjunctive) potential losses through group processes (i.e., free-rider; social loafing; sucker effect). The expectancy-instrumentality-value model then helps explain why these processes may occur within the structure.

While Steiner's model provides a way to classify group tasks and task structure so that researchers may study productivity losses, there are other psychosocial factors at play that may actually induce productivity gains. The expectancy-instrumentality-value model, as a motivation framework, can further aid in understanding why these gains might occur. One such motivation gain results when one group member values the group goal and compensates for a weaker member. Social compensation may reduce or even reverse the overall performance losses as the other members increase their productivity in anticipation of the group member's reduced performance (Williams & Karau, 1991).

Another potential performance gain may be the result of simply being aware that another person is observing your activity. However, performing in the presence of another group member may have a positive or negative effect on performance. This *social facilitation* (Zajonic, 1965) is possible in a coactive (i.e., simultaneous, independent) environment, as well as any of Steiner's group task structures. The effect of this highly variable phenomenon is thought to be dependent on the complexity and familiarity of the task demands (Strauss, 2002). In other words, when one is more familiar with a task or is performing a task without complex demands, their performance may not be as affected by the presence of others. When studying motivation phenomena and group dynamics, any variation in performance due to social facilitation is often controlled for by always keeping the presence of others constant.

An additional manifestation of group dynamics comes about as a consequence of members comparing themselves to each other (Festinger, 1954). Festinger provided evidence that this common comparison in ability may stem from self-evaluation needs (or drives), as people appraise themselves against their perceptions of other people. This drive to gauge one's ability against the other group member is a somewhat selective process; as Festinger suggested, there is an increased tendency to do so when the target of comparison is closer in ability. In fact, this comparison process is unidirectional and upward, so that it often initiates from a desire to either maintain one's superiority over the target of comparison or work to reduce the perceived discrepancy (Festinger, 1954). This process may be rooted in people's judgments of similarity and dissimilarity, whether they then use the comparative information, and how they might use it in interactions with others (Mussweiler, 2003). For example, upward social comparison may result in competition with the other person, as a source of comparison, or may be the impetus for self-enhancement to attain the goal inspired by the comparison (Collins, 1996). Therefore, upward social comparison shall play a prominent role in many motivation processes explaining behavior.

The Köhler Effect. While group process losses (free-rider; social loafing; sucker effect) may exist in additive and disjunctive task structures, in particular if one's contribution expectancy, instrumentality, and outcome value suffer, it is possible that the performance losses will be off-set by group gain processes (social compensation; social facilitation; social comparison). In Steiner's task model of group productivity, these process losses and gains would increase or decrease the difference between the potential and actual productivity of the group. Yet, it may be possible to utilize task structure (and inherent demands) to realize performance gains above that predicted from combined individual performance (Faber, Hausser, & Kerr, 2015). One such attempt at motivation gains through controlling elements of a task structure can exist in conjunctive settings (outcome depends on the weakest member). Evidence for these performance gains in conjunctive task structures comes from research on the Köhler effect (Kerr & Hertel, 2011). Studying a club rowing team in the 1920s, Otto Köhler noted performance during repeated sets of bicep curls by weaker rowers was better when their efforts were yoked to stronger rowers. Individual rowers lifted 41 kg weights for as long as possible and were compared with two-rower shared 82 kg weight trials (see figures below).

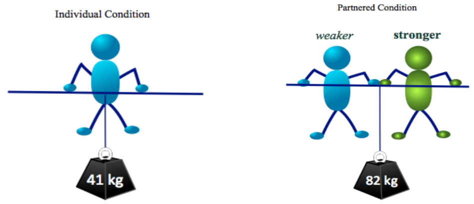

Figure 1.0 Individual and Conjunctive Trials

With Köhler's conjunctive task structure, this motivation to increase performance was founded on the rowers' understanding that the shared task would end when weaker members became exhausted and quit. These trials not only compared individual persistence with the average of the team trials, but also considered how the discrepancy in rower ability impacted performance. Köhler noted that the greatest motivation gains came when the weaker member perceived the performance discrepancy was moderate and not insurmountable. As noted previously, this social comparison may instigate a competition with the stronger partner or simply activate the goal by the weaker partner to focus on improving their performance (self-enhancement). In this conjunctive group structure, the Köhler effect also emphasizes the weaker partner's effort as clearly *indispensible* to team success, thought to be an integral factor in any resultant motivation gain (Kerr et al., 2007). While group gain mechanisms, such as social facilitation, social comparison, and indispensability may occur in the Köhler effect paradigm, processes losses (free-rider, social loafing) are controlled by this task structure with the outcome being determined on the weakest member's performance. Separately, both social comparison and group indispensability have been demonstrated in additive and coactive performance settings but it is the indispensability of one's effort, combined with upward social comparison by the weaker partner, that creates the critical recipe for realizing consistent motivation gains with the Köhler effect (Kerr et al., 2007).

Other group processes. While this dissertation focuses on motivation gains in exercise groups as a result of the Köhler effect and its core components (upward social comparison and indispensability), other motivation processes that may moderate group performance are briefly reviewed. Three such processes are cohesion, social support, and interpersonal synchronization.

Cohesion. Cohesion is another group process capable of increasing performance (Castaño, Watts, & Tekleab, 2013; Mullen & Copper, 1994). Cohesion has also been identified as a predictor of adherence in exercise and sports groups (Carron & Brawley, 1988; Estabrooks, 2000). Performance gains as a result of cohesive teamwork have been, in turn, identified as a predictor of cohesion (Mullen & Copper, 1994). Cohesion in a group has been defined as a multidimensional process that describes a variable tendency for members of a group to be unified in the pursuit of task-related objectives (Carron, Brawley, & Widmeyer, 1998). Carron also noted a social dimension of cohesion in which group interactions create and enhance members' affective needs and attraction to the group. An earlier, yet similar perspective, maintained that interacting and cooperating interdependently toward shared goals may serve as a common attraction between members and encourages them to continue as a group member (Sherif & Sherif, 1969). Yet, it was Carron and associates who outlined a conceptual model, not only of task and social aspects of cohesion, but one that also highlighted the importance of attractiveness and integration components (Carron & Brawley, 2000). Integration describes the unification perception by group members and social perceptions of closeness and bonding. Whether the group satisfies personal needs of the members, thereby enticing them to continue as a member, is what Carron termed attractions to the group. Thus, the perception of cohesion in a group can be manifest in the members being attracted and integrated to the shared task or feel attracted and integrated to the social roles and social interactions afforded within a group.

There are multiple strategies to enhancing group cohesion. In a review of group processes utilized to promote physical activity, Estabrooks and colleagues elaborated on the group environment, process, and structure variables previously identified as effective targets for cohesion-building interventions (Carron, Spink, & Prapavessis, 1997; Estabrooks, Harden, Burke, 2012). Each of the three variables link to key components that can be operationalized in cohesion building interventions. For example, emphasizing group distinctiveness relates to the group environment; work on collective goal-setting and supporting member cooperation is encompassed in the group process principle; and, focus on managing member roles and group norms falls within the group structure set of variables for increasing cohesion (Estabrooks et al., 2012). The authors noted that all of the studies reviewed demonstrated significance in promoting physical activity through the use of these various interventions, whether they directly targeted cohesion building or not.

Collective efficacy has also been suggested to have a significant and reciprocal relationship with cohesion (Myers, Payment, & Feltz, 2004; Paskevich, Brawley, Dorsch, & Widmeyer, 1999). Bandura (1997) proposes that collective efficacy represents the "group's shared belief in its conjoint capabilities to organize and execute the courses of action required to produce given levels of attainments." Fostering members' judgments on the group's capabilities may increase cohesion and, likewise, increasing group cohesion may result in perceptions that the group can attain its goals.

In summary, a higher degree of attraction and integration to shared task and social elements of group membership represents a perceived unity that may be beneficial to individual group members and to group performance measures. There is evidence that successful performance is a better predictor of high cohesion than cohesion is of performance. Nevertheless, enhancing group task and social cohesion can be an effective process to harness when seeking to enhance motivation in groups.

Social support. Social support has been studied as a mediator between health behaviors and mortality and morbidity (Cohen, 1988; Uchino, 2006; Uchino, Cacioppo, & Kiecolt-Glaser

1996), as a predictor of medical regimen compliance (DiMatteo, 2004), and as a significant factor in overall physical activity behavior (Carron, Hausenblas, Mack, 1996; Resnick, Orwig, Magaziner, & Wynne, 2002; Stralen, Vries, Mudde, Bolman, & Lechner, 2009; Warner, Ziegelmann, Schuz, Wurm, & Schwarzer, 2011).

Social support is often characterized as “any process through which social relationships might promote health and well-being.” (Cohen, Underwood, & Gottlieb, 2000). Social support processes may include the use of emotional, informational, or instrumental resources or those that come about as a result of social participation in groups (Cohen et al., 2000). Participation in groups may influence cognitions, emotions, behaviors, and biological responses so that support emerges from interactions and relationships with others.

From a sociologic perspective, social support mechanisms derive from the level of one’s integration or engagement within a social network (MacGeorge, Feng, & Burleson, 2011). Mechanisms by which support may benefit the receiver include: social influence on behavior; receipt of social resources (tangible or direct assistance); the promotion of positive cognitive and affective states (self-esteem, social competence, self-efficacy, affect); and, influence physiologic processes, such as stress responses (Berkman, Glass, Brissette, & Seeman, 2000). The behavioral, psychological, and physiologic pathways describe potential mediators of social support and well-being. There are also multiple other factors that may moderate the effect of social support depending on the integration or connectedness one has to people and the social environment (Berkman et al., 2000).

In physical activity research, in addition to overcoming barriers with instrumental or tangible support, self-efficacy and self-regulatory behaviors have been consistently identified as primary mechanisms by which social support exerts influence on physical activity (Ayotte, Margrett, & Hicks-Patrick, 2010; Bandura, 1997; Duncan & McAuley, 1993; Rovniak, Anderson, Winett, & Stephens, 2002).

Clearly, social support is a process that can serve to increase participation in physical activity. However, very little research has explored the relationship between social support and group performance gains. Hüffmeier and Hertel (2011) offered the Model of Social Support within Teams (MSST) as a new theoretical model describing social support as a unique source of group performance-related process gains. Elements of group interaction related to enhancing task coordination and affective needs are suggested as individual sources of support. For example, information or physical assistance may benefit the group tasks, where as emotion recognition and encouragement messages (praise, reassurance, empathy) may result in positive affective support. Both modes of support are thought to boost motivational and group coordination gains.

The authors hypothesize that affective support mechanisms would include self-efficacy beliefs, role clarity, and goal setting. When a group member offers affective support by recognizing or reassuring another member, it is possible that this support reinforces roles and validates one's perception of performance. They suggest that affective supportive messages may also increase perceived social cohesion and mediate the effect between support and performance.

Task support mechanisms exchanged between members are hypothesized to have a direct effect on coordination processes within the team. For example, information shared between members can serve to elaborate and clarify task-related efforts, improving the accuracy of cognitions each member has about the task. It is plausible that collective-efficacy can also mediate the relationship between task support and performance.

Another mechanism by which these group member perceptions of support may result in process gains is through reciprocity norms (Gouldner, 1960). Gouldner's norm of reciprocity describes the feeling that we are obligated to return favors or repay others simply because we have received something from them. This social exchange norm enables feelings of trust, rapport, and equity in relationships and is recognized as a powerful form of influence (Cialdini & Trost, 1998). The power of giving one's time, effort, or possessions often initiates a reciprocal social pressure, common across many cultures and situations (Cialdini, 2008). This perceived obligation to repay the gift is particularly strong if the giving was uninvited, as the human conditioning that makes most feel uncomfortable when indebted is magnified by receiving the unexpected favor. Furthermore, the psychological cost of not reciprocating can be so strong, the recipient often feels compelled to return an even larger favor (Cialdini, 2008). In the team relationship, the mutual give-and-take exchange of helping favors may work to boost the social bonding and strengthen reliability of the partner's task performance. This exchange may be accomplished in the form of communicating instructional or helpful information and feedback. Performance losses, such as loafing or task noncompliance, may be mitigated when indebtedness from the help is instilled between partners. The benefit to the team relationship from reciprocity not only stems from obligation but, also in the potential for the receiver to increase his/her likability of the giver. All things being equal, one tends to look at another more favorably after receiving help or a gift. Hüffmeier and Hertel point to receiving and providing support among group members as a trigger for this social norm with a synergetic effect on group performance.

These hypotheses for support mediators in team performance gains inherent to supportive relationships mirror those of Jehn and Shah's (1997) conclusions that friendship, cooperation, task monitoring, and commitment increase performance. Additionally, trust has been widely shown to indirectly influence group processes by encouraging joint efforts and subsequent group performance, versus distrust that resulted in mostly individual efforts (Dirks, 1999).

There is evidence of a positive relationship between social support and performance gains in business professionals, students, and athletes as predicted by Hüffmeier and Hertel's model of team support (Hüffmeier, Wessolowski, Randenborgh, Bothin, Schmid-Loertzer, & Hertel, 2014; Osca, Urien, González-Camino, Martínez-Pérez, & Martínez-Pérez, 2005).

So, integration and engagement with the social environment, including interpersonal interactions with others, can be a significant factor in determining whether one will initiate or maintain physical activity. Group activity allows for the provision and receipt of social support and its potential benefits (although not all group interactions are supportive and beneficial). The mechanisms by which social support influences physical activity are varied and depend on the perceived needs of the individual. Finally, there are few studies that have examined how social support might actually result in motivation gains within the group that are above what would be predicted from the individual efforts.

Interpersonal synchronization. Intuitively, positive perceptions of one's relationship with a partner, when working on a unitary task, would seem to be more likely to motivate than not. To that end, the concept of interpersonal synchronization (IPS) may be an effective and subtle social bonding mechanism to exploit within the Köhler effect paradigm. Enhancing perceptions of one's partner may also enhance a willingness to cooperate and work toward a team goal. IPS holds that rhythmic adjustments in human movement behavior strongly affect social rapport, cooperative attitudes, and perceived group entitativity (forming a social unit) (Delaherche et al., 2012; Hove & Risen, 2009). External synchronization cues, such as rhythmic sounds generated from another person enhance likeability and trust (Launay, Dean, & Bailes, 2013; Launay, Dean, & Bailes, 2014) and elicit automatic adaptations of motor behavior to stay in synchrony with the partner. In other words, IPS is a fundamental behavioral and physiological mechanism in which one adapts to the rhythms of an interaction partner, dependent on the degree of interaction engagement by each person (Delaherche et al., 2012). IPS is closely tied to mimicry and the so-called chameleon effect, recognized as an adaptive nonconscious social-behavioral function (Chartrand & Bargh, 1999). Chartrand and Bargh have explored a direct causal link between the matching of one's behavior to another and feelings of rapport. They have suggested that the perception of another's behavior causes similar behavior (without interpersonal goals) and the shared behavior results in the feelings of rapport and empathy (Chartrand and Bargh, 1999). Both synchrony and mimicry mechanisms relate to simple human motor actions (tapping, stride, waving). These natural adaptive processes have been found to boost liking and cohesion in groups, and partner likability, collaboration, and rapport (Chartrand & Bargh, 1999; Lakens & Stel, 2011; Lakin & Chartrand, 2003). Interpersonal synchrony of team members may be another manipulation to moderate potential free-riding losses (Wiltermuth & Heath, 2009). Synchronous movement in time between group members may increase perceptions of comfort (i.e. rapport, cohesion, liking). Additionally, the synchrony process may decrease coordination losses, as teammates not only hold enhanced perceptions of their partner and the desire to meet expectations, but may also attempt to adapt movement to align with their partner. In turn, synchrony may develop from coordination of movement, sounds, or speech from which one senses an adaptation, responsiveness, or reciprocity from the partner (Delaherche et al., 2012). Therefore, it may also be possible to positively affect a partner relationship by supplying simulated motor functions (visual or audible) emanating from a software-generated partner that are nonconsciously perceptible to the human partner. Even slight deviations in software-generated partner rhythm may cause human partners to automatically re-synchronize their motor responses. This interplay between initial and recurring synchronization and subtle de-synchronization may be a useful influence on social and performance outcomes. In summary, IPS is a fundamental behavioral and physiological mechanism in which one adapts to the rhythms of an interaction partner (Delaherche et al., 2012). It is based on basic social content and social process coordination that people are programmed to attempt with others from an early age. Synchronization may occur when individuals converse with others, pausing at the right time, matching the level of interaction and vocal patterns, and nonconsciously timing our social interactions. IPS may occur when people walk in step, sing or dance together, rock beside another in a chair, and smile when another smiles. Importantly, seeking and responding to others through these processes are believed to be natural social behavior. As a result, when synchrony occurs, individuals may feel differently about those with whom they have interacted. There is some evidence, when using a Köhler effect paradigm, that the motivation gains in the weaker partner might be strengthened by enhancing the social relationship between group members (Kerr & Seok, 2010; Kerr, Seok, Poulsen, Harris, & Messe´, 2008). Interpersonal synchronization may be one novel way of enhancing the social relationship to affect task performance.

How well partners like each other may moderate each of the three group processes briefly reviewed here (cohesion, support, IPS). Likability, while not essential between partners, clearly has the potential to moderate the team's social relationship. Just as reciprocity and interpersonal synchronization have the potential to increase likability, other factors may do so as well. The appearance of another may have a powerful conscious and nonconscious effect on one's perceptions. People who are judged to be attractive may be better liked and perceived as more persuasive, as possessing more desirable personality traits, and as harboring superior intellectual capacities (Cialdini, 2008). Although many people often deny attributing these characteristic judgments to others simply based on good looks, the nonconscious perceptions have the ability to drive behavior as a result of these attributions. It is not uncommon for likability to be a result of partner similarity also. Relatively slight similarities between two people can produce a positive response, an increase in likability, and a behavioral compliance (Cialdini, 2008). Similarities in personality traits or background, even if superficial, can appeal to commonality, relatedness, and attractiveness. Pointing out similarities may even be construed as a form of flattery, as most people tend to like themselves and, thus, appreciate the features of the common interest. Indeed, flattery is one of the more robust stimuli of likability, often not even needing to be accurate to please the receiver (Cialdini, 2008). Positive comments work to promote pro-social relationships through likability so much so that they may also compel the recipient to reciprocate the flattery. Along with attractiveness and similarity, flattery and reciprocity can have significant positive effects on partner perceptions of likability. Of course, this likability manifests as social influence, potentially stabilizing the team dynamic and leading to a supportive environment. While the concept of likability may not directly impact group performance gains, it is relevant to the effectiveness of other group processes, as well as the predicted efficacy of utilizing software-generated partners in group research.

Software-generated exercise partners. Applying the Köhler paradigm in real (human) groups poses some challenges inherent in social and task relationships. Exercising with a virtual (i.e., software-generated, non-human) partner is an attractive alternative to their traditional human counterparts, particularly from a social-psychological perspective. Software-generated partners (SGPs) avoid the significant potential motivational barrier of finding and coordinating exercise with a human partner, but it also affords the possibility of manipulating group social and task dynamics for the user's benefit. Using a SGP for exercise also does not require addressing the motivational needs for both members of the team (only the human target of the intervention), a lack of perceived benefit that the non-targeted human partner might not tolerate. Features can be adapted to those the individual user finds pleasing so that, along with the ability to dictate the logistics of exercise, autonomy is supported through allowing this control and choice. Other elements can also be tailored, such as: partner characteristics or mannerisms; dialogue and interaction; and, story or dramatic immersion. Reduced social concerns may also result from the use of non-human partners in exercise. Self-presentation concerns potentially influence one's initiation or continued participation with group exercise, especially if one perceives another person potentially being critical of him/her in that environment. Group members, particularly in task-oriented groups, may alter their performance as a result of attempts to maintain a positive image or present themselves in a positive manner during interactions (Baumeister, 1982). These concerns may moderate any performance intensity or persistence changes that were due to social facilitation. Finally, it is plausible that humans will be willing to participate in an exercise team with a software-generated partner, as the need to belong and form social attachments is thought to be a powerful instinctive force (Baumeister & Leary, 1995).

Computers are social actors. To form social attachments and capitalize on the benefits of motivational group dynamics, the user must accept that his/her software-generated partner is an effective representation of human counterparts. The *Computers are Social Actors* (CASA) paradigm (Nass, Fogg, & Moon, 1996) or the *Media Equation* (Reeves & Nass, 1996) posits that the social dynamics of human interaction with computers are similar to human interactions. Nass and colleagues demonstrated study participants' ability to perceive computers as teammates and experience team interdependence dynamics similar to a strictly human team. Mumm & Mutlu (2011) suggest that the human-computer relationship may be strong enough to invoke social facilitation of performance. People can cooperate with and respond to perceived computer personalities just as they would to humans, even following their computer teammate's suggestions (Parise, Kiesler, Sproull, & Waters, 1999). Media Equation predicts that humans will likely interact naturally and unconsciously with media, as if the content represented reality (Reeves & Nass, 1996).

Uncanny valley. While humans may form relationships with many different types of software-generated media, one well-known barrier to becoming comfortable with a virtual partner is its perceived eeriness. Masahiro Mori (1970) used the term *uncanny valley* to describe a threshold for human tolerance for accepting a human likeness. Mori warned of a valley of discomfort in which the character's imperfections become strange and unsettling (MacDorman & Ishiguro, 2006). Eeriness can accompany any mismatch in expectations of reality when interfacing with non-human characters. A non-human character may eerily fail to meet what is expected, by being too human-like or by representing an off-putting or uncanny anthropomorphism (Ho & MacDorman, 2010). This eeriness can have a negative affect on likability and acceptance of one's partner, mitigating the effectiveness of group dynamic interventions on motivation.

Self-disclosure. Another social relationship bolstering technique (to affect performance) available when using software-generated (or computer-mediated) partners is to modulate the level of interaction when the partners initially meet. The exchange of personal information or self-disclosure may establish a group norm of reciprocity and serve as a powerful symbol of ingratiation and the desire to build trust (Cialdini & Trost, 1998). There is evidence demonstrating positive subsequent interactions and higher social attraction with a computer after an exchange of personal information (Kang & Gratch, 2011; Lee, Kiesler, & Forlizzi, 2010;

Moon, 2000). To boost the impact of the partner self-disclosure and perceptions of realism, response interactivity can be built into computer-human dialogue exchanges (Burgoon et al., 2000).

Overview of Previous Research

This review of previous research summarizes the linear progression of work focused on exploring the Köhler motivation gain effect, from the original psychological studies by Otto Köhler to ongoing research applying the conjunctive paradigm to exercise settings. As noted previously, the Köhler effect is thought to be one of the few group dynamics paradigms capable of realizing performance gains in groups and is the core of the methodology for the three studies presented in this dissertation.

Early Köhler effect studies. Most of what is known about the Köhler effect was not revealed by Köhler's original work with rowers. It was not until Köhler's findings were replicated by Stroebe, Diehl, and Abakoumkin (1996) that a better understanding of this phenomenon emerged. The researchers first attempted to replicate Köhler's experimental protocol and moderate participant ability discrepancy. Although the male student participants suffered intense pain, limiting their performance, the researchers were able to explain similar findings. The weaker member's performance increase was surmised as his desire to adopt the stronger member's performance goal. Following up on this study, the researchers changed the design to require participants to simultaneously turn a hand crank wheel as fast as they could for 10 minutes. Dyads were told to maintain the same speed or compensation would be withheld. The task of matching the speed of one's partner to avoid penalty prevented the paradigm from being truly conjunctive. In a third experiment, Stroebe varied the ability discrepancies (performance ratios) of dyads versus individuals with a sample of high school students. Similar to Experiment 2, participants turned a hand wheel, while viewing performance feedback. The researchers went on to complete a fourth experiment in which the feedback was varied, concluding that continuous information on performance moderated performance improvements in the conjunctive dyads. Finally, a fifth experiment was conducted utilizing a new physical persistence exercise during which participants held their arm out horizontally, with a 1 kg weight, as long as they could. Lowering their arm would trigger a string indicator set up to signal that the task was then finished. The results demonstrated some support for Köhler's task persistence findings, but somewhat mixed findings for a relationship between the dyad performance ratio and the average composite of the individual performances. Stroebe and colleagues concluded that, despite a lack of clarity regarding the mechanisms by which the Köhler effect occurred, the experiments demonstrated an increase in dyad performance under conjunctive conditions of unequal strength.

As the horizontal arm suspension task is simple and participant performance relies on little except their own effort, it was chosen as the experimental model in the next series of studies examining the Köhler effect (Hertel, Kerr, & Messé, 2000). Researchers hoped to exclude any confound posed by task requirements for training, skill, or intelligence. Varying the task to better represent unified task performance, the researchers used a weighted bar, held horizontally by the dyad instead of individual arm weights. Similar to Stroebe's prediction of an optimal experimental situation, the researchers also sought a design that allowed for improvements between the participant's average performance and their best performance by instructing participants to simply try their best until uncomfortable (i.e., initial level of discomfort set the threshold for stopping). Along with this, Hertel et al. went on to establish much of what is currently employed as the Kohler experimental paradigm. That is, the researchers speculated about the inclusion of multiple variables that might optimize the motivation gain findings. These include: dyads should be physically 'yoked' so that when one can no longer continue, the partner must also stop; each group member should be in the other's physical presence and, thus, be able to act and react to each other's performance (this requirement was later altered for efficiency reasons); the setting should be such that both members care about performing well for the other (and potentially, for others nearby); membership in the task group is something with which both members strongly identify; and, the task is low physical risk to either member.

Experimental manipulations included informing participants that the study focus would concern a comparison of physical task persistence between men and women. Multiple trials recorded the persistence with the arm extension task individually and in dyads, with the latter ending when one teammate dropped his/her arm and touched a trip wire to stop both members. Weaker members were identified by the lowest individual persistence time of those participants later joined together in a dyad. This initial experiment did indeed replicate the Köhler motivation gain in the weaker members using the new experimental design. Overall, the researchers reported a weaker member dyad performance increase of 10% compared to the mean of their individual attempts.

In a second experiment, Hertel et al (2000) sought to compare probable mechanisms for the Köhler effect: goal comparison and indispensability. Stroebe had previously suggested that goal comparisons form when there is no clear standard for good performance. In that case, group members socially compare to each other (e.g., perceptions of the other's ability) to establish what performance goal might be reasonable to achieve. In conjunction with this scenario, it was believed that members would lower goals to that of the weakest member if the performance is not valued and heighten goals to that of the strongest member if the performance was valued.

Group indispensability was hypothesized as another plausible explanation, based on expectancy-instrumentality-value models (discussed previously in this dissertation). If this mechanism is responsible for increases in effort, researchers predict this motivation effect would depend on the member's perception of how instrumental their effort is to the expected outcome. Hertel and colleagues' second experiment contrasted the two possible explanations using conjunctive, additive, and control conditions. By now, using two weighted bars (each member held his/her own), the researchers were able to calculate persistence times for conjunctive groups (i.e. both must stop when the first member lowers the arm to trigger the bar) and additive groups (i.e. the second person may continue alone after the first member ceases to extend the arm above the threshold). Although social comparison may occur in either condition, indispensability should only occur in the conjunctive group due to the group outcome being dependent on the weakest performance and the potential of feeling like that member let the group down. Results supported the perceived group indispensability explanation, as motivation gains were only observed in the conjunctive conditions. No performance gains were noted in the additive condition and, most interesting, no moderation of the weakest member's performance was correlated with ability discrepancy. With these findings, the researchers suggested that social comparison was not a moderator of motivation gains in this paradigm. However, considering the sparse research on the Köhler effect up to that time, the researchers offered several possible factors that could have impacted the results: insufficient understanding of the conjunctive nature for the task; extrinsic rewards may have inhibited intrinsic motivation and confounded perceived value of the task performance; group or social identity may be a necessary component and may not have been strong enough; although positive affect was related to motivation gains, perhaps this affect preceded and was a basis for performance, instead of a consequence; and, although participants were able to observe their partner's performance, they may not have had accurate knowledge of the ability discrepancy.

Yet, it may be that no motivation gains occurred in the additive condition as a result of losses associated with social loafing or free-riding effects. This might explain why social comparison could not be isolated in the previous research using additive conditions. To explore this possibility and further examine other potential variables, the Köhler paradigm was tested in conjunctive versus coactive conditions using an all-female sample (Kerr et al., 2007). Kerr and colleagues proposed that social comparison could occur in coactive settings, where no true interdependence exists, eliminating the risk of social loafing. Results of the first experiment in Kerr's lab, using a similar protocol to compare coactive and conjunctive conditions, indicated that neither explanation alone (social comparison or team indispensability) was sufficient to explain the full Köhler effect and the researchers concluded that both processes were needed.

Kerr added a second experiment replicating the previous protocol, except enrolling both male and female participants in comparison groups. This insight regarding a possible moderation of the two mechanisms by gender was based on prior work suggesting males may be generally more competitive, leading to comparison goals and females may tend to set more pro-social goals, predisposing them to be influenced more by perceptions of group indispensability. As expected, the researchers found motivation gains for both genders in the coactive condition but significant differences between coactive and conjunctive conditions were only noted for females. The ability to socially compare in the coactive condition, thought to be more highly motivating to males, negated any differences between the conditions. The researchers extended these findings related to gender differences in a third experiment in which women did *not* react to the indispensability of their efforts when primed with competitive goals.

Weber and Hertel (2007) conducted a meta-analysis of 17 studies in which researchers examined motivation gains of inferior group members and reported a moderate to strong effect size across the studies (g = 0.6). Weber and Hertel confirmed inferior member motivation gains for additive and coactive conditions, confirming social comparison as a plausible mechanism. They also noted even stronger conjunctive (versus individual) motivation gains and a significant effect size for comparisons of these conjunctive studies to non-conjunctive studies, supporting indispensability as a mechanism. Motivation gains were also noted in study designs that involved both physical and cognitive tasks (although effects in physical tasks were significantly higher than those for cognitive).

Köhler effect moderators. While the previous Köhler effect research has solidified much of the necessary parameters for this group dynamic, many potential moderating factors have also either been identified or theorized to be key in this line of research moving forward (Kerr & Hertel, 2011; Weber & Hertel, 2007). Potential moderators that were explored in early Köhler effect studies include variables related to group sex composition, relative ability of partners, self-efficacy, partner anonymity, competition, performance information available to the weakest partner, stability of group membership, friendship between partners and ostracism, and performance norms.

Sex composition of the group. Lount, Messé, and Kerr, (2000) were able to demonstrate the Köhler motivation gain on a physical persistence task, irrespective of the sex of the participants' partner. The authors speculated that self-presentational concerns may have been responsible for further findings that male participants demonstrated even greater gains when partnered with a superior female.

Ability discrepancy. A key moderator of the Köhler effect was observed in Köhler's original research; that is, the ability discrepancy between partners moderates task performance (Köhler, 1926). This relative ability effect or *Köhler discrepancy effect* (Hertel, Kerr, Scheffler, Geister, & Messé, 2000) was replicated by Messé and colleagues, who noted motivational gains were maximal when a moderate discrepancy between partner ability was known to the weaker member (Messé, Hertel, Kerr, Lount, & Park, 2002). Likewise, motivation gains were diminished when the known discrepancy was either too similar or too discrepant.

Perceived self-efficacy of the least able partner. When self-efficacy and performance feedback were manipulated for the third of three persistence exercises, researchers noted significant motivation gains in high self-efficacy conditions (Seok, 2004). However, the researchers noted the greatest motivation gains in those participants with low self-efficacy feedback. This motivation gain effect was most pronounced when the discrepancy between the participant and partner was moderate.

Partner gender. Comparing males and females in a same-gender computer-mediated task, researchers noted that females demonstrated significant motivation gains in conjunctive conditions, (team indispensability and social comparison mechanisms), but not in coactive conditions (Weber, Wittchen, & Hertel, 2009). Whereas males demonstrated significant gains in the coactive conditions (social comparison mechanism), they did not do so in the conjunctive conditions. Gender appeared to moderate the Köhler effect's two core mechanisms (team indispensability and social comparison). Females seemed to be more responsive to team members in terms of role obligation, and motivation gains in males more likely to be due to a desire to compare in an upward direction.

Partner anonymity. In line with the gender-moderated finding, Weber, Wittchen, and Hertel (2009) also examined whether knowing and being known by a partner moderates Köhler motivation gains. Females decreased effort when working with someone they knew, regardless of conjunctive or coactive condition and increased effort when the other person's identity was anonymous. Men increased effort when they knew the partner in both conjunctive and coactive conditions.

Competition. When primed with competitive terms (versus neutral), coactive participants increased simple task persistence performance over baseline but those in conjunctive and individual conditions did not (Sambolec, Kerr, & Messé, 2007). Yet, measures of trait competitiveness were not significantly correlated to task performance. The authors point out that none of the three conditions were explicitly competitive in nature and this may have affected between competitiveness and performance.

Performance feedback. Eliminating feedback regarding partner or participant performance resulted in a mitigation of the Köhler effect but the authors noted that continuous feedback of both members' performance was not necessary (Kerr, Messe, Park, & Sambolec, 2005). However, Weber and Hertel's (2007) review of feedback availability suggested that there is a positive relationship between partner-related information availability and higher effort by the participant. High specificity of partner performance information was crucial for perceived indispensability effects to occur in one study of Olympic relay swimmers (Hüffmeier, Kanthak, & Hertel, 2013).

Stability of group membership and uncertain relative abilities. In a study of group membership stability, participants held a small weight above a tripwire for as long as they felt comfortable over six trials (Lount, Kerr, Messé, Seok, & Park, 2008). Conjunctive and coactive conditions were compared to control, with partnered condition membership split between a consistent partner or a new partner substituted every two trials. Motivation gains were more robust for groups with varying partners versus those with stable membership. The authors speculated that changing partners (with uncertain relative abilities) over time may re-activate social comparison processes that diminish over time with the same partner.

Friendship and ostracism. Experimenters asked male and female participants to perform multiple persistence trials (weight above tripwire) after either being the subject of social ostracism, inclusion, or a no-interaction control (Kerr & Seok, 2010; Kerr, Seok, Poulsen, Harris, & Messé, 2008). The CyberBall electronic tossing game was used to include or exclude the participant from the group toss around, while group members were purportedly the same as those who would work with them as a partner or cofactor during the persistence task. Ostracism did attenuate but not eliminate the Köhler motivation gain in conjunctive conditions but not in coactive conditions. It is possible that ostracism devalued the conjunctive shared goal and feelings of obligation and accounted for differences between experimental conditions. Kerr and colleagues suggested that indispensability (but not social comparison processes) is sensitive to the effects of ostracism.

Performance norms. Kerr and Seok (2010) once again utilized coactive and conjunctive conditions in a simple persistence task to examine the moderating effect of friendship and performance norms on performance. Friend or stranger norms were reported to participants as those of low or high task effort. Significant motivation gains were noted in conjunctive conditions versus coactive conditions when partners were friends or effort norms were high. Coactive performance (versus control) was not moderated by friendship or performance norms.

As noted, all of these moderators are thought to exert their effect on one, or both, of the primary Köhler effect mechanisms, team indispensability and upward social comparison, and are now largely controlled when utilizing the Köhler paradigm (Kerr & Hertel, 2011).

Köhler effect with exercise tasks. With the goal of extending this promising line of laboratory research to exercise tasks as a way of improving health outcomes, Feltz, Kerr, and Irwin (2011) adapted the Köhler paradigm to exergames. Realizing that the motivation gains derived from the Köhler mechanisms may be mitigated by common personal or group activity concerns experienced by exercisers, the researchers adapted the paradigm to the use of a virtually-presented human partner. By using an exercise partner that is presented over a video display, the experimental design can control for several of the Köhler paradigm attributes discussed earlier as potential moderators of the Köhler motivation effect (visual performance feedback, perceptions of ability can be manipulated, intensity and duration of the stronger member performance can be tailored, gender of the partner can be prearranged).

Participants in this new design were assigned to one of four conditions: individual control, coactive, additive, or conjunctive. The video game consisted of a PlayStation 2 (PS2) gaming module, with EyeToy: Kinetic software that included an abdominal plank exercise regimen and a software-generated trainer to present exercise instructions. An additional accessory (Eye Toy camera) displayed images of the participant on a television monitor so they could view their performance, as well as ostensibly allowing the participant performance to be recorded or broadcast to another lab for partner viewing (in this experiment, no such broadcast occurred).

All participants completed five abdominal plank exercises for as long as they felt comfortable while the researcher measured persistence. After a rest period, control participants completed a second block of five plank exercises. During their rest, the other participants completed a video introduction and a brief exchange of personal information with a same-sex partner over a video connection. Unknown to the participants, the partner was actually a confederate, recorded previously to control aspects of the experimental design. Before proceeding with a second block of five plank exercises, the experimental condition participants were provided false feedback related to the performance ability of their partner. This came in the form of presenting the partner's performance on the first five planks (in another lab) as 1.4 times the actual plank persistence times recorded for the participant. This superior performance was meant to create the perception of the partner superiority. Once participants commenced with the second block of exercises, they could simultaneously observe their partner on a video projection. Again, without the participant's knowledge, the partner video was actually prerecorded and looped so that the participant would always quit the plank before their partner. Incentives aided in establishing the experimental condition parameters. Coactive participants earned lottery tickets solely dependent upon individual performance. Additive and conjunctive participants lottery ticket reward would be a result of the team score: additive to be an average of the two members' individual persistence scores and, conjunctive would be the persistence score of the first teammate to quit the plank exercise.

Results confirmed upward social comparison as a mechanism to motivation to persist with this exercise, as all experimental condition participants held the abdominal plank longer than control. The 53.86-second difference in persistence times equates to a 24.1% increase in this simple effort-based task, using the video game design core with a Köhler paradigm. However, no differences were noted between the conjunctive and other experimental conditions, preventing any contribution toward indispensability as a Köhler effect mechanism. Researchers proposed possible reasons why this might have occurred: insufficient group identification; exercising with college-aged peer created competitive goals; and, extrinsic reward inhibited intrinsic motivation.

A subsequent experiment in this lab demonstrated motivation gains in the conjunctive condition, again with the use of a video game, virtually-presented partnered design (Feltz, Irwin, & Kerr, 2012). In this study, incentive (course credit) was not tied to task structure and ability discrepancy was tested so that college-aged participants were assigned to one of four conditions: individual control or low-, moderate-, or high-partner discrepancy (all with conjunctive task demands). Persistence with the plank exercises was significantly greater in all of the experimental conditions compared with the individual control condition. The moderate-partner discrepancy participants recorded longer persistence times than either one of the other two experimental conditions, representing a 54% increase over individual control.

It is possible that social comparison diminishes the longer one is partnered with another, negating any motivational effect. It is also possible that perceptions of indispensability increase over time, as one has time to identify with the group and strengthen the relationship with their partner. To explore whether the two mechanisms thought to be responsible for the Köhler motivation gains would attenuate over time, researchers adapted a Köhler conjunctive paradigm to an aerobic cycling activity with college women (Irwin, Scorniaenchi, Kerr, Eisenmann, & Feltz, 2012). Conjunctive condition participants were compared to those in coactive and control conditions in a stationary bike task in six sessions over a 2-week period. Cycling intensity was controlled for all conditions so that participants pedaled at 65% of their predicted maximum heart rate reserve. Similar to other video game designs in this lab, participants met a confederate same-sex partner of a video connection and exchanged greeting information. False feedback of partner performance and manipulation instructions was provided. During the bike rides, the confederate partner video of the ride was played back with a loop so that she would never quit before the conjunctive partner participant. Conjunctive participants averaged longer rides than those in the coactive condition and significantly longer (11 minutes average) versus control participants.

Using the PlayStation 2 gaming module, EyeToy: Kinetic software, and Eye Toy camera with confederate partners, researchers replicated the Köhler paradigm again but added a condition in which participants were allowed to beat their partner on a performance task (Kerr, Forlenza, Irwin, & Feltz, 2013). Adding a wall-sit exercise (squatting down while leaning against a wall) to the abdominal plank exercises, participants were set up to be the weaker team member in one of the exercises and the stronger in the other. The other conditions included a traditional conjunctive condition and a control condition. No differences were noted between experimental conditions but the partnered participants held each exercise significantly longer than control.

As consistent motivation gains have been demonstrated with the Köhler effect paradigm and simple effort-based isometric exercise task and aerobic cycling tasks, other studies have varied other potential moderators. Exercising with an older or significantly heavier partner may bias or disrupt perceptions of that partner's ability and potential contribution to the group task performance. Additionally, if the perceived discrepancy is too great or too little, participants may give up any belief in an attainable or valued performance goal. Researchers examined this issue with a non-obese college-aged sample and paired conjunctive condition participants with various combinations of older age and heavier weight (Forlenza, Kerr, Irwin, & Feltz, 2012). Engaging in an abdominal plank physical activity task with a heavier weight, virtually-presented (i.e. video projection) partner did not attenuate persistence gains in a non-obese college student sample. The results showed that conjunctive female team participants persisted longer, relative to individual exercisers, regardless of their virtually-presented partner's weight and age. Males in the conjunctive condition also exceeded their control counterparts but their partner's weight marginally moderated this effect. When males planked with a heavier partner, they tended to persist longer. The authors speculated that the male participants might have perceived the weight of the heavier partner as general dissimilarity in ability that they should outperform.

Köhler effect with software-generated partners. More recent research has asked the question: would exercisers accept and be willing to partner with a non-human, software-generated teammate? Moving to software-generated partners (SGPs) may help control group dynamic forces and offer greater flexibility to both exercisers and to researchers looking to test Köhler effect moderators. To test the Köhler effect in SGPs, experimenters enrolled 120 college-aged participants in an abdominal plank exercise protocol, using a program designed for the study (CyBuddy Exercise; Feltz, Forlenza, Winn, & Kerr, 2014). As in previous studies, participants completed a block of abdominal planks alone and then, conjunctive condition participants greeted their partner and completed a second block. In this design, participants were randomly assigned to either: a 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). Results showed a significant motivation gain for SGPs, though this effect was smaller than with human partners (Feltz et al., 2014). These results were consistent with Media Equation research (Reeves & Nass, 1996), which suggests that people can respond socially to computer or software agents as if they were human.

Summary. The results from this line of research have demonstrated that working with a superior partner under conjunctive task demands dramatically improved performance on exercise tasks. Also, motivation gain effects to persist with the exercise were achieved without aversion to the task. That is, there was no evidence that partnered participants enjoyed the exercise less while persisting longer than no-partner controls (Feltz et al., 2011; Feltz et al., 2014; Forlenza et al., 2012; Kerr et al., 2013). Similarly, participants partnered in the conjunctive task setting have not reported levels of overall exertion to be higher, despite working harder, except in Forlenza and colleague's (2012) dissimilar weight condition (Feltz et al., 2011; Feltz et al., 2014; Irwin et al., 2012; Kerr et al., 2013). All of the studies reviewed here have also noted perceptions of self-efficacy were unchanged from baseline in the conjunctive condition participants, even subsequent to being outperformed by their teammate. In a 6-session aerobic cycle study of the Köhler effect, self-efficacy ratings for the conjunctive participants actually increased over the 2 weeks compared to control participants (Irwin et al., 2012). These findings are significant, as the constructs of enjoyment, exertion, and self-efficacy may share a positive relationship and are each known to be key determinants in exercise behavior. Enjoyment, defined here as a positive affect based on feelings and perceptions of interest, pleasure, liking, and fun can influence how people judge their capabilities (Bandura, 1998). A positive affect, such as enjoyment, can enhance perceptions of self-efficacy, and vice versa. When persisting with exercise, enjoyment can limit the extent fatigue reduces their self-efficacy to continue with the task (Bandura, 1998). Although researchers target the key Köhler effect mechanisms of indispensability and upward social comparison, they can not ignore the impact of enjoyment, exertion, and self-efficacy on motivation in exercise settings. The fact that the Köhler effect is one of the few group dynamic strategies that is able to induce performance gains (not just avoid losses) in group settings, without the side effect of diminished enjoyment or self-efficacy, certainly supports its use in future research and interventions.

Overview of Current Research

The aim of current research was to replicate a previously successful Köhler effect motivation gain paradigm to examine several potential moderators of this effect on exercise persistence. Further, the robustness of the Köhler effect model was explored when utilizing software-generated partners in lab and in free-living conditions. These experiments seek to manipulate variables thought to moderate a motivation gain in exercise partner groups so that this positive effect may be sustained or enhanced when using software-generated partners. The use of non-human partners and adaptation to free-living environments is an attempt to move closer to practical applications supporting efforts to persist with physical activity.

Pairing people together to boost overall persistence with exercise is somewhat risky, as the small group dynamics may have a positive or negative effect on motivation. The conjunctive task structure is unique and offers a method of minimizing performance losses (free-rider effect, social loafing, or stronger member compensation) that are difficult to control in simple coactive or additive group dynamics. By instilling true task interdependence and a moderate ability discrepancy into the conjunctive structure, the weaker member is unconsciously encouraged to increase performance above what she/he may have achieved individually. Evidence suggests upward social comparison and group indispensability drive motivation gains in this setting, yet clearly aspects of the social relationship with one's exercise partners may moderate task performance. The following three experiments test one or more potential social relationship moderators that may interfere with the conjunctive mechanisms. As interpersonal and environmental factors in these studies were unique in Köhler research thus far, the primary concern was the loss of participant response to his/her superior exercise partner and the conjunctive task paradigm manipulations, resulting in decremental Köhler effect motivation to persist. Additionally, Experiment 3 tested the temporal decline of the motivation effect.

Experiment 1: Does Weight Matter? Partner Weight as a Moderator of Exercise Motivation in an Obese Sample (Samendinger, S., Beckles, J., Forlenza, S.T., Pfeiffer, K.A., & Feltz, D.L., 2015), questioned whether or not partner weight characteristics moderate the Köhler effect with adult obese participants. The answer to this question is important because obese individuals have reported feelings of being too overweight, feeling self-conscious, and experiencing high levels of distress when exercising among others (i.e., social physique anxiety) (Napolitano, Papandonatos, Borradaile, Whiteley, & Marcus, 2011; Smits, Tart, Presnell, Rosenfield, & Otto, 2010). In light of prior robust Köhler motivation gains, identifying optimal partner characteristics could potentially allow this powerful source of motivation to be targeted when matching human partners or within an exergame design to increase exercise intensity and duration for obese populations.

Specifically, the weight of the partner relative to weight of the person exercising could impact the perceived discrepancy in ability between partners or decrease the likelihood that the partner would even be suitable as a comparison. Feltz et al. (2012) tested whether there is an optimal level of ability discrepancy between an exergame player and a virtually-presented partner. The authors found that the Köhler effect was smaller when one's virtually-presented partner was either only slightly more capable or extremely more capable than the participant. This Köhler "discrepancy effect" can weaken performance gains by undermining the motivation in partner comparison processes. Therefore, a moderate discrepancy in ability seems to encourage comparison (Feltz, Irwin, & Kerr, 2012). In terms of partner weight, it is plausible that exercising with a lighter weight partner, versus a similar weight partner, might instill unfavorable comparison responses, which could attenuate any motivation gains from the Köhler effect (Schwartz, Vartanian, Nosek, & Brownell, 2006). For example, because obese individuals may perceive lighter weight people as being more capable at the exercise task, they may view them as an incomparable partner and reject the team goal as unrealistic. Yet, little is known about the influence of an exercise partner's weight as a potential moderator of Köhler motivation gain effect. Further, no studies have explored this moderator in an obese sample, considering both the weight of the partner and participant.

Engaging in a physical activity task with a heavier weight, virtually-presented (i.e., video projection) partner did not significantly attenuate persistence gains in a non-obese college student sample (vs. a similar-weight partner; Forlenza, Kerr, Irwin, & Feltz, 2012). The results showed that conjunctive team participants persisted longer, relative to individual exercisers, regardless of their virtually-presented partner's weight. However, other studies on the Köhler effect in exercise, as with this prior study, have employed only lighter weight, college-aged participants. Using an obese (≥ 30 BMI) community sample, Experiment 1 examined the motivation to persist at an exergame task when exercising with a lighter or same weight virtually-presented partner. In addition, obese participants' weight perceptions (own and partner) and ability perceptions (own and partner) were explored in relation to performance outcomes.

Experiment 2: During Introductory Dialogue and Köhler Group Dynamics in Software-Generated Workout Partners (Samendinger, S., Forlenza, S.T., Winn, B., Max, E.J., Kerr, N.L., Pfeiffer, K.A., & Feltz, D.L.; manuscript submitted), participants were exclusively partnered with a same-sex software-generated partner (SGP) to explore the question that Feltz and colleagues (Feltz et al., 2014) asked: would exercise participants willingly team up with an SGP, or would they view the SGP as an incomparable *other* with the effect of weakening the Köhler motivation gain. As discussed, results of this study showed a significant motivation gain for SGPs, though this effect was smaller than with human partners (Feltz et al., 2014). These results were consistent with Media Equation research (Reeves & Nass, 1996), which suggests that people will often respond socially to software agents as if they were human. Additionally, there was no evidence that working with SGPs harmed enjoyment or increased perceived exertion (Feltz et al., 2014), which is consistent with most prior findings in this area (Feltz et al., 2011; Feltz, Irwin, & Kerr, 2012; Forlenza, Kerr, Irwin, & Feltz, 2012; Kerr et al., 2013). While a promising start, Feltz et al. (2014) had been the only study to explore the Köhler effect in exergames with SGPs. Furthermore, this study was conducted with college students; older age participants may react differently to SGPs because they play video games less frequently than college-aged adults (Lenhart, Jones, & Macgill, 2008; Pew, 2013).

In the Feltz et al. (2014) exergame with an SGP, the same protocol was used to introduce participants to their partner as in previous human partner experiments (Feltz et al., 2011). In the protocol, participants were informed that they would be working with a partner, and that his/her gameplay would be visible via a projection onto a screen. Before they exercised together, participants met their SGP via a webcam-like connection, during which each introduced themselves to share basic information (e.g., favorite television shows, what they like to do for fun). While this protocol works well for human partners, it may not be optimal for attempting to build a connection with SGPs (Feltz et al., 2014). Yet, having familiarity with one's partner is beneficial for improving motivation (Kerr & Seok, 2010). Prior research has also suggested that people may have positive subsequent interactions and higher social attraction with a computer after an exchange of personal information (Kang & Gratch, 2011; Lee, Kiesler, & Forlizzi, 2010; Moon, 2000). One alternative strategy to a simple exchange of spoken information is to use a dialogue tree, which is more interactive and allows the introduction to be back-and-forth, like real conversations. Such interactivity may enhance perceptions of the SGP-human social relationship (Burgoon et al., 2000). This possibility was explored in Experiment 2.

Experiment 3: BOOST: A Virtual Partner Smartphone App to Boost Walk Motivation (Samendinger, S., Pfeiffer, K.A., Kerr, N.L., Smith, A.L., & Feltz, D.L.; in preparation) sought to take advantage of the potential benefits of exercising with a software-generated partner by extending prior research to a field study using a mobile application (app), providing participants ubiquitous access to partnered exercise. The mobile iPhone app, titled BOOST, was used in a free-living setting for the first time to motivate adults to persist in walking for exercise. The Köhler effect had never been tested with SGPs on physical exertion tasks under free-living conditions. This project sought to directly measure behavioral, psychological and physical outcomes of a SGP walking app with potential mass appeal and broad reach.

Mobile access to assistive health-based tools was hypothesized to be an effective method to increase exercise motivation, again utilizing a Köhler effect paradigm. In April 2013, the President's Council on Fitness, Sports & Nutrition launched an initiative to highlight active video games as one way to help Americans lead more active lives. Similarly, health and fitness smartphone apps were recognized as a popular and attractive way to present a walking SGP intervention. As of 2014, 58% of adults own a smartphone, with 50% downloading at least one app (Pew, 2014). Nielson estimated one-third of U.S. smartphone owners (46 million people) accessed a fitness and health app in January 2014 and accessed such apps 16 times per month for over an hour each time (Nielsen, 2014). Although there are many apps to increase physical activity and manage weight, none provide research evidence of objective changes in physical activity behavior (Stephens & Allen, 2013).

Walking was chosen as an ideal exercise with which to partner participants and SGPs in a free-living environment. In 2013, the Surgeon General put forth a call to action in support of walking, for its long-tem health benefits and as an initiative to reach the 2008 Physical Activity Guidelines (PAG; General, 2013). Walking is easy to do, is low cost, and requires no special training, equipment, or facilities. Walking has mass appeal and huge potential to help Americans reach the PAG (Lee & Buchner, 2008), as it is consistently the most common adult physical activity. As of 2005, an estimated 41.5% of adults walked for leisure (Kruger, Ham, Berrigan, & Ballard-Barbash, 2008). The Centers for Disease Control and Prevention (CDC) suggests walking as a way to meet the PAG, as walkers are much more likely to meet the PAG than non-walkers (Centers for Disease Control and Prevention, 2012).

Motivation gains may diminish when moving away from using human partners and toward SGPs so, participants were able to select their exercise partner from a choice of two same-sex SGPs and a novel synchronization feature was applied to the BOOST app. To benefit from an exercise SGP, a user must form a social bond and coordinate activities with his/her teammate. The BOOST app employed audible SGP-simulated footsteps (sync condition only) during a limited pre-walk warm-up period in an attempt to apply the potential social connection benefits of interpersonal synchronization (IPS). Thus, if the participant synchronizes to the SGP's footsteps (via an audio signal), favorable perceptions of the SGP might strengthen the dyad relationship and produce positive motivational outcomes.

REFERENCES

REFERENCES

Ayotte, B. J., Margrett, J. A., & Hicks-Patrick, J. (2010). Physical Activity in Middle-aged and Young-old Adults The Roles of Self-efficacy, Barriers, Outcome Expectancies, Self-regulatory Behaviors and Social Support. *Journal of Health Psychology*, *15*(2), 173–185. http://doi.org/10.1177/1359105309342283

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W.H. Freeman and Company.

Bandura, A. (1998). Health promotion from the perspective of social cognitive theory. *Psychology and Health*, *13*(4), 623–649.

Baron, R. S., & Kerr, N. L. (2003). *Group process, group decision, group action* (2nd ed.). Buckingham, UK: Open University Press.

Baumeister, R. F. (1982). A self-presentational view of social phenomena. *Psychological Bulletin*, *91*(1), 3–26. http://doi.org/10.1037/0033-2909.91.1.3

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.

Bell, J. A., Hamer, M., Batty, G. D., Singh-Manoux, A., Sabia, S., & Kivimaki, M. (2014). Combined effect of physical activity and leisure time sitting on long-term risk of incident obesity and metabolic risk factor clustering. *Diabetologia*, *57*(10), 2048–2056. http://doi.org/10.1007/s00125-014-3323-8

Berkman, L. F., Glass, T., Brissette, I., & Seeman, T. E. (2000). From social integration to health: Durkheim in the new millennium. *Social Science & Medicine*, *51*(6), 843–857. http://doi.org/10.1016/S0277-9536(00)00065-4

Burgoon, J. K., Bonito, J. A., Bengtsson, B., Cederberg, C., Lundeberg, M., & Allspach, L. (2000). Interactivity in human–computer interaction: A study of credibility, understanding, and influence. *Computers in Human Behavior*, *16*(6), 553–574.

Burke, S. M., Carron, A. V., Eys, M. A., Ntoumanis, N., & Estabrooks, P. A. (2006). Group versus individual approach? A meta-analysis of the effectiveness of interventions to promote physical activity. *Sport and Exercise Psychology Review*, *2*(1), 19–35.

Carron, A. V., & Brawley, L. R. (2000). Cohesion Conceptual and Measurement Issues. *Small Group Research*, *31*(1), 89–106. http://doi.org/10.1177/104649640003100105

Carron, A. V., Brawley, L. R., & Widmeyer, W. N. (1998). The measurement of cohesiveness in sport groups. *Advances in Sport and Exercise Psychology Measurement*, 213–226.

Carron, A. V., Hausenblas, H. A., & Mack, D. (1996). Social influence and exercise: A meta-analysis. *Journal of Sport and Exercise Psychology*, *18*, 1–16.

Carron, A. V., Neil, W., & Brawley, L. R. (1988). Group cohesion and individual adherence to physical activity. *Journal of Sport & Exercise Psychology*, 10(2), 127–138.

Carron, A. V., Spink, K. S., & Prapavessis, H. (1997). Team building and cohesiveness in the sport and exercise setting: Use of indirect interventions. *Journal of Applied Sport Psychology*, 9(1), 61–72. http://doi.org/10.1080/10413209708415384

Castaño, N., Watts, T., & Tekleab, A. G. (2013). A reexamination of the cohesion–performance relationship meta-analyses: A comprehensive approach. *Group Dynamics: Theory, Research, and Practice*, *17*(4), 207–231. http://doi.org/10.1037/a0034142

Centers for Disease Control and Prevention (CDC). (2012). Vital signs: walking among adults--United States, 2005 and 2010. *MMWR. Morbidity and Mortality Weekly Report*, *61*(31), 595–601.

Chartrand, T. L., & Bargh, J. A. (1999). The chameleon effect: the perception-behavior link and social interaction. *Journal of Personality and Social Psychology*, *76*(6), 893–910.

Cialdini, R. B. (2008). *Influence: Science and Practice* (5th ed.). Allyn and Bacon.

Cialdini, R. B., & Trost, M. R. (1998). Social influence: Social norms, conformity and compliance. In D. T. Gilbert, S. T. Fiske, & G. Lindzey (Eds.), *The handbook of social psychology, Vols. 1 and 2 (4th ed.)* (pp. 151–192). New York, NY, US: McGraw-Hill.

Cohen, S. (1988). Psychosocial models of the role of social support in the etiology of physical disease. *Health Psychology*, *7*(3), 269–297. http://doi.org/http://dx.doi.org.proxy2.cl.msu.edu/10.1037/0278-6133.7.3.269

Cohen, S., Underwood, L. G., & Gottlieb, B. H. (2000). Social relationships and health. In S. Cohen, L.G. Underwood, & B.H. Gottlieb (Eds.), *Social support measurement and intervention: A guide for health and social scientists*. Oxford University Press.

Collins, R. L. (1996). For better or worse: The impact of upward social comparison on self-evaluations. *Psychological Bulletin*, *119*(1), 51.

Delaherche, E., Chetouani, M., Mahdhaoui, A., Saint-Georges, C., Viaux, S., & Cohen, D. (2012). Interpersonal synchrony: A survey of evaluation methods across disciplines. *Affective Computing, IEEE Transactions on*, *3*(3), 349–365.

DiMatteo, M. R. (2004). Social Support and Patient Adherence to Medical Treatment: A Meta-Analysis. *Health Psychology*, *23*(2), 207–218. http://doi.org/http://dx.doi.org.proxy2.cl.msu.edu/10.1037/0278-6133.23.2.207

Dickinson, A., & Balleine, B. (1994). Motivational control of goal-directed action. Animal Learning & Behavior, 22(1), 1-18.

Dirks, K. T. (1999). The effects of interpersonal trust on work group performance. *The Journal of Applied Psychology*, *84*(3), 445–455.

Dishman, R. K. (2001). The Problem of Exercise Adherence: Fighting Sloth in Nations With Market Economies. *Quest*, *53*(3), 279–294. http://doi.org/10.1080/00336297.2001.10491745

Dishman, R. K., & Buckworth, J. (1996). Increasing physical activity: a quantitative synthesis. *Medicine & Science in Sports & Exercise June 1996*, *28*(6), 706–719.

Duncan, T. E., & McAuley, E. (1993). Social support and efficacy cognitions in exercise adherence: A latent growth curve analysis. *Journal of Behavioral Medicine*, *16*(2), 199–218.

Estabrooks, P. A. (2000). Sustaining Exercise Participation through Group Cohesion. *Exercise & Sport Sciences Reviews*, 28(2), 63–67.

Estabrooks, P. A., Harden, S. M., & Burke, S. M. (2012). Group Dynamics in Physical Activity Promotion: What works? *Social and Personality Psychology Compass*, *6*(1), 18–40. http://doi.org/10.1111/j.1751-9004.2011.00409.x

Faber, N. S., Häusser, J. A., & Kerr, N. L. (2015). Sleep Deprivation Impairs and Caffeine Enhances My Performance, but Not Always Our Performance How Acting in a Group Can Change the Effects of Impairments and Enhancements. *Personality and Social Psychology Review*, 1088868315609487.

Feltz, D. L., Forlenza, S. T., Winn, B., & Kerr, N. L. (2014). Cyber Buddy Is Better than No Buddy: A Test of the Köhler Motivation Effect in Exergames. *Games for Health Journal*, *3*(2), 98–105. http://doi.org/10.1089/g4h.2013.0088

Feltz, D. L., Irwin, B., & Kerr, N. (2012). Two-player partnered exergame for obesity prevention: using discrepancy in players' abilities as a strategy to motivate physical activity. *Journal of Diabetes Science and Technology*, *6*(4), 820-827.

Feltz, D. L., Kerr, N. L., & Irwin, B. C. (2011). Buddy up: the Köhler effect applied to health games. *Journal of Sport & Exercise Psychology*, *33*(4), 506–526.

Festinger, L. (1954). A Theory of Social Comparison Processes. *Human Relations*, *7*(2), 117–140. http://doi.org/10.1177/001872675400700202

Focht, B. C., & Hausenblas, H. A. (2004). Perceived Evaluative Threat and State Anxiety During Exercise in Women with Social Physique Anxiety. *Journal of Applied Sport Psychology*, *16*(4), 361–368. http://doi.org/10.1080/10413200490517968

Forlenza, S. T., Kerr, N. L., Irwin, B. C., & Feltz, D. L. (2012). Is My Exercise Partner Similar Enough? Partner Characteristics as a Moderator of the Köhler Effect in Exergames. *Games for Health Journal*, *1*(6), 436–441. http://doi.org/10.1089/g4h.2012.0047

Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I.-M., & Swain, D. P. (2011). Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise. *Medicine & Science in Sports & Exercise*, *43*(7), 1334–1359. http://doi.org/10.1249/MSS.0b013e318213fefb

Gellert, P., Ziegelmann, J. P., Warner, L. M., & Schwarzer, R. (2011). Physical activity intervention in older adults: does a participating partner make a difference? *European Journal of Ageing*, *8*(3), 211–219. http://doi.org/10.1007/s10433-011-0193-5

Gouldner, A. W. (1960). The Norm of Reciprocity: A Preliminary Statement. *American Sociological Review*, *25*(2), 161–178. http://doi.org/10.2307/2092623

Hackman, J. R., & Morris, C. G. (1975). Group tasks, group interaction process, and group performance effectiveness: A review and proposed integration. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 8, pp. 45–99). New York, NY: Academic Press. doi:10.1016/S0065-2601(08)60248-8

Heath, G. W., Parra, D. C., Sarmiento, O. L., Andersen, L. B., Owen, N., Goenka, S., … Brownson, R. C. (2012). Evidence-based intervention in physical activity: lessons from around the world. *The Lancet*, *380*(9838), 272–281. http://doi.org/10.1016/S0140-6736(12)60816-2

Hertel, G., Kerr, N. L., & Messé, L. A. (2000). Motivation gains in performance groups: paradigmatic and theoretical developments on the Köhler effect. *Journal of Personality and Social Psychology*, *79*(4), 580–601.

Hertel, G., Kerr, N. L., Scheffler, M., Geister, S., & Messé, L. A. (2000). Exploring the Köhler motivation gain effect: Impression management and spontaneous goal setting. *Zeitschrift für Sozialpsychologie*.

Ho, C.-C. & MacDorman, K. F. (2010). Revisiting the uncanny valley theory: Developing and validating an alternative to the Godspeed indices. *Computers in Human Behavior*, *26*(6), 1508–1518. http://doi.org/10.1016/j.chb.2010.05.015

Hove, M. J., & Risen, J. L. (2009). It's all in the timing: Interpersonal synchrony increases affiliation. *Social Cognition*, *27*(6), 949–960.

Hüffmeier, J., & Hertel, G. (2011). Many cheers make light the work: how social support triggers process gains in teams. *Journal of Managerial Psychology*, 26(3), 185–204. http://doi.org/10.1108/02683941111112631

Hüffmeier, J., Kanthak, J., & Hertel, G. (2013). Specificity of partner feedback as moderator of group motivation gains in Olympic swimmers. *Group Processes & Intergroup Relations*, *16*(4), 516–525. http://doi.org/10.1177/1368430212460894

Hüffmeier, J., Wessolowski, K., van Randenborgh, A., Bothin, J., Schmid-Loertzer, N., & Hertel, G. (2014). Social support from fellow group members triggers additional effort in groups: Social support causes effort gains. *European Journal of Social Psychology*, *44*(4), 287–296. http://doi.org/10.1002/ejsp.2021

Irwin, B. C., Scorniaenchi, J., Kerr, N. L., Eisenmann, J. C., & Feltz, D. L. (2012). Aerobic exercise is promoted when individual performance affects the group: a test of the Kohler motivation gain effect. *Annals of Behavioral Medicine: A Publication of the Society of Behavioral Medicine*, *44*(2), 151–159. http://doi.org/10.1007/s12160-012-9367-4

Jago, R., Macdonald-Wallis, K., Thompson, J. L., Page, A. S., Brockman, R., & Fox, K. R. (2011). Better with a Buddy: Influence of Best Friends on Children's Physical Activity. *Medicine & Science in Sports & Exercise*, *43*(2), 259–265. http://doi.org/10.1249/MSS.0b013e3181edefaa

Jehn, K. A., & Shah, P. P. (1997). Interpersonal relationships and task performance: An examination of mediation processes in friendship and acquaintance groups. *Journal of Personality and Social Psychology*, *72*(4), 775.

Kahn, E. B., Ramsey, L. T., Brownson, R. C., Heath, G. W., Howze, E. H., Powell, K. E., & Corso, P. (2002). The effectiveness of interventions to increase physical activity. A systematic review. *American Journal of Preventive Medicine*, *22*(4 Suppl), 73–107.

Kang, S.-H. & Gratch, J. (2011). People like virtual counselors that highly-disclose about themselves. *Studies in Health Technology and Informatics*, *167*, 143–148.

Karau, S. J. & Williams, K. D. (1993). Social loafing: A meta-analytic review and theoretical integration. *Journal of Personality and Social Psychology*, *65*(4), 681–706. http://doi.org/10.1037/0022-3514.65.4.681

Kassavou, A., Turner, A., & French, D. P. (2013). Do interventions to promote walking in groups increase physical activity? A meta-analysis. *The International Journal of Behavioral Nutrition and Physical Activity*, *10*,18.

Kerr, N. L. (1983). Motivation losses in small groups: A social dilemma analysis. *Journal of Personality and Social Psychology*, *45*(4), 819.

Kerr, N. L., & Bruun, S. E. (1983). Dispensability of member effort and group motivation losses: Free-rider effects. *Journal of Personality and Social Psychology*, *44*(1), 78.

Kerr, N. L., Forlenza, S. T., Irwin, B. C., & Feltz, D. L. (2013). "… been down so long …": Perpetual vs. intermittent inferiority and the Köhler group motivation gain in exercise groups. *Group Dynamics: Theory, Research, and Practice*, *17*(2), 67–80. http://doi.org/10.1037/a0031588

Kerr, N. L. & Hertel, G. (2011). The Köhler Group Motivation Gain: How to Motivate the "Weak Links" in a Group. *Social and Personality Psychology Compass*, *5*(1), 43–55. http://doi.org/10.1111/j.1751-9004.2010.00333.x

Kerr, N. L., Messé, L. A., Park, E. S., & Sambolec, E. J. (2005). Identifiability, performance feedback and the Köhler effect. *Group Processes & Intergroup Relations*, *8*(4), 375–390.

Kerr, N. L., Messé, L. A., Seok, D.-H., Sambolec, E. J., Lount, R. B., Jr, & Park, E. S. (2007). Psychological mechanisms underlying the Köhler motivation gain. *Personality & Social Psychology Bulletin*, *33*(6), 828–841. http://doi.org/10.1177/0146167207301020

Kerr, N. L., & Seok, D.-H. (2008). *Intergroup Competition and the Köhler Effect*. Presented at the Third Annual INGRoup Conference, Kansas City, MO.

Kerr, N. L., & Seok, D.-H. (2010). "... with a little help from my friends": friendship, effort norms, and group motivation gain. *Journal of Managerial Psychology*, *26*(3), 205–218. http://doi.org/http://dx.doi.org.proxy2.cl.msu.edu.proxy1.cl.msu.edu/10.1108/02683941111112640

Kerr, N. L., Seok, D.-H., Poulsen, J. R., Harris, D. W., & Messé, L. A. (2008). Social ostracism and group motivation gain. *European Journal of Social Psychology*, *38*(4), 736–746. http://doi.org/10.1002/ejsp.499

Kruger, J., Ham, S. A., Berrigan, D., & Ballard-Barbash, R. (2008). Prevalence of transportation and leisure walking among U.S. adults. *Preventive Medicine*, *47*(3), 329–334. http://doi.org/10.1016/j.ypmed.2008.02.018

Kruger, J., Lee, C.-D., Ainsworth, B. E., & Macera, C. A. (2008). Body size satisfaction

and physical activity levels among men and women. *Obesity*, 16, 1976-1979.

http://dx.doi.org/10.1038/oby.2008.311.

Lakens, D. & Stel, M. (2011). If they move in sync, they must feel in sync: Movement synchrony leads to attributions of rapport and entitativity. *Social Cognition*, *29*(1), 1–14.

Lakin, J. L. & Chartrand, T. L. (2003). Using nonconscious behavioral mimicry to create affiliation and rapport. *Psychological Science*, *14*(4), 334–339.

Latane, B., Williams, K., & Harkins, S. (1979). Many hands make light the work: The causes and consequences of social loafing. *Journal of Personality and Social Psychology*, *37*(6), 822.

Launay, J., Dean, R. T., & Bailes, F. (2013). Synchronization Can Influence Trust Following Virtual Interaction. *Experimental Psychology (formerly Zeitschrift Für Experimentelle Psychologie)*, *60*(1), 53–63. http://doi.org/10.1027/1618-3169/a000173

Launay, J., Dean, R. T., & Bailes, F. (2014). Synchronising movements with the sounds of a virtual partner enhances partner likeability. *Cognitive Processing*, *15*(4), 491–501. http://doi.org/10.1007/s10339-014-0618-0

Lee, I.-M. & Buchner, D. M. (2008). The Importance of Walking to Public Health. *Medicine & Science in Sports & Exercise*, *40*(Supplement), S512–S518. http://doi.org/10.1249/MSS.0b013e31817c65d0

Lee, M. K., Kiesler, S., & Forlizzi, J. (2010). Receptionist or information kiosk: how do people talk with a robot? In *Proceedings of the 2010 ACM conference on Computer supported cooperative work* (pp. 31–40). ACM.

Lenhart, A., Jones, S., & Macgill, A. (2008). *Pew Internet & American Life Project data memo*. Retrieved from www.pewinternet.org

Lombard, D. N., Lombard, T. N., & Winett, R. A. (1995). Walking to meet health guidelines: the effect of prompting frequency and prompt structure. *Health Psychology*, *14*(2), 164.

Lount, R. B., Kerr, N. L., Messé, L. A., Seok, D.-H., & Park, E. S. (2008). An examination of the stability and persistence of the Köhler motivation gain effect. *Group Dynamics: Theory, Research, and Practice*, *12*(4), 279–289. http://doi.org/10.1037/1089-2699.12.4.279

Lount Jr., R. B., Messé, L. A., & Kerr, N. L. (2000). Trying harder for different reasons: Conjunctivity and sex composition as bases for motivation gains in performing groups. *Zeitschrift Für Sozialpsychologie*, *31*(4), 221–230. http://doi.org/10.1024//0044-3514.31.4.221

MacDorman, K. F., & Ishiguro, H. (2006). The uncanny advantage of using androids in cognitive and social science research. *Interaction Studies*, *7*(3), 297–337.

MacGeorge, E., Feng, B., & Burleson, B. (2011). Supportive Communication. In M. L. Knapp & J. A. Daly (Eds.), *The Sage handbook of interpersonal communication* (4th ed, pp. 317–354). Thousand Oaks: SAGE.

Maturo, C. C., & Cunningham, S. A. (2013). Influence of friends on children's physical activity: a review. *American Journal of Public Health*, *103*(7), e23–e38.

McGrath, J. E. (1984). *Groups: Interaction and performance* (Vol. 14). Prentice-Hall Englewood

Messé, L. A., Hertel, G., Kerr, N. L., Lount, R. B., Jr., & Park, E. S. (2002). Knowledge of partner's ability as a moderator of group motivation gains: An exploration of the Köhler discrepancy effect. *Journal of Personality and Social Psychology*, *82*(6), 935–946. http://doi.org/10.1037//0022-3514.82.6.935

Moon, Y. (2000). Intimate Exchanges: Using Computers to Elicit Self‐Disclosure From Consumers. *Journal of Consumer Research*, *26*(4), 323–339. http://doi.org/10.1086/209566

Mori, M. (1970). The uncanny valley. *Energy*, *7*(4), 33–35.

Mullen, B., & Copper, C. (1994). The relation between group cohesiveness and performance: An integration. *Psychological bulletin*, *115*(2), 210.

Mumm, J., & Mutlu, B. (2011). Designing motivational agents: The role of praise, social comparison, and embodiment in computer feedback. *Computers in Human Behavior*, *27*(5), 1643–1650. http://doi.org/10.1016/j.chb.2011.02.002

Mussweiler, T. (2003). Comparison processes in social judgment: Mechanisms and consequences. *Psychological Review*, *110*(3), 472–489. http://doi.org/10.1037/0033-295X.110.3.472

Myers, N. D., Payment, C. A., & Feltz, D. L. (2004). Reciprocal Relationships Between Collective Efficacy and Team Performance in Women's Ice Hockey. *Group Dynamics: Theory, Research, and Practice*, *8*(3), 182–195. http://doi.org/10.1037/1089-2699.8.3.182

Napolitano, M. A., Papandonatos, G. D., Borradaile, K. E., Whiteley, J. A., & Marcus, B. H. (2011). Effects of weight status and barriers on physical activity adoption among previously inactive women. *Obesity* (Silver Spring, Md.), *19*(11), 2183–2189. http://doi.org/10.1038/oby.2011.87

Nass, C., Fogg, B. J., & Moon, Y. (1996). Can computers be teammates? *International Journal of Human-Computer Studies*, *45*(6), 669–678. http://doi.org/10.1006/ijhc.1996.0073

Nielsen (2014). *Hacking health: How consumers use smartphones and wearable tech to track their health*. Retrieved from: http://www.nielsen.com/us/en/insights/news/2014/hacking-health-how-consumers-use-smartphones-and-wearable-tech-to-track-their-health.html

Osca, A., Urien, B., González-Camino, G., Martínez-Pérez, M., & Martínez-Pérez, N. (2005). Organisational support and group efficacy: A longitudinal study of main and buffer effects. *Journal of Managerial Psychology*, *20*(3/4), 292–311. http://doi.org/10.1108/02683940510589064

Parise, S., Kiesler, S., Sproull, L., & Waters, K. (1999). Cooperating with life-like interface agents. *Computers in Human Behavior*, *15*(2), 123–142.

Paskevich, D. M., Brawley, L. R., Dorsch, K. D., & Widmeyer, W. N. (1999). Relationship between collective efficacy and team cohesion: Conceptual and measurement issues. *Group Dynamics: Theory, Research, and Practice*, *3*(3), 210.

Peterson, M. D., Al Snih, S., Stoddard, J., Mcclain, J., & Lee, I.-M. (2014). Adiposity and Insufficient MVPA Predict Cardiometabolic Abnormalities in Adults: *Medicine & Science in Sports & Exercise*, *46*(6), 1133–1139. http://doi.org/10.1249/MSS.0000000000000212

Pew Internet (2014). *Smartphone ownership 2013*. Retrieved from: http://www.pewinternet.org/fact-sheets/mobile-technology-fact-sheet/

Pew Internet & American Life Project spring tracking survey (2013). www.pewinternet.org/.

Rafferty, A. P., Reeves, M. J., McGee, H. B., & Pivarnik, J. M. (2002). Physical activity patterns among walkers and compliance with public health recommendations. *Medicine and Science in Sports and Exercise*, *34*(8), 1255–1261.

Reeves, B. & Nass, C. (1996). *The media equation: how people treat computers, television, and new media like real people and places*. New York, NY, USA: Cambridge University Press.

Resnick, B., Orwig, D., Magaziner, J., & Wynne, C. (2002). The Effect of Social Support on Exercise Behavior in Older Adults. *Clinical Nursing Research*, *11*(1), 52–70. http://doi.org/10.1177/105477380201100105

Rovniak, L. S., Anderson, E. S., Winett, R. A., & Stephens, R. S. (2002). Social cognitive determinants of physical activity in young adults: A prospective structural equation analysis. *Annals of Behavioral Medicine*, *24*(2), 149–56. http://doi.org/http://dx.doi.org.proxy2.cl.msu.edu/10.1207/S15324796ABM2402_12

Sambolec, E. J., Kerr, N. L., & Messé, L. A. (2007). The Role of Competitiveness at Social Tasks: Can Indirect Cues Enhance Performance? *Journal of Applied Sport Psychology*, *19*(2), 160–172. http://doi.org/10.1080/10413200601185164

Samendinger, S., Beckles, J., Forlenza, S. T., Pfeiffer, K. A., & Feltz, D. L. (2015). Partner Weight as a Moderator of Exercise Motivation in an Obese Sample. *Medical Research Archives*, (3). http://doi.org/10.18103/mra.v0i3.277

Samendinger, S., Forlenza, S. T., Winn, B., Max, E.J., Kerr, N.L., Pfeiffer, K. A., & Feltz, D. L. (*submitted*) Introductory Dialogue and Köhler Group Dynamics in Software-Generated Workout Partners.

Schwartz, M. B., Vartanian, L. R., Nosek, B. A., & Brownell, K. D. (2006). The Influence of One's Own Body Weight on Implicit and Explicit Anti-fat Bias. *Obesity*, *14*(3), 440–447.

Seok, D.-H. (2004). *Exploring self-efficacy as a possible moderator of the Koehler discrepancy effect* (M.A.). Michigan State University, United States. Michigan. Retrieved from http://search.proquest.com.proxy2.cl.msu.edu/docview/305155564/abstract

Services, H. (2008). *Two Thousand Eight Physical Activity Guidelines for Americans: Be Active, Healthy, and Happy*. Government Printing Office. Retrieved from http://www.health.gov/paguidelines/guidelines/default.aspx

Sherif, M. & Sherif, C. W. (1969). Ingroup and intergroup relations: Experimental analysis. *Social psychology*, 221-266.

Smits, J. A. J., Tart, C. D., Presnell, K., Rosenfield, D., & Otto, M. W. (2010). Identifying Potential Barriers to Physical Activity Adherence: Anxiety Sensitivity and Body Mass as Predictors of Fear During Exercise. *Cognitive Behaviour Therapy*, *39*(1), 28–36. http://doi.org/10.1080/16506070902915261

Song, H., Kim, J., & Lee, K. M. (2014). Virtual vs. real body in exergames: Reducing social physique anxiety in exercise experiences. *Computers in Human Behavior*, *36*, 282–285. http://doi.org/10.1016/j.chb.2014.03.059

Spink, K. S. (1992). Relation of anxiety about social physique to location of participation in physical activity. *Perceptual and Motor Skills*, 74, 1075–1078.

http://dx.doi.org/10.2466/pms.1992.74.3c.1075.

Steiner, I. D. (1966). Models for inferring relationships between group size and potential group productivity. *Behavioral Science*, *11*(4), 273–283.

Steiner, I. D. (1972). *Group process and productivity*. New York

Stephens, J. & Allen, J. (2013). Mobile phone interventions to increase physical activity and reduce weight: a systematic review. *The Journal of Cardiovascular Nursing*, *28*(4), 320–329. http://doi.org/10.1097/JCN.0b013e318250a3e7

Stralen, M. M. van, Vries, H. D., Mudde, A. N., Bolman, C., & Lechner, L. (2009). Determinants of initiation and maintenance of physical activity among older adults: a literature review. *Health Psychology Review*, *3*(2), 147–207. http://doi.org/10.1080/17437190903229462

Strauss, B. (2002). Social facilitation in motor tasks: a review of research and theory. *Psychology of Sport and Exercise*, *3*(3), 237–256.

Stroebe, W., Diehl, M., & Abakoumkin, G. (1996). Social compensation and the Kohler Effect: Toward a theoretical explanation of motivation gains in group productivity. In E. Witte & J. Davis (Eds.), *Understanding group behavior: Consensual action by small groups* (Vol. 2), 51-63. Mahwah, NJ: Erlbaum.

Treasure, D. C., Lox, C. L., & Lawton, B. R. (1998). Determinants of physical activity in a sedentary, obese female population. *Journal of Sport & Exercise Psychology*, 20(2), 218.

Tucker, J. M., Welk, G. J., & Beyler, N. K. (2011). Physical activity in U.S.: adult's compliance with the Physical Activity Guidelines for Americans. *American Journal of Preventive Medicine*, *40*(4), 454–461. http://doi.org/10.1016/j.amepre.2010.12.016

Uchino, B. N. (2006). Social Support and Health: A Review of Physiological Processes Potentially Underlying Links to Disease Outcomes. *Journal of Behavioral Medicine*, *29*(4), 377–387. http://doi.org/10.1007/s10865-006-9056-5

Uchino, B. N., Cacioppo, J. T., & Kiecolt-Glaser, J. K. (1996). The relationship between social support and physiological processes: a review with emphasis on underlying mechanisms and implications for health. *Psychological Bulletin*, *119*(3), 488–531.

U.S. Department of Health and Human Services. (2008). *Two Thousand Eight Physical Activity Guidelines for Americans: Be Active, Healthy, and Happy*. Government Printing Office. Retrieved from http://www.health.gov/paguidelines/guidelines/default.aspx

US Burden of Disease Collaborators. (2013). The state of US health, 1990-2010: burden of diseases, injuries, and risk factors. *JAMA: The Journal of the American Medical Association*, *310*(6), 591–608. http://doi.org/10.1001/jama.2013.13805

Vroom, V. H. (1964). *Work and motivation*. 1964. NY: John Wiley & Sons, 47-51.

Warner, L. M., Ziegelmann, J. P., Schuz, B., Wurm, S., & Schwarzer, R. (2011). Synergistic effect of social support and self-efficacy on physical exercise in older adults. *Journal of Aging and Physical Activity*, *19*(3), 249–261.

Weber, B. & Hertel, G. (2007). Motivation gains of inferior group members: a meta-analytical review. *Journal of Personality and Social Psychology*, *93*(6), 973–993. http://doi.org/10.1037/0022-3514.93.6.973

Weber, B., Wittchen, M., & Hertel, G. (2009). Gendered Ways to Motivation Gains in Groups. *Sex Roles*, *60*(9-10), 731–744. http://doi.org/http://dx.doi.org.proxy1.cl.msu.edu/10.1007/s11199-008-9574-4

Williams, K. D. (2010). Dyads Can Be Groups (and Often Are). *Small Group Research*. http://doi.org/10.1177/1046496409358619

Williams, K. D., & Karau, S. J. (1991). Social loafing and social compensation: the effects of expectations of co-worker performance. *Journal of Personality and Social Psychology*, *61*(4), 570–581.

Wiltermuth, S. S., & Heath, C. (2009). Synchrony and cooperation. *Psychological Science*, *20*(1), 1–5.

Zajonc, R. B. (1965). Social Facilitation. *Science*, *149*(3681), 269–274. http://doi.org/10.2307/1715944

CHAPTER 2

DOES WEIGHT MATTER? PARTNER WEIGHT AS A MODERATOR OF EXERCISE MOTIVATION IN AN OBESE SAMPLE

Preface

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This study started as the master's thesis of the second author (J. Beckles), under the direction of the last author (D. Feltz) with help in data collection and methodology from the first author (S. Samendinger). The thesis was defended in January 2014 with a smaller sample size (*N* = 35) than is included in the published study. The thesis was never revised and submitted to the Graduate School. The first author continued the study with a larger sample size and additional analyses on body image and perceived partner ability. The fourth author (K.A. Pfeiffer) was a committee member on J. Beckles thesis and contributed to the body image assessment and edits on the manuscript. The third author (S. Forlenza) assisted with the original study design and guidance, serving as a student member on the thesis committee.

Abstract

Objective: Köhler motivation gain principles were utilized (based on the group dynamics principles of upward social comparison and indispensability) to explore increasing exercise duration in an obese community sample (mean BMI = 38 kg·m^{-2}) with a lighter versus same weight virtually-presented interactive exergame partner.

Methods: Community adults (N = 48; age = 45.3 ± 15.86 years) completed the first block of three isometric abdominal exercises alone. After resting, participants completed the second block either alone (Control), with a lighter weight (LW), or with a same weight partner (SW). Partners were actually confederates recorded earlier and presented virtually as live, from another lab. Exercise persistence, self-efficacy beliefs, enjoyment, perceived exertion, perceptions of one's own and relative partner ability, and body image were collected.

Results: Mean persistence was greater for participants in the LW (23.2 sec) condition than for those in the Control condition (-12.44 sec; 95% CI: 11.57, 59.3, $p < 0.002$). Mean persistence was also greater for participants in the SW (21 sec) condition than for those in the Control condition (-12.44 sec; 95% CI: 8.74, 58.14, $p < 0.006$). Despite persisting longer than Controls, SW participants rated their own ability lower than Controls ($p = 0.027$). Body image assessment choice correlated with BMI ($r = .69$), but was not significantly related to persistence.

Conclusions: The Köhler motivation effect increased persistence with abdominal isometric exercises in obese adults and was not moderated by the relative weight of one's partner.

Introduction

The majority of Americans do not meet recommended standards of physical activity to maintain or improve health, with those adults in the highest obesity class reported to have the lowest levels (Tucker, Welk, & Beyler, 2011). Measured with accelerometry, 5.1% of adults with a body mass index (BMI) of 30-34.9 $kg \cdot m^{-2}$ met the guidelines of 150 minutes per week of moderate-to-vigorous physical activity and only 3.5% of those with a BMI of higher than 35 $kg \cdot m^{-2}$ met the guidelines (Tucker, Welk, & Beyler, 2011). In an analysis of the National Health and Nutrition Examination Survey (NHANES) 2003-2005 data, researchers examined the relationship between obesity and accelerometer-derived moderate-to-vigorous physical activity and noted a consistent inverse association, regardless of sedentary behavior (Maher, Mire, Harrington, Staiano, & Katzmarzyk, 2013).

Increasing the amount of time spent in moderate-to-vigorous physical activity has been a key intervention strategy to reduce obesity and associated health risk. However, motivation also has been a key issue related to these intervention strategies, especially at higher exercise intensities (Pearson, 2012; Gourlan, Trouilloud, & Sarrazin, 2011; Dishman, 2001). For instance, high-intensity, intermittent exercise has been shown to be effective when body weight reduction is a goal (Trapp, Chisholm, Freund, & Boutcher, 2008), and weight training has been shown to prevent increases in body fat percentage in middle-aged women (Schmitz, Jensen, Kugler, Jeffery, & Leon, 2003), but exercise duration is harder to maintain as intensity increases (Boutcher, 2011). Thus, finding ways to motivate people who are at risk for obesity to exercise longer at higher intensities is needed to help them realize associated health benefits.

One line of research has explored a successful method to increase the duration of exercise by providing a tailored exercise partner and framing the exercise performance task (e.g., performing abdominal exercises as a team) to operationalize specific group dynamics processes of motivation (Feltz, Kerr, & Irwin, 2011; Feltz, Irwin, & Kerr, 2012; Irwin, Scorniaenchi, Kerr, Eisenmann, & Feltz, 2012). This research has employed the group-motivation dynamic known as the *Köhler effect* with virtually-presented partners in exergames. The Köhler effect was named after a German industrial psychologist, Otto Köhler (Hertel, Kerr, & Messé, 2000), who found that the less capable member of a dyad performed longer at a simple but physically-exerting task (standing biceps curls) when paired with someone moderately better than when performing alone. This effect occurred in *conjunctive* task conditions, where the pair could persist no longer than its weaker partner (i.e., when the weaker partner quit, the stronger partner was not allowed to continue). Conjunctive task conditions are team-oriented, involve upward social comparison, and stress the indispensability of people's efforts when they see their efforts as being highly instrumental in achieving team success (i.e., the weaker partner's motivation to perform well is enhanced). The conjunctive task environment avoids common team performance losses, such as partner performance variability and perceived team dispensability (i.e., free-riding or social loafing) (Karau & Williams, 1993). Therefore, the Köhler effect, with its social comparison, sense of indispensability, and conjunctive-task environment, has shown promise for improving effort and motivation in exercise (Feltz, Kerr, & Irwin, 2011; Feltz, Irwin, & Kerr, 2012; Irwin, Scorniaenchi, Kerr, Eisenmann, & Feltz, 2012).

Using virtually-presented partners in exergames, Feltz and her colleagues demonstrated significant increases in physical activity persistence ranging from 15% to 48% with abdominal isometric exercises (i.e., planks) and wall-sit exercises and increases of 125% utilizing an aerobic cycling task (Feltz, Kerr, & Irwin, 2011; Feltz, Irwin, & Kerr, 2012; Irwin, Scorniaenchi, Kerr, Eisenmann, & Feltz, 2012; Forlenza, Kerr, Irwin, & Feltz, 2012; Kerr, Forlenza, Irwin, & Feltz, 2013). These types of exercises were used because they required considerable effort but did not require much skill/coordination, thus making them ideal for testing physical effort. Feltz et al. (2011) argued that for this paradigm, virtually-presented partners were more practical than finding an ideally-matched, live exercise partner (i.e., someone who is moderately more capable with similar exercise goals), trying to coordinate a time to exercise with another person, and having possible social physique anxiety (i.e., anxiety about one's body shape being evaluated). Additionally, potential moderators of the Köhler effect could be investigated more efficiently using a virtual-partner paradigm.

There are recognized moderators that may regulate the Köhler effect, potentially interfering with the key conjunctive mechanisms, and affecting whether the exerciser responds to the partner and manipulated condition (Forlenza, Kerr, Irwin, & Feltz, 2012; Kerr & Seok, 2010; Kerr & Hertel, 2011). One potential moderator is the discrepancy in ability between partners. Feltz et al. (2012) tested whether there is an optimal level of ability discrepancy between an exergame player and a virtually-presented partner. The authors found that the Köhler effect was smaller when one's virtually-presented partner was either only slightly more capable or extremely more capable than the participant. This Köhler "discrepancy effect" can weaken performance gains by undermining the motivation in partner comparison processes. A moderate discrepancy in ability seems to encourage comparison, but not so if the partner discrepancy is slight or very discrepant (Feltz, Irwin, & Kerr, 2012).

Another potential moderator is the weight of the partner relative to weight of the person exercising. In terms of partner weight, it is plausible that exercising with a lighter weight partner, versus a similar weight partner, might instill unfavorable comparison responses, which could attenuate any motivation gains from the Köhler effect (Schwartz, Vartanian, Nosek, & Brownell, 2006). For example, because obese individuals may perceive lighter weight people as being more capable at the exercise task, they may view them as an incomparable partner and reject the team goal as unrealistic. Yet, little is known about the influence of an exercise partner's weight as a potential moderator of Köhler motivation gain effect. Further, no studies have explored this moderator in an obese sample, considering both the weight of the partner and participant.

Engaging in a physical activity task with a heavier weight, virtually-presented (i.e., video projection) partner did not attenuate persistence gains in a non-obese college student sample (Forlenza, Kerr, Irwin, & Feltz, 2012). The results showed that conjunctive team participants persisted longer, relative to individual exercisers, regardless of their virtually-presented partner's weight. However, other studies on the Köhler effect in exercise, as with this prior study, have employed only lighter weight, college-aged participants. Whether or not partner weight characteristics moderate the Köhler effect with adult obese participants has not been explored. The answer to this question is important because obese individuals have reported feelings of being too overweight, feeling self-conscious, and experiencing high levels of distress when exercising among others (i.e., social physique anxiety) (Napolitano, Papandonatos, Borradaile, Whiteley, & Marcus, 2011; Smits, Tart, Presnell, Rosenfield, & Otto, 2010) and thus, the use of virtually-presented partners with optimal partner characteristics could potentially add powerful sources of motivation to exergame design to increase exercise intensity and duration for obese populations. Using an obese (≥ 30 BMI) community sample, we examined the motivation to persist at an exergame task when exercising with a lighter or same weight virtually-presented partner. In addition, obese participants' weight perceptions (own and partner) and ability perceptions (own and partner) were explored in relation to performance outcomes.

Method

Participants.

Forty-eight adult community members in Michigan, USA (M = 45.3 ± 15.86 years) were randomly assigned to three experimental same-sex conditions: Lighter Weight partner (LW), Same Weight partner (SW), or no partner Control (CON). The experiment was powered on the repeated measures ANOVA used to evaluate the primary dependent variable of persistence to detect a medium effect size. The sample consisted of 41 females and 7 males (6 African-American, 42 Caucasian) meeting the inclusion criteria of a BMI ≥ 30. Obese was defined by the National Heart, Lung, and Blood Institute's weight categories (US, 1998): obesity equal or greater than 30.0 BMI (Grade 1 obesity as a BMI of 30-34.9, Grade 2 obesity as a BMI of 35-39.9, and Grade 3 obesity as a BMI of 40 or greater). Participants were compensated with a Tanita BC-418 body composition analyzer assessment (e.g., BMI, percent body fat, fat free mass, estimate of total body water) and an opportunity to win one of the three $50 gift cards.

Procedure.

Participants were recruited through a variety of online and posted advertisements, as well as in collaboration with a local weight management clinic. All experimental sessions were held in a laboratory at a university or in a private room at the weight management clinic. The authors' Institutional Review Board provided ethical approval.

Upon arrival at either lab space, all participants completed the informed consent process, a demographics questionnaire, and the Physical Activity Readiness Questionnaire (PAR-Q), and they subsequently viewed an instructional video that explained and demonstrated a series of three abdominal isometric exercises: a front plank, right side plank, and left side plank. Afterward, participants performed the three plank exercises by holding each of them for as long as possible (Block 1). Using the EyeToy: Kinetic™ exergame for the PlayStation2 (Sony, Tokyo, Japan), a webcam captured their live performance and projected it onto a screen alongside the exergame's virtual trainer (who demonstrated each exercise). After completing Block 1 individually, and following a 10-minute rest period, each participant was randomly assigned to complete the second block of exercises (Block 2) alone (CON), with an LW partner, or with an SW partner. Partners were pre-recorded confederates who were presented as live in another lab by manipulating video recordings and looped images.

Prior to Block 2 (which was the same as Block 1, i.e., holding the same set of three plank exercises for as long as possible), experimental condition participants met their pre-recorded partner via a mock Skype internet introduction. During these introductions, participants and their partners exchanged four pieces of personal information: name, age, what they do for a living, and their favorite television programs. Participants were then provided truthful feedback on their own Block 1 performance (i.e., the average length of time the exercises were held) and false feedback on their partner's prior performance (always calculated as 40% longer to establish a moderate discrepancy in ability). Partnered participants were also told that the team score would be determined by the teammate who quit holding the abdominal plank exercise first, and that once one partner quits, the other partner must also quit.

Just as with Block 1, participants' live performance was projected onto a screen using the exergame, but those in the experimental conditions were also able to view their partner's 'live' performance on another screen. The partner video was pre-recorded and synchronized so that the partner always outperformed the participant by holding the exercises longer (i.e., until participants quit holding the exercise). The CON condition participants simply repeated the three exercises individually, without a partner.

Köhler conjunctive partner conditions were established by providing participants comparative feedback for a moderately superior partner's first block performance and 'live', simultaneous Block 2 exercise performance. Additional conjunctive conditions were created with team indispensability cues (e.g., dyad score based upon performance of weakest member). In addition to performing the plank exercises, participants completed questionnaires during and after the experiment (described subsequently). Following completion of the study, participants were debriefed and thanked for their participation.

Measures

Persistence. Because it is difficult to measure motivation (a cognitive process) directly, motivation gain was inferred from effort at the persistence task as is typical in the Köhler effect paradigm. Persistence was defined as the total number of seconds that the exercise position was held. Block scores were calculated by taking the summed total of the three exercise position times within each trial.

***Body image assessment*.** Following completion of all exercises and other measures, participants rated their body image utilizing the Body Image Assessment for Obesity (BIA-O) silhouette cards (Williamson et al., 2000), which were shuffled and displayed in front of participants. These 18 cards each had a silhouette image of a person on their front, each with a different body size. Numbers on the back of each card (1 = thinnest, 18 = heaviest) were recorded when a participant chose the silhouette. Participants from partnered conditions were told to select the image that ”most accurately depicts your partner’s body size as you perceive it to be.” Participants were then told to “select the silhouette that most accurately depicts your body size as you perceive it to be.” These images have been validated in individuals up to a BMI of 50 in Caucasian and African-American male and female adults (Williamson et al., 2000).

***Perceptions of fitness and partner’s ability*.** Prior to beginning the experiment, ratings of personal fitness were collected (1 = poor, 2 = below average, 3 = average, 4 = good, 5 = excellent) for all participants. As a manipulation check for invoking a conjunctive task demand, after the second block of exercises, participants estimated their partner’s relative competence by responding how their partner compared to them in ability (1 = “much less capable”, 9 = “much more capable”). Participants should have perceived their partner as more competent relative to their own ability, if the manipulation check held true.

Self-efficacy beliefs. Participants recorded how many seconds they believed they could hold each exercise at three different time points as a measure of self-efficacy beliefs (SE). Participants estimated the number of seconds they were completely confident they could hold each exercise before Block 1, before Block 2 (after meeting the partner and receiving comparative feedback), and after all exercises were completed. For each rating, a sum of the three estimated times was calculated as the total SE score.

Enjoyment. The Physical Activity Enjoyment Scale (PACES; Raedeke, 2007) was used to assess perceptions of physical activity enjoyment with an 8-item, 7-point bipolar scale (1 = I loved it, 7 = I hated it) after completion of Block 2.

Perceived exertion. Immediately after quitting each plank exercise, participants were prompted to verbally report ratings of overall perceived exertion for that exercise using the Borg Rating of Perceived Exertion scale (RPE; Borg, 1998). The scale ranges from 6 to 20, with 6 being “no exertion at all” and 20 being “maximal exertion.” An explanation, including anchoring, and poster of the scale was provided.

Results

Primary Analysis

Participant characteristics. Mean BMI was higher in the LW and SW groups than CON but was not significantly different, $F(2,45) = 1.98$, $p = .15$ (see Table 1.1). Participants self-reported having “below average” fitness ($M = 2.50$, ± .799) with no significant differences among conditions, $F(2,45) = 1.18$, $p = .32$.

Table 1.1 Participant Body Mass Index (BMI)

Condition	*N*	*Mean (SD)*
Control	16	40.33 (5.84)
Lighter Weight	16	36.92 (5.85)
Same Weight	16	36.83 (5.32)
Total	48	38.03 (5.79)
Gender	*N*	*Mean (SD)*
Male	7	40.26 (6.78)
Female	41	37.64 (5.61)
Total	48	38.03 (5.79)

Persistence effects. The overall mean for persistence time in Block 1 was 86.7 sec. (± 54.15). A sum of the participant's three plank persistence times was used to calculate a difference score between Block 2 and Block 1, which permitted a control for individual differences in strength (estimated by Block 1 performance). There were significant differences in Mean persistence times between the partnered conditions and the control condition $F(2,43) = 8.05$, $p < 0.001$ (Figure 1.1). Mean persistence difference times were significantly greater for participants in the LW partnered condition ($M = 23.2 \pm 29.71$ s) than for those in the CON condition ($M = -12.44 \pm 30.82$ s), 95% CI: 11.5, 59.3, $d = 1.17$. Mean persistence difference times were also significantly greater for participants in the SW partner condition ($M = 21.00 \pm 21.05$ s) than for those in the CON condition ($M = -12.44 \pm 30.82$ s) 95% CI: 8.74, 58.14, $d = 1.29$. For the persistence difference times, there was not a significant difference between the three group's variances (Levene's $F(2,43) = 1.082$ $p = 0.348$).

There was no significant difference in persistence times for gender (41 female and 7 male), $F(1,44) = 0.029$ $p = 0.87$ or race (Caucasian 42, African-American 6), $F(1,44) = 0.69$ $p = 0.41$. Male and female data were combined for each condition for all other analyses.

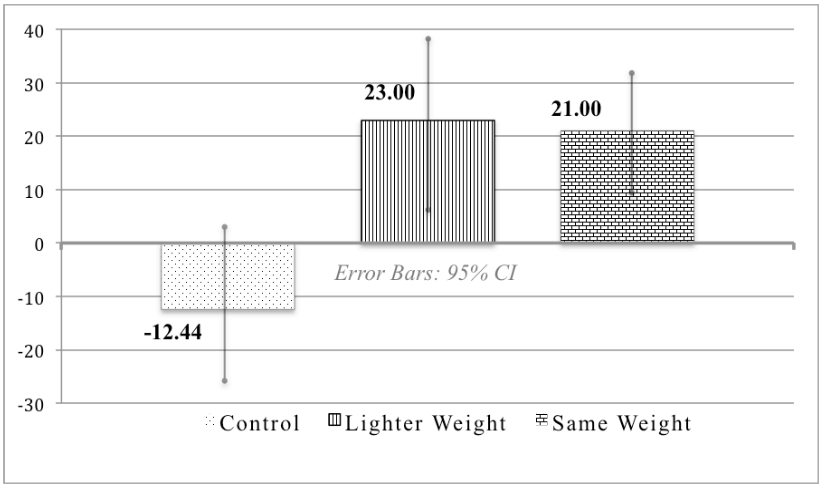

Figure 1.1 Persistence: Block2 – Block1 (Mean seconds & 95% CI)

Ancillary Analyses

Body image assessment. For the BIA-O silhouette choices, the mean in the LW condition for the participant selection of own body size (OwnSize) was 9.75 (± 2.77) compared to 5.44 (± 2.58) for partner's body size (PartSize). In the SW condition, the OwnSize mean was 9.80 (± 1.98) versus a mean for PartSize of 9.56 (± 1.55). There was a significant difference in participant perceptions of body size relative to their partner in the LW condition, while no such difference was perceived in the SW condition, suggesting the partner-weight conditions were valid.

A Pearson correlation was run to assess the relationship between body image assessment and other variables of interest. OwnSize perceptions were positively related to BMI ($r = .69$ $N = 31$ $p < .001$). OwnSize perceptions for the partnered conditions were not correlated to plank block difference times ($r = .01$, N = 29 $p = .96$) nor did there appear to be a relationship between OwnSize perceptions and the experimental condition each of the partnered participants were randomly assigned to ($r_s = -.077$, N = 31 $p = .68$). OwnSize did not appear to be tied to measures of self-efficacy or exertion, yet there was a negative relationship between OwnSize and enjoyment (r = -.44 N = 31 p = .03).

Perceived partner ability. As a manipulation check for the conjunctive task demand, at the end of the exercises, participants provided a best estimate of how their partner compared to them in ability, "much less capable = 1" to "much more capable = 9." Both SW and LW groups perceived Partner Ability (SW: 7.13 ± 2.42; LW: 5.94 ± 3.13) as higher than their own and there was not a significant difference between the two conditions, $F(1,30) = 1.44$, $p = .24$).

Self-efficacy beliefs. Participants' estimates (in seconds) of confidence in holding each plank exercise were summed to obtain an SE score for each measurement point. There were no significant differences in SE between conditions at each time point. SE was positively correlated with persistence at each plank block of exercises (Block 1: $r = 0.49$, N = 47, $p < 0.001$; Block 2: $r = .79$, $N = 46$, $p < 0.001$).

Enjoyment. Physical activity enjoyment was measured using an 8-item, 7-point bipolar scale (1 = I loved it, 7 = I hated it) after completion of the Block 2 exercises. There were no differences among conditions in overall ratings of enjoyment, $F(2,45) = 1.02$, $p = .37$. Persisting longer did not impact perceptions of enjoyment in the partnered conditions.

Perceived exertion. Self-reported ratings of perceived exertion (RPE) were collected after each plank was completed and averaged for each block to obtain block exertion scores. Overall mean ratings at Block 1 (M= 14.15, ±1.82) and Block 2 (M = 14.5, ± 1.81) fell between the scale's verbal anchors of "somewhat hard" (13) and "hard" (15). Exertion ratings did not differ across conditions, Block 1: $F(2,43) = .32$, $p = .73$; Block 2: $F(2,43) = .390$, $p = .68$), regardless of increased persistence in the partnered groups.

Discussion

This study explored partner's weight as a potential moderator of the Köhler motivation gain effect in an adult sample with grade 2 obesity (a mean BMI of 38). We showed that obese adults persisted significantly longer in an exergame based on abdominal strength exercises when partnered with either a same weight or lighter weight partner, under conjunctive-task conditions, compared to no partner. Persistence averages for the combined partnered conditions (22 s) versus the no-partner condition (-12.44 s) demonstrated a 36% performance gain. The Köhler effect continues to be effective in motivating exercise persistence in an exergame setting, despite weight as a potential moderator.

For the obese individuals in our study, similarity/dissimilarity in appearance may not have been the most salient partner characteristic. Participants may have been more motivated by wanting to make a good impression (not be the weak link) on their partner regardless of his/her size (Ede, Forlenza, & Feltz, 2015). Even though there are multiple weight-related social psychological mechanisms (e.g., anti-fat bias, social physique anxiety, stereotyping, and internalization of weight stigma) that may be powerful enough to interfere with the desired upward social comparison and team indispensability, discrepant weight and perceptions of ability (own and partner) did not seem to trigger social cues or other mechanisms that might have otherwise inhibited the Köhler effect in this sample.

Our findings may be clinically important to obese and overweight adults who want to increase short but intense bouts of physical activity, weight or circuit-type training (Schmitz, Jensen, Kugler, Jeffery, & Leon, 2003) and/or control their diabetes (Dunstan et al., 1998) by incorporating Köhler motivation gain principles into the design of future exergames and other healthy lifestyle software applications. Further, the use of a virtually-presented partner has the practical advantages for this population of overcoming the challenges of finding an ideally-matched exercise partner who can be available at any given time and location, and can help with possible social physique anxiety. For instance, web-based applications could be developed to optimally match exercise/training partners (similar to online dating services) (Irwin & Feltz, in press). However, a virtually-presented partner is still a real person, just pre-recorded and adjusted in relation to the target participant's ability level. It also involves providing false feedback of partner ability, which may be impractical in exercise settings or games (Feltz, Forlenza, Winn, & Kerr, 2014). The ideal solution would be to create software-generated partners whose appearances, movements, and ability discrepancies could be manipulated.

The motivation gains achieved with a more capable partner, regardless of lighter weight or same weight, did not come at the expense of aversion to the task. No differences were observed in self-efficacy, enjoyment, or perceived exertion among the groups, which mirrors previous research (Feltz, Kerr, & Irwin, 2011; Feltz, Forlenza, Kerr, Irwin, & Feltz, 2012; Forlenza, Winn, & Kerr, 2014). Participants did not perceive they were working any harder, enjoy the exercise less, or have lower self-efficacy about the task than controls. These findings are encouraging as they show it may be plausible to extend exercise duration without leading to adverse consequences.

The limitations of this study are that we used a single type of isometric strength task in a one-time exercise session. Future research should examine other types of moderate-to-vigorous exercise (e.g., interval-based aerobic exercise, other types of resistance training) and examine the Köhler effect over multiple sessions. Although race and gender did not significantly differ in our sample's analysis, a larger sample size may reveal meaningful differences. Considering the relatively high mean BMI of this sample (M = 38.03, SD = 5.79), only lighter and same weight partners were utilized to compare against controls. Ideally, a greater weight condition would have also been useful to more fully explore weight as a moderator on the Köhler motivation gain effect in the obese sample. However, including greater weight male and female partners would require significantly heavier confederates to ensure the successful manipulation of the participant's perception of a greater weight partner. As mentioned, non-obese college students did demonstrate persistence gains when engaging in an abdominal plank exercise task with a heavier weight, virtually-presented partner similar to those with a same weight partner (Forlenza, Kerr, Irwin, & Feltz, 2012). Finally, considering the popularity of video games and virtual reality software, application of this line of research to software-generated partners promises to present additional opportunities to manipulate relevant characteristics and conditions toward eliciting exercise performance gains.

In conclusion, our results support the Köhler motivation effect with obese adults in an exergame task. We showed that obese adults will persist significantly longer in an exergame based on abdominal strength exercises when partnered with either a same weight or lighter weight partner, under conjunctive task conditions, compared to no partner. The Köhler effect was not moderated by the relative weight of one's partner. These findings may also be incorporated into the design of future exergames and other healthy lifestyle software applications to motivate those who prefer this growing segment of electronic personal devices.

REFERENCES

REFERENCES

(US), N. O. E. I. E. P. on the I., Evaluation, and Treatment of Obesity in Adults. (1998). *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults*. National Heart, Lung, and Blood Institute.

Borg, G. (1998). *Borg's perceived exertion and pain scales* (Vol. viii). Champaign, IL, US: Human Kinetics.

Boutcher, S. H. (2011). High-Intensity Intermittent Exercise and Fat Loss. *Journal of Obesity*, *2011*. http://doi.org/10.1155/2011/868305

Dishman, R. K. (2001). The Problem of Exercise Adherence: Fighting Sloth in Nations With Market Economies. *Quest*, *53*(3), 279–294. http://doi.org/10.1080/00336297.2001.10491745

Dunstan, D. W., Puddey, I. B., Beilin, L. J., Burke, V., Morton, A. R., & Stanton, K. G. (1998). Effects of a short-term circuit weight training program on glycaemic control in NIDDM. *Diabetes Research and Clinical Practice*, *40*(1), 53–61.

Ede A., Forlenza S.T, Feltz D.L. (2015). Buddy up for exergames: how group dynamics principles can be applied to active health games. In: Novak D., Tulu B., Brendryen H. (eds). *Holistic Perspectives in Gamification for Clinical Practice*. DOI: 10.4018/978-1-4666-9522-1

Feltz, D. L., Forlenza, S. T., Winn, B., & Kerr, N. L. (2014). Cyber Buddy Is Better than No Buddy: A Test of the Köhler Motivation Effect in Exergames. *Games for Health Journal*, *3*(2), 98–105. http://doi.org/10.1089/g4h.2013.0088

Feltz, D. L., Irwin, B., & Kerr, N. (2012). Two-player partnered exergame for obesity prevention: using discrepancy in players' abilities as a strategy to motivate physical activity. *Journal of Diabetes Science and Technology*, *6*(4), 820-827.

Feltz, D. L., Kerr, N. L., & Irwin, B. C. (2011). Buddy up: the Köhler effect applied to health games. *Journal of Sport & Exercise Psychology*, *33*(4), 506–526.

Forlenza, S. T., Kerr, N. L., Irwin, B. C., & Feltz, D. L. (2012). Is My Exercise Partner Similar Enough? Partner Characteristics as a Moderator of the Köhler Effect in Exergames. *Games for Health Journal*, *1*(6), 436–441. http://doi.org/10.1089/g4h.2012.0047

Gourlan, M. J., Trouilloud, D. O., & Sarrazin, P. G. (2011). Interventions promoting physical activity among obese populations: a meta-analysis considering global effect, long-term maintenance, physical activity indicators and dose characteristics. *Obesity Reviews*, *12*(7), e633–e645. http://doi.org/10.1111/j.1467-789X.2011.00874.x

Hertel, G., Kerr, N. L., & Messé, L. A. (2000). Motivation gains in performance groups: paradigmatic and theoretical developments on the Köhler effect. *Journal of Personality and Social Psychology*, *79*(4), 580–601.

Irwin, B. C., Scorniaenchi, J., Kerr, N. L., Eisenmann, J. C., & Feltz, D. L. (2012). Aerobic exercise is promoted when individual performance affects the group: a test of the Kohler motivation gain effect. *Annals of Behavioral Medicine: A Publication of the Society of Behavioral Medicine*, *44*(2), 151–159. http://doi.org/10.1007/s12160-012-9367-4

Irwin, B.C., & Feltz, D.L. (in press). Interpersonal influences and motivation in physical activity. In Schinke, R., McGannon, K., & Smith, B. (Eds.), *The Routledge International Handbook of Sport Psychology.*

Karau, S. J., & Williams, K. D. (1993). Social loafing: A meta-analytic review and theoretical integration. *Journal of Personality and Social Psychology*, *65*(4), 681–706. http://doi.org/10.1037/0022-3514.65.4.681

Kerr, N. L., & Hertel, G. (2011). The Köhler Group Motivation Gain: How to Motivate the "Weak Links" in a Group. *Social and Personality Psychology Compass*, *5*(1), 43–55. http://doi.org/10.1111/j.1751-9004.2010.00333.x

Kerr, N. L., Forlenza, S. T., Irwin, B. C., & Feltz, D. L. (2013). "… been down so long …": Perpetual vs. intermittent inferiority and the Köhler group motivation gain in exercise groups. *Group Dynamics: Theory, Research, and Practice*, *17*(2), 67–80. http://doi.org/10.1037/a0031588

Kerr, N. L., & Seok, D.H. (2010). "...with a little help from my friends": friendship, effort norms, and group motivation gain. *Journal of Managerial Psychology*, *26*(3), 205–218.

Maher, C. A., Mire, E., Harrington, D. M., Staiano, A. E., & Katzmarzyk, P. T. (2013). The independent and combined associations of physical activity and sedentary behavior with obesity in adults: NHANES 2003-06. *Obesity*, *21*(12), E730–E737. http://doi.org/10.1002/oby.20430

Napolitano, M. A., Papandonatos, G. D., Borradaile, K. E., Whiteley, J. A., & Marcus, B. H. (2011). Effects of weight status and barriers on physical activity adoption among previously inactive women. *Obesity* (Silver Spring, Md.), *19*(11), 2183–2189. http://doi.org/10.1038/oby.2011.87

Pearson, E. S. (2012). Goal setting as a health behavior change strategy in overweight and obese adults: A systematic literature review examining intervention components. *Patient Education and Counseling*, *87*(1), 32–42. http://doi.org/10.1016/j.pec.2011.07.018

Raedeke, T. D. (2007). The Relationship Between Enjoyment and Affective Responses to Exercise. *Journal of Applied Sport Psychology*, *19*(1), 105–115. http://doi.org/10.1080/10413200601113638

Schmitz, K. H., Jensen, M. D., Kugler, K. C., Jeffery, R. W., & Leon, A. S. (2003). Strength training for obesity prevention in midlife women. *International Journal of Obesity*, *27*(3), 326–333. http://doi.org/10.1038/sj.ijo.0802198

Schwartz, M. B., Vartanian, L. R., Nosek, B. A., & Brownell, K. D. (2006). The Influence of One's Own Body Weight on Implicit and Explicit Anti-fat Bias. *Obesity*, *14*(3), 440–447.

Smits, J. A. J., Tart, C. D., Presnell, K., Rosenfield, D., & Otto, M. W. (2010). Identifying Potential Barriers to Physical Activity Adherence: Anxiety Sensitivity and Body Mass as Predictors of Fear During Exercise. *Cognitive Behaviour Therapy*, *39*(1), 28–36. http://doi.org/10.1080/16506070902915261

Trapp, E. G., Chisholm, D. J., Freund, J., & Boutcher, S. H. (2008). The effects of high-intensity intermittent exercise training on fat loss and fasting insulin levels of young women. *International Journal of Obesity*, *32*(4), 684–691. http://doi.org/10.1038/sj.ijo.0803781

Tucker, J. M., Welk, G. J., & Beyler, N. K. (2011). Physical activity in U.S.: adult's compliance with the Physical Activity Guidelines for Americans. *American Journal of Preventive Medicine*, *40*(4), 454–461. http://doi.org/10.1016/j.amepre.2010.12.016

Williams, K. D. (2010). Dyads Can Be Groups (and Often Are). *Small Group Research*. http://doi.org/10.1177/1046496409358619

Williamson, D. A., Womble, L. G., Zucker, N. L., Reas, D. L., White, M. A., Blouin, D. C., & Greenway, F. (2000). Body image assessment for obesity (BIA-O): development of a new procedure. *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity*, *24*(10), 1326–1332.

CHAPTER 3

INTRODUCTORY DIALOGUE AND KÖHLER GROUP DYNAMICS IN SOFTWARE-GENERATED WORKOUT PARTNERS

Preface

This manuscript was submitted to *Computers in Human Behavior* on October 1, 2015 and is in review. This study was financially supported by research grant 1R21HL111916-01A1 from the National Heart, Lung, and Blood Institute (National Institutes of Health).

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This manuscript is based on a study conducted under the direction of the last author (D.L. Feltz) who was Principal Investigator on the NIH grant, along with Co-PI, B. Winn, and Co-Is, N.L. Kerr and K.A. Pfeiffer. The first author (Samendinger) was project manager of the study, oversaw data collection, conducted the analyses, and drafted much of the manuscript. The second author (Forlenza) helped with the original grant proposal and draft of the manuscript. The third author (Winn) designed the software for the study and assisted in the original grant proposal. N.L. Kerr assisted in design and writing of the original grant proposal, design of this particular study, and assisted with analyses and writing of the manuscript. K.A. Pfeiffer assisted in writing of the original proposal and editing of the manuscript.

Abstract

Purpose: Previous Köhler motivation gain effect research has demonstrated an increase in exergame persistence with human and software-generated partners (SGPs). This study further explored the Köhler effect utilizing only SGPs, hypothesizing that the duration of exergame play

would be greater in SGP conditions versus exergaming alone and compared the type of participant-SGP introductory dialogue as a means of moderating the Köhler effect.

Methods: Adults randomly assigned to 1 of 3 conditions: dialogue tree introduction, spoken introduction, or individual control (IC), completed a series of abdominal plank exercises using the CyBuddy Exercise 2 program.

Results: SGP condition participants persisted 18.3-s longer compared to IC. Planned contrasts of the difference times for SGP conditions versus IC suggest a non-significant difference in persistence, $t(86)= 1.87$, $P= .064$, $d= 0.42$. A contrast between SGP conditions was not significant, $t(86)= .683$, $P= .49$, $d= .18$. No condition differences in perceptions of self-efficacy, enjoyment, or exertion were noted.

Conclusion: Although not statistically significant, the SGP condition 18.3-s difference was likely meaningful. Using SGPs can elicit a valuable motivation gain in persistence during a single exergame session compared to exercising individually. Differences between introductory dialogue methods were not significant but tended to favor the dialogue tree technique.

Introduction

U.S. adults are not getting enough exercise at the recommended levels to maintain health and reduce the risk of chronic disease (U.S. Department of Health and Human Services, 2008). Motivation is a key issue in the physical inactivity epidemic (Dishman, 2001). Because it takes time and commitment to initiate and maintain a regular exercise program, especially when people’s lives are busy, it is easy to lose motivation. Exergames have become a popular solution to try to boost motivation with games that are entertaining and engaging (Lieberman, 2006). However, as Feltz and her colleagues noted (Feltz, Kerr, & Irwin, 2011), few exergames have taken advantage of the potential of group dynamics to motivate play, such as creating interdependence among exercisers where their progress and/or outcomes are mutually determined.

Recent research has applied the Köhler motivation gain effect (i.e., the less capable partner of a team exhibits greater motivation in terms of effort, relative to individual performance, when performing as part of a team on effort-based tasks) to partnered or cooperative exergame play (Feltz et al., 2011; Irwin, Scorniaenchi, Kerr, Eisenmann, & Feltz, 2012; Kerr, Forlenza, Irwin, & Feltz, 2013). This performance gain is thought to be the result of increased levels of motivation that stem from being indispensable to the group and making a comparison to one's higher-ability partner (Kerr & Hertel, 2011).

The latest research in this area has shifted toward software-generated partners (SGPs; Feltz, Forlenza, Winn, & Kerr, 2014). Using SGPs provides game designers and players with greater flexibility (e.g., partner availability, easier to change appearance, more programmable exercises). The major question that Feltz and colleagues (Feltz et al., 2014) asked was whether participants would willingly team up with an SGP or view the SGP as an incomparable other (weakening the Köhler Effect). Results showed a significant motivation gain for SGPs, though this effect was smaller than with human partners (Feltz et al., 2014). These results were consistent with Media Equation research (Reeves & Nass, 1996), which suggests that people will often respond socially to software agents as if they were human.

Additionally, there was no evidence that working with SGPs harmed enjoyment or increased perceived exertion (Feltz et al., 2014), consistent with most prior findings in this area (Feltz et al., 2011; Kerr et al., 2013; Feltz, Irwin, & Kerr, 2012; Forlenza, Kerr, Irwin, & Feltz, 2012). While a promising start, Feltz et al. (2014) has been the only study to explore the Köhler Effect in exergames with SGPs thus far. Furthermore, this study was conducted with college students; older age groups may react differently to SGPs because they play video games less frequently than college-aged adults (Lenhart, Jones, & Macgill, 2008; Pew, 2013).

In the Feltz et al. (2014) exergame with an SGP, the same protocol was used to introduce participants to their partner as in previous human partner experiments (Feltz et al., 2011). In the protocol, participants were informed that they would be working with a partner, and that his/her gameplay would be visible, projected onto a screen. Before they exercised together, participants met their SGP via a webcam-like connection, during which each introduced themselves to share basic information (e.g., favorite television shows, what they like to do for fun).

While this protocol works well for human partners, it may not be optimal for attempting to build a connection with SGPs (Feltz et al., 2014). Yet, having familiarity with one's partner is beneficial for improving motivation (Kerr & Seok, 2010). Prior research has also suggested that people may have positive subsequent interactions and higher social attraction with a computer after an exchange of personal information (Kang & Gratch, 2011; Lee, Kiesler, & Forlizzi, 2010; Moon, 2000). One alternative strategy to a simple exchange of spoken information is to use a dialogue tree, which is more interactive and allows the introduction to be back-and-forth, like real conversations. Such interactivity may enhance perceptions of the SGP-human social relationship (Burgoon et al., 2000).

The purpose of this study was to replicate and extend prior findings based on two questions. First, would a significant Köhler Effect be observed with SGPs in a sample of middle-aged adults? Second, would the type of introduction (standard verbal versus interactive dialogue) affect the Köhler Effect? Our hypotheses were as follows: (1) Participants would persist longer when exercising with SGPs compared to exercising alone, (2) A larger Köhler Effect would be observed when an interactive dialogue tree was used, and (3) There would be no adverse consequences to secondary variables like exertion, enjoyment, and self-efficacy beliefs.

Method

Experimental Design and Participants

After Institutional Review Board approval, participants (N = 90) were recruited from a mid-western city, completed informed consent, and were randomly assigned to 1 of the 3 experimental conditions: Individual Control without a partner (IC), Non-interactive Partner (NIP), or Interactive Partner (IP). Participants were adults (M_{age} = 38.8, SD = 7.7), 57 females (IP = 19, NIP = 20, IC = 18), 33 males (IP = 11, NIP = 10, IC = 12) and received the same small cash incentive at the end of the session.

Exergame

CyBud-X2 was built on the Unity3D game engine, based roughly on the PlayStation 2 EyeToy: Kinetic exergame and modified from the Cy Buddy Exercise (CyBud-X) game. The 3-dimensional characters were created with Mixamo's Fuse software and modified in Autodesk Maya and Photoshop to create a human-looking partner, comparable to those present in modern video games (see Figure 2.1). The CyBud-X2 uses a webcam to project the participant's image onto the screen during plank exercises. Partnered versions of CyBud-X2 included two experimental participant-SGP introduction options. In the IP condition, the conversation was built using a dialog tree where the SGP would speak followed by two or three answer options for the participant. For example, the SGP offered his/her name (Chris) and asked the participant if they are 'from around here'. If the participant selected 'Yeah, I am', the SGP replies: 'Ah, I knew it. You just kinda had that look about you. I am too! I love our sports teams. But, wait, do you even like sports?' The dialogue tree conversation proceeds through four branches of dialogue based on the choices the participant made and more closely paralleled an actual conversation where both parties have some control over how the conversation plays out. In the NIP condition, the participant-SGP introduction is through a linear, scripted exchange of basic information (e.g., name, hometown, occupation, fun pastimes), with no participant influence on what the SGP said.

Figure 2.1 Experimental Condition Software-Generated Partners (SGPs)

Procedure

Each participant watched an instructional video that provided an overview of the session, an explanation of the exertion scale, and a demonstration of five abdominal plank exercises. Participants were instructed to hold each plank for as long as possible, with 30-s breaks between exercises.

All participants completed five plank exercises (Block 1) individually. Upon completion of Block 1, participants in the IC condition were told the average time they held the exercises and informed they would complete the same set of exercises again (Block 2) after a 10-min rest. The IP and NIP condition participants were informed they would repeat the exercises with a same-gender SGP, tailored to be slightly more in shape than they were, working together towards a team score.

Participants in partnered conditions completed the SGP introduction, after which the Köhler Effect manipulations took place. Participants were informed that they, and their SGP, would simultaneously hold the planks for as long as possible and the team's score would be the number of seconds the first team member to quit was able to hold the plank. This conjunctive task set-up (Steiner, 1972) was followed by veridical performance feedback from the participant's first set of plank exercises. Participants were then informed that, had their SGP completed the same set of planks, he/she would have held them for roughly 40% longer (in seconds). This superior SGP performance data invites upward social comparison toward SGPs, tempered with an additional explanation that SGPs were unable to hold the exercises forever and would tire, just like a real person. The moderate performance discrepancy of 40% was chosen based on previous research (Feltz et al., 2012; Messé, Hertel, Kerr, Lount, & Park, 2002). Unbeknownst to participants, SGPs were programmed to hold the exercises indefinitely, never quitting first. Hence, the SGP partner always persisted longer than the participant so the participant always defined the group's score. Upon completing Block 2, participants completed the remaining questionnaires and were debriefed.

Measures

Persistence. A Block score (i.e., time in seconds) was the average of all five plank exercises, each measured from when the position was achieved to when the participant stopped. The difference between Block 2 and Block 1 was used as the persistence score.

Ratings of perceived exertion. The Borg Rating of Perceived Exertion scale (RPE; Borg, 1998) captured ratings of overall exertion immediately upon quitting each exercise. The scale ranges from 6 to 20, with 6 being "no exertion at all" and 20 being "maximal exertion." Exertion ratings were later averaged over the five planks in each Block.

Self-efficacy beliefs. Participants estimated the number of seconds they were completely confident they could hold each exercise immediately before Blocks 1 and 2, and after Block 2. For each time point, the estimated five hold times were averaged as the self-efficacy score.

Enjoyment. After finishing Block 2, participants completed the Physical Activity Enjoyment Scale (PACES; Kendzierski & DeCarlo, 1991; Raedeke & Amorose, 2013). The 5-item version utilizes a 3-point bipolar scale and responses were averaged for an overall task enjoyment score.

Participant-Partner relationship. As attitudes toward the SGP and perceptions of the validity of a relationship with the SGP may affect Köhler group dynamics (social comparison and indispensability), measures of the participants' relationship with their SGPs were collected upon completing Block 2. Participants' feelings toward their partner were surveyed using 4-items on a 5-point rating scale (e.g., I liked my partner; I felt comfortable with my partner). Exercise team perceptions (5-items, e.g., "I felt I was part of a team", "I thought of my partner as a teammate") were also collected using a 9-point scale (Nass, Fogg, & Moon, 1996).

IP and NIP participants also completed the Alternative Godspeed Indices (Ho & MacDorman, 2010), a 19-item semantic differential survey with 3 sub-scales: humanness (e.g., artificial vs. natural), eeriness (e.g., bland vs. uncanny), and attractiveness (e.g., repulsive vs. agreeable). This questionnaire attempts to capture participants' emotional responses to the SGP, to probe whether the SGP might fall into the so-called "Uncanny Valley" (Mori, 1970).

Results

Primary Analysis

Persistence. Block 2 – Block 1 difference scores were the primary dependent variable. A labeling rule was initiated, after extreme outliers were noted, and the persistence values were winsorized (Frigge, Hoaglin, Iglewicz, 1989; Hoaglin, Iglewicz, & Tukey, 1986; Hoaglin & Iglewicz, 1987). The conservative multiplier of 2.2 was applied to the difference between the upper and lower quartiles and the product was added to each of the quartiles to create outlier fences, which served as the markers for identifying extreme values. Three extreme negative observations were modified to match the lower quartile outlier fence values, representing approximately 3% of the total mean values. The winsorized data set was utilized for all persistence analyses.

No significant differences were observed between conditions for baseline Block 1 plank times ($F_{2,88} = 0.49$ $P = .614$). There was an overall gender effect on the difference scores between Block 2 and Block 1 ($F_{1,88} = 4.78$, $P < .03$). Females held the second block of five planks an average of 10.1-s less than their first block; whereas, the average second block times for men were 30.7-s less than their average first block. Although gender seemed to influence persistence (in favor of females), no gender by condition interaction was observed, $F_{2,89} = 0.05$, $P = .954$. The persistence pattern for each condition was similar by gender and is plotted in Figure 2.2. The test of the condition main effect yielded no significant results, $F_{2,88} = 2.00$, $P = .141$.

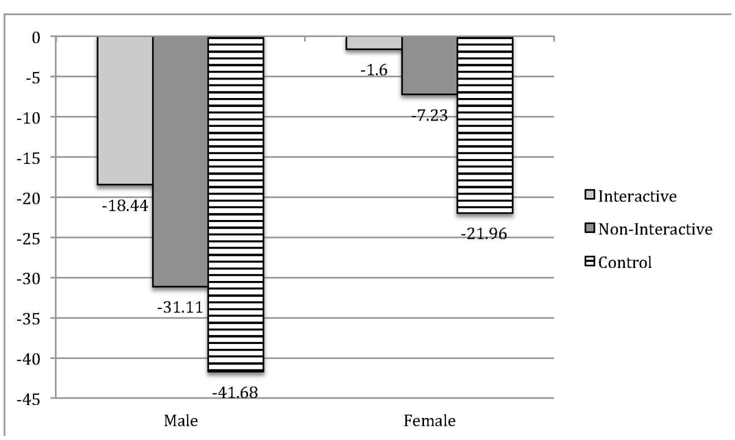

Figure 2.2 Condition x Gender Persistence Scores (Block 2 – Block 1, in seconds)

Table 2.1 Persistence Scores (Block 2 – Block 1 in seconds), (Standard Deviation)

	Interactive (IP)	Non-Interactive (NIP)	Individual Control (IC)
Combined	-7.74 sec (43.3) *n* = 30	-15.46 sec (44.5) *n* = 29	-29.85 sec (42.5) *n* = 30
Male	-18.35 sec (63.79) *n* = 11	-31.11 sec (46.71) *n* = 10	-41.68 sec (44.93) *n* = 12
Female	-1.60 sec (25.52) *n* = 19	-7.23 sec (42.27) *n* = 19	-21.96 sec (40.13) *n* = 18

In line with the primary hypothesis, participants in the combined partnered conditions persisted for 18.3-s longer compared to IC. Planned contrasts of the difference scores for the partnered conditions versus IC suggest a Köhler motivation gain effect may explain persistence differences, $t(86) = 1.87$, $P = .064$. Although not statistically significant, differences between partnered groups and IC approached the conventional critical *p*-value, demonstrating an effect size of $d = 0.42$, and show a similar pattern to previous research (Feltz et al., 2014). Mean block difference times between the IP condition and IC, and the NIP and IC condition, equated to effect sizes of $d = 0.52$ and $d = 0.33$ respectively. A contrast run between partnered conditions was not significant, $t(86) = .68$, $P = .49$, $d = 0.18$, disconfirming Hypothesis 2.

Ancillary Analyses

No significant differences between conditions emerged for perceived exertion, self-efficacy beliefs, and enjoyment ratings. The average rating of exertion for Block 1 (all conditions) was 15.1 and the average for Block 2 was 15.5, representing “Hard/Heavy” exertion. There were no self-efficacy differences by gender between conditions at any time point. Enjoyment ratings were nearly identical for all conditions ($F_{2,85} = 0.001$, $P = .999$) and gender ($F_{1,85} = 0.54$, $P = .465$). The overall average enjoyment rating ($M = 2.4$) was significantly higher than the scale mid-point (t = 6.56, $P < .000$), indicating moderately positive feelings of enjoyment about the physical activity performed. No relationship was noted between enjoyment and self-efficacy, exertion perceptions, or Block 1 and 2 persistence times.

Participant-Partner relationship. Participants' feelings toward their partner were nearly identical for both the IP and the NIP conditions (IP M = 3.3, SD = 0.66; NIP M = 3.3, SD = 0.69), with the combined mean significantly greater than the scale mid-point toward positive partner feelings, $t_{58} = 3.62$, $P < .001$.

There were no significant differences between the two conditions ($F_{1,58} = 0.59$, $P = .446$) in team perceptions. The combined mean (M = 3.96, SD= 1.66) was significantly lower than the mid-point (4.5), suggesting participants in both conditions did not strongly agree that they were part of a team, $t_{58} = -4.79$, $P = .000$. However, gender differences in team perception were significant, $F_{1,58} = 4.99$, $P < .029$. Males' disagreement ratings (M = 3.3, SD=1.7) influenced the low combined score, as females' ratings were closer to the neutral mid-point (M = 4.3, SD = 1.5). Partner perceptions were correlated to team ($r = .46$, $P < .001$) perceptions.

Alternative Godspeed Indices (humanness, attractiveness, eeriness) were not different between the SGP groups and did not reveal gender differences. Indices for eeriness (M = 2.4, SD = 0.55) and humanness (M = 2.4, SD = 0.94) were negatively and significantly different from the scale mid-point (3), implying that participants in both partnered conditions perceived the partner to be not exactly like a human but also not eerie, $t_{57} = -8.1$, $P < .001$; $t_{57} = -5.3$, $P < .000$. The index (M =3.6, SD = 0.57) for attractiveness was also significantly different from the mid-point (3), suggesting the participants in both conditions found the partners to be more attractive than not, $t_{57} = 7.7$, $P < .001$.

Discussion

This study sought to provide further support that the Köhler Effect can be demonstrated with an exergame using only software-generated partners (SGPs) to improve motivation and performance in an adult sample. This study also explored whether an interactive, conversation-like meeting with the SGP would strengthen the Köhler Effect.

Overall, participants working with an SGP persisted 18.3-s longer compared to participants working individually. This difference trended toward statistical significance and achieved a medium effect size (Cohen, 1988). While these results are slightly weaker than previously obtained findings (Feltz et al., 2014), this study was the first to use middle-aged adults, suggesting SGPs may not be as effective at boosting motivation for an older population. The second hypothesis was not supported, as there were no statistically significant differences between partner conditions. However, the results were aligned with predictions in that participants who met their partner using an interactive dialogue (IP) persisted for about 8-s longer than non-interactive introduction (NIP) participants, suggesting interactive introductions may still be meaningful.

The third hypothesis concerning ancillary measures was supported, consistent with prior research (Feltz et al., 2011; Kerr et al., 2013; Feltz et al., 2012; Forlenza et al., 2012). Interestingly, even though participants with an SGP performed as the "weak link" in the dyad, beliefs in their ability, exertion, and enjoyment of the game did not suffer compared to the control group.

Participants generally had positive feelings toward their partners regardless of which type of interaction they had, but this did not translate to strong feelings of being part of a team. This seems to be driven by responses from male participants, who disagreed with this notion to a stronger extent than female participants. One possible explanation for this gender difference is that stereotypical gender roles ascribe cooperativeness to women and competitiveness to men, thus plausibly meaning that female participants more readily viewed their SGP as a teammate, while male participants viewed their SGP as a rival first and teammate second (Kerr et al., 2007). Even though male participants were not particularly affiliated with their partner, they still tended to persist longer compared to working individually. Measures of humanness, eeriness, and attractiveness did not differ by condition. Participants judged their partners as not human-like, yet did not find that non-humanness to be eerie or unattractive. Rather, coupled with the positive feelings towards their SGPs, it seems that participants developed a favorable impression of the SGP.

Feltz et al. (2014) explored partner humanness as a potential moderator of the Köhler Effect, and found that the effect was significantly weaker with SGPs than with human partners. The effect size diminished as the partner became less human, moving from a human (d= 1.41) to a nearly human-like partner (d= 0.76) and, finally to an SGP (d= 0.57). We found no significant differences in motivation related to the two introductory dialogue options in the current study; the combined SGP condition effect versus control resulted in a marginally significant effect (d= 0.42). We also conducted a meta-analysis combining data from the current study and Feltz et al. (2014). This analysis produced a significant overall difference between individual controls and SGP conditions ($F_{1,179}$ = 12.19, P< .001) which was not moderated by subject sample (college students vs. nonstudents), ($F_{1,179}$ = 1.16, P= .283). Thus, the motivation gain achieved so far with SGPs seems to be real, comparable for younger and older people, but smaller in magnitude (g = 0.56) than has been observed with a human partner (estimated to be g = 0.72 for conjunctive versus control in a 2007 meta-analysis: Weber & Hertel, 2007). This leaves an interesting open question to pursue: how to strengthen the effect with SGPs, particularly in light of growing video and exergame use. We suggest the focus should be on enhancing the relationship between participants and their SGPs, whether through alternative forms of interaction or creative ways to boost mutual trust and identification (e.g., inducing greater mutual interdependence before exergame participation; manipulating common bonds).

REFERENCES

REFERENCES

Borg, G. (1998). *Borg's perceived exertion and pain scales* (Vol. viii). Champaign, IL, US: Human Kinetics.

Burgoon, J. K., Bonito, J. A., Bengtsson, B., Cederberg, C., Lundeberg, M., & Allspach, L. (2000). Interactivity in human–computer interaction: A study of credibility, understanding, and influence. *Computers in Human Behavior*, *16*(6), 553–574.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*. Lawrence Erlbaum Associates.

Dishman, R. K. (2001). The Problem of Exercise Adherence: Fighting Sloth in Nations With Market Economies. *Quest*, *53*(3), 279–294. http://doi.org/10.1080/00336297.2001.10491745

Feltz, D. L., Forlenza, S. T., Winn, B., & Kerr, N. L. (2014). Cyber Buddy Is Better than No Buddy: A Test of the Köhler Motivation Effect in Exergames. *Games for Health Journal*, *3*(2), 98–105. http://doi.org/10.1089/g4h.2013.0088

Feltz, D. L., Irwin, B., & Kerr, N. (2012). Two-player partnered exergame for obesity prevention: using discrepancy in players' abilities as a strategy to motivate physical activity. *Journal of Diabetes Science and Technology*, *6*(4), 820.

Feltz, D. L., Kerr, N. L., & Irwin, B. C. (2011). Buddy up: the Köhler effect applied to health games. *Journal of Sport & Exercise Psychology*, *33*(4), 506–526.

Forlenza, S. T., Kerr, N. L., Irwin, B. C., & Feltz, D. L. (2012). Is My Exercise Partner Similar Enough? Partner Characteristics as a Moderator of the Köhler Effect in Exergames. *Games for Health Journal*, *1*(6), 436–441. http://doi.org/10.1089/g4h.2012.0047

Frigge, M., Hoaglin, D. C., & Iglewicz, B. (1989). Some Implementations of the Boxplot. *The American Statistician*, *43*(1), 50–54. http://doi.org/10.1080/00031305.1989.10475612

Hoaglin, D. C., & Iglewicz, B. (1987). Fine-Tuning Some Resistant Rules for Outlier Labeling. *Journal of the American Statistical Association*, *82*(400), 1147–1149. http://doi.org/10.1080/01621459.1987.10478551

Hoaglin, D. C., Iglewicz, B., & Tukey, J. W. (1986). Performance of Some Resistant Rules for Outlier Labeling. *Journal of the American Statistical Association*, *81*(396), 991–999. http://doi.org/10.1080/01621459.1986.10478363

Ho, C.-C., & MacDorman, K. F. (2010). Revisiting the uncanny valley theory: Developing and validating an alternative to the Godspeed indices. *Computers in Human Behavior*, *26*(6), 1508–1518. http://doi.org/10.1016/j.chb.2010.05.015

Irwin, B. C., Scorniaenchi, J., Kerr, N. L., Eisenmann, J. C., & Feltz, D. L. (2012). Aerobic exercise is promoted when individual performance affects the group: a test of the Kohler motivation gain effect. *Annals of Behavioral Medicine: A Publication of the Society of Behavioral Medicine*, *44*(2), 151–159. http://doi.org/10.1007/s12160-012-9367-4

Kang, S.-H., & Gratch, J. (2011). People like virtual counselors that highly-disclose about themselves. *Studies in Health Technology and Informatics*, *167*, 143–148.

Kendzierski, D., & DeCarlo, K. J. (1991). Physical Activity Enjoyment Scale: Two Validation Studies. *Journal of Sport and Exercise Psychology*, *13*(1), 50–64.

Kerr, N. L., Forlenza, S. T., Irwin, B. C., & Feltz, D. L. (2013). "… been down so long …": Perpetual vs. intermittent inferiority and the Köhler group motivation gain in exercise groups. *Group Dynamics: Theory, Research, and Practice*, *17*(2), 67–80. http://doi.org/10.1037/a0031588

Kerr, N. L., & Hertel, G. (2011). The Köhler Group Motivation Gain: How to Motivate the "Weak Links" in a Group. *Social and Personality Psychology Compass*, *5*(1), 43–55. http://doi.org/10.1111/j.1751-9004.2010.00333.x

Kerr, N. L., Messé, L. A., Seok, D.-H., Sambolec, E. J., Lount, R. B., Jr, & Park, E. S. (2007). Psychological mechanisms underlying the Köhler motivation gain. *Personality & Social Psychology Bulletin*, *33*(6), 828–841. http://doi.org/10.1177/0146167207301020

Kerr, N. L., & Seok, D.-H. (2010). "...with a little help from my friends": friendship, effort norms, and group motivation gain. *Journal of Managerial Psychology*, *26*(3), 205–218. http://doi.org/http://dx.doi.org.proxy2.cl.msu.edu.proxy1.cl.msu.edu/10.1108/02683941111112640

Lee, M. K., Kiesler, S., & Forlizzi, J. (2010). Receptionist or information kiosk: how do people talk with a robot? In *Proceedings of the 2010 ACM conference on Computer supported cooperative work* (pp. 31–40). ACM.

Lenhart, A., Jones, S., & Macgill, A. (2008). *Pew Internet & American Life Project data memo*. Retrieved from www.pewinternet.org

Lieberman, D. A. (2006). What can we learn from playing interactive games. In P. Vorderer & J. Bryant (Eds.), *Playing video games: Motives, responses, and consequences* (pp. 379–397). Lawrence Erlbaum Associates.

Messé, L. A., Hertel, G., Kerr, N. L., Lount, R. B., Jr., & Park, E. S. (2002). Knowledge of partner's ability as a moderator of group motivation gains: An exploration of the Köhler discrepancy effect. *Journal of Personality and Social Psychology*, *82*(6), 935–946. http://doi.org/10.1037//0022-3514.82.6.935

Moon, Y. (2000). Intimate Exchanges: Using Computers to Elicit Self-Disclosure From Consumers. *Journal of Consumer Research*, *26*(4), 323–339. http://doi.org/10.1086/209566

Mori, M. (1970). The uncanny valley. *Energy*, *7*(4), 33–35.

Nass, C., Fogg, B. J., & Moon, Y. (1996). Can computers be teammates? *International Journal of Human-Computer Studies*, *45*(6), 669–678. http://doi.org/10.1006/ijhc.1996.0073

Pew Internet & American Life Project spring tracking survey (2013). www.pewinternet.org/.

Raedeke, T. D., & Amorose, A. J. (2013). A psychometric evaluation of a short exercise enjoyment measure. In *Journal of Sport & Exercise Psychology* (Vol. 35, pp. S75–122). Human Kinetics.

Reeves, B., & Nass, C. (1996). *The media equation: how people treat computers, television, and new media like real people and places*. New York, NY, USA: Cambridge University Press.

Steiner, I. D. (1972). *Group process and productivity*. New York

U.S. Department of Health and Human Services. (2008). *Two Thousand Eight Physical Activity Guidelines for Americans: Be Active, Healthy, and Happy*. Government Printing Office. Retrieved from http://www.health.gov/paguidelines/guidelines/default.aspx

Weber, B., & Hertel, G. (2007). Motivation gains of inferior group members: a meta-analytical review. *Journal of Personality and Social Psychology*, *93*(6), 973–993. http://doi.org/10.1037/0022-3514.93.6.973

CHAPTER 4

BOOST: A VIRTUAL PARTNER SMARTPHONE APP TO BOOST WALK MOTIVATION

Preface

This study was financially supported, in part, by a student grant from Society of Health and Physical Educators awarded to the first author in April 2014. The study also was submitted as a grant proposal to National Institutes of Health (NIH) under the direction of Deborah Feltz (PI) in February 2015. Additional contributors to the NIH grant proposal include Co-Is K.A. Pfeiffer, G. Bente, and F. Lawrence. I conceived of the design of the study, collaborated with a software engineer to develop a mobile phone application, managed the project and collected the data.

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Abstract

Purpose: This project extends recent Köhler motivation gain effect research to a field study of a mobile phone app with a software-generated partner (SGP). The mobile phone app was used in a free-living setting for the first time, specifically to motivate adults to persist in walking for exercise (at a minimum moderate intensity). The Köhler effect paradigm applies group dynamics principles (social comparison and indispensability) to create a team walking task, with the outcome dependent on the weakest member. This study also explored a novel application of interpersonal synchrony to boost perceptions of rapport and interpersonal connectedness with the SGP.

Methods: Community adults (N = 46; M_{age} = 37.98, SD = 10.25) were randomized to 1 of 3 conditions: a no-partner individual control (IC), a conjunctive partner (SGP), and a synchronous conjunctive partner (syncSGP). Participants walked with the phone app in the environment of choice for 3 weeks. Numerical and graphic data were displayed for the participant (and SGP) performance during the walk. Perceptions of enjoyment and exertion were collected with an in-app survey immediately after each walk. Other measures were collected via online weekly surveys.

Results: Non-significant differences for mean minutes of walking per week, taken across all three weeks, favored the syncSGP condition (M = 33.25, SD = 14.98). SGP condition participants averaged more minutes (M = 29.19, SD = 11.86) than walkers in the IC group (M = 27.6, SD = 8.01). Mean minute differences demonstrated a moderate effect size between the syncSGP condition and the IC (d = 0.47). No significant differences in persistence were noted for Gender. Participant ratings for Enjoyment, Exertion, and Self-Regulatory Self-Efficacy were not different between conditions. There were no significant differences between partnered condition perceptions of relationship variables (team, groupness, entatitivity, rapport, synchrony).

Conclusion: The specific Köhler motivation gain paradigm was compatible with mobile technology and free-living environments. Group persistence differences and trends appear to provide initial support for this proof of concept physical activity motivational tool with community adults. Lessons learned, limitations, and recommendations are discussed for future research.

Introduction

The 2008 Physical Activity Guidelines for Americans (PAG) provide physical activity recommendations to reduce many adverse health risks. The evidence-based recommendations are helpful in defining a minimum guideline by which to overcome some of the threats posed by inactivity (Services, 2008). The PAG recommended minimum of 150 min/week of moderate-vigorous physical activity (MVPA) is associated with lower rates of cardiovascular disease and improvements in glucose intolerance, insulin resistance, dyslipidemia, and inflammatory markers (Garber et al., 2011; Services, 2008). Brisk walking (3 mph) expends a moderate amount of energy (Ainsworth et al., 1993) and can help many adults to meet the PAG minimum. Even without weight loss, beneficial changes in visceral abdominal and total body fat can occur (Garber et al., 2011). Activity above minimum levels may have even more benefits in a dose-dependent fashion (Services, 2008). Unfortunately, amounts of physical activity recorded from accelerometry that satisfy the guidelines for adult physical activity have been found to be less than 10% (Tucker, Welk, & Beyler, 2011). Low levels of MVPA (relative to high levels) are strongly associated with obesity and metabolic risk (Bell et al., 2014; Peterson, Al Snih, Stoddard, Mcclain, & Lee, 2014).

Walking has been suggested as a potential bridge to assisting more Americans to meet the PAG, as well as an important strategy that should hold a higher emphasis in any national health plan (Bricker, America Walks, 2012). In 2013, the Surgeon General put forth a call to action in support of walking, for its long-tem health benefits and as an initiative to reach the 2008 Physical Activity Guidelines (General, 2013). It is easy to do, is low cost, and requires no special training, equipment, or facilities. Walking has mass appeal and huge potential to help Americans reach the PAG (Lee & Buchner, 2008), as it is the most common adult physical activity, with an estimated

41.5% of adults walking for leisure, as of 2005 (Kruger, Ham, Berrigan, & Ballard-Barbash, 2008). The Centers for Disease Control and Prevention (CDC) suggests walking as a way to meet the PAG, as walkers are much more likely to meet the PAG than non-walkers (Centers for Disease Control and Prevention, 2012). Yet, even with walkers, motivation is a problem as less than 40% of walkers reach 150 min/week (Rafferty, Reeves, McGee, & Pivarnik, 2002).

This project explored a novel intervention relevant to motivation gains (a software-generated walking buddy) as a means to increase persistence motivation for walking toward meeting the PAG in free-living conditions. Motivation usually refers to the process of initiating, guiding, and maintaining goal-directed behavior. For this project, it was operationalized as maintaining physical activity with pace and persistence of effort. There is strong evidence that exercise companions (or walking buddies) increase regular physical activity (Gellert, Ziegelmann, Warner, & Schwarzer, 2011; Kahn et al., 2002; Kassavou, Turner, & French, 2013). Walking buddies significantly boost motivation and offer social support, but not without potential problems: finding a partner, coordinating time to walk, negotiating different exercise goals, and meeting a partner's slow or fast pace. Unless partners are compatible, recommended MVPA levels may not be met. Social physique anxiety (anxiety about one's body shape being evaluated) may also decrease participation, persistence, and pleasure with exercise in overweight and obese adults (Atlantis, Barnes, & Ball, 2007; Ekkekakis & Lind, 2005; Ekkekakis, Lind, & Vazou, 2010; Treasure, Lox, & Lawton, 1998), especially in the company of a fellow walker. Walking with a virtual (non-human) software-generated partner (SGP) offers several innovative advantages (e.g., availability, adaptability, autonomy, reduced social concerns) and a way to adjust abilities automatically over time to a level the walker always finds motivating.

Mobile access to psychosocial intervention tools may be a method to increase exercise motivation. In April 2013, the President's Council on Fitness, Sports & Nutrition launched an initiative to highlight active video games as one way to help Americans lead more active lives. Health and fitness smartphone apps are an attractive way to present a walking SGP. As of 2014, 58% of adults own a smartphone, with 50% downloading at least one app (Pew, 2014). Nielson estimated one-third of U.S. smartphone owners (46 million people) accessed a fitness and health app in January 2014 and those surveyed accessed such apps 16 times per month for over an hour each time (Nielsen, 2014). Although there are many apps to increase physical activity and manage weight, none, to our knowledge, have provided research evidence of objective changes in physical activity behavior (Stephens & Allen, 2013). Further, none take advantage of evidence-based group dynamics to motivate pace and duration of physical activity. What apps lack are theory-driven, tailored partner dynamics and interaction related to exercise and task motivation.

Team affiliation has been demonstrated between humans and computers, representing an interdependent relationship (Nass, Fogg, & Moon, 1996). Particularly, in task-oriented situations, these reported social responses to computers may translate to mobile devices as well. Tied to the use of hardware and software as informative and assistive tools, is the concept of Media Equation (or Computers as Social Actors paradigm; Reeves & Nass, 1996). This theory posits that the social dynamics of human interaction with computers are similar to human interactions (Nass, Fogg, & Moon, 1996). Nass and colleagues observed that people can perceive computers as teammates and experience team interdependence dynamics similar to a strictly human team. People can cooperate with and respond to perceived computer personalities just as they would to humans (Parise, Kiesler, Sproull, & Waters, 1999). For example, they can apply politeness and gender norms to computers, along with experiencing other social interactions. Media Equation recognizes that many people interact with media naturally and unconsciously, as if the content represented reality (Reeves & Nass, 1996). Thus, Media Equation offers support for research with a software-generated partner, task-oriented achievement in exergame physical activity and predicts similar outcomes when applied to mobile devices.

Recent results (Feltz, Irwin, & Kerr, 2012; Feltz, Kerr, & Irwin, 2011; Irwin, Scorniaenchi, Kerr, Eisenmann, & Feltz, 2012; Samendinger, Beckles, Forlenza, Pfeiffer, & Feltz, 2015) demonstrate significantly increased persistence in physical activity (from 24% - 125%) when participants partner with a moderately more capable teammate in an exergame lab task condition by capitalizing on the motivation phenomenon called the *Köhler effect* (Hertel, Kerr, & Messé, 2000; Kerr & Hertel, 2011; Kerr et al., 2007). Studying a club rowing team in the 1920s, Otto Köhler noted performance on a physical task (bicep curls) by weaker rowers was better when their efforts were yoked to stronger rowers. This increased motivation was based on rowers' understanding that their shared task would end when weaker members became exhausted and quit. The greatest motivation gains, Köhler found, came when performance discrepancy was moderate and partners did not perceive performance differences as too great. The Köhler effect emphasizes the weaker partner's effort as indispensable to team success (i.e., a conjunctive task). This indispensability perception and the associated desire for success have been theorized as key to the motivation gain (Kerr et al., 2007). Also integral is an upward social comparison to the moderately more capable teammate by the weaker partner (Kerr et al., 2007). The weaker partner may either set a goal to improve his or her own performance or decide to compete with the stronger partner. Either way, comparison to a stronger partner is thought to be critical to the

Köhler effect. The results of these exergame studies are highly encouraging for using SGPs to help people meet physical activity goals.

In ongoing research, testing is underway to examine whether a Köhler effect will occur with a moderately superior SGP. Preliminary results show, although the effect is not as strong as it is when exercising with a human partner, a significant effect has been demonstrated compared to exercising alone in a single-session of abdominal endurance (Feltz, Forlenza, Winn, & Kerr, 2014; Samendinger et al., in press). Results also indicate that middle-aged male adults who cycle with an SGP 3 days/week over 4 weeks sustain motivation versus cycling without an SGP, but females did not demonstrate an improved persistence (Max et al., 2015).

The current project extends this line of research to a field study of mobile phone app SGPs, giving participants ubiquitous access to partnered exercise. The mobile iPhone app, titled BOOST, was used in a free-living setting for the first time, specifically to motivate adults to persist in walking for exercise. BOOST's design on interdependency with a partner in a conjunctive task demand (Köhler effect) is unique and differs from exercise scenarios founded upon co-active (side by side) or additive (the sum of partner results equals the total outcome) team results, which are prone to certain motivation losses, such as loafing or free riding (Karau & Williams, 1993; Karau & Williams, 1997; Kerr & Bruun, 1981). Yet, the Köhler effect has never been tested with SGPs on physical exertion tasks under free-living conditions. This project sought to directly measure behavioral, psychological, and physical outcomes of a Köhler-based SGP walking app with potential mass appeal and broad reach to diverse sub-populations.

To benefit from an exercise SGP, it is reasonable to assume that the user must accept the character and form a social bond with his/her partner. Because motivation gains may diminish when moving away from using human partners (toward artificial partners), a novel interpersonal synchronization (IPS) feature was applied to the BOOST app. IPS is a fundamental behavioral and physiological mechanism in which one adapts to the rhythms of an interaction partner, dependent on the degree of one's perceptions of these rhythms and congruence of engagement (Delaherche et al., 2012). IPS is closely tied to mimicry and the so-called chameleon effect, recognized as an adaptive unconscious social-behavioral function (Chartrand & Bargh, 1999). Both mechanisms relate to simple human motor actions (e.g., tapping, stride, waving, smiling). These natural adaptive processes have been found to boost liking and cohesion in groups, and partner likability, collaboration, and rapport (Chartrand & Bargh, 1999; Lakens & Stel, 2011; Lakin & Chartrand, 2003). IPS holds that rhythmic adjustments in human movement behavior strongly affect social rapport, perceived group entitativity (forming a social unit), and cooperative attitudes (Delaherche et al., 2012; Hove & Risen, 2009). Likewise, external synchronization cues, such as rhythmic sounds enhance likeability and trust (Launay, Dean, & Bailes, 2013; Launay, Dean, & Bailes, 2014) and elicit automatic adaptations of motor behavior to stay in synchrony with the partner. The BOOST app employs audible SGP footsteps for a limited time, during a warm-up period, in an attempt to apply the potential social connection benefits of IPS. Thus, when the user is unconsciously cued to synchronize to the SGP's footsteps (via an audio signal), favorable perceptions of the SGP may result that might strengthen the dyad relationship and produce positive motivational outcomes. Further, slight deviations in rhythm between the user and SGP footsteps, may cause automatic motor responses in the user to re-synchronize (or, desire to again match the SGP's footsteps). This interplay between initial and recurring synchronization and subtle de-synchronization cycles may influence social and performance outcomes when compared to users who will not have the IPS feature. To avoid interference with inherent ability discrepancies thought to be key to the effectiveness of the

Köhler effect, the SGP footstep IPS feature is only utilized during a walk warm-up period, during which the user-SGP partnership should “walk together for 3 minutes.”

The purpose of this field experiment was to examine the effect of a smartphone exercise application using an SGP, and programmed to replicate Köhler principles, on walking motivation (walk duration at a minimum intensity). The hypothesis was that the basic Köhler motivation gain effect will positively affect the persistence motivation of walkers when linked in a conjunctive task with a software-generated walking partner. This study also explored a novel application of interpersonal synchrony to boost perceptions of rapport and interpersonal connectedness with the SGP. Using average minutes walked as the primary dependent variable, this experiment compared participant walk persistence and psychosocial perception measures across three randomly assigned conditions: a no-partner individual control (IC), a conjunctive task software-generated partner (SGP), and a synchronous conjunctive task software-generated partner (syncSGP). The experimental design was a 3 (Condition: syncSGP, SGP, IC) x 2 (Gender) x 3 (Weeks), with repeated measures on weeks.

Method

Mobile App Development

Two similar iOS (Apple iPhone) applications were developed and utilized for this study and the final versions are described here. One app (without a software-generated partner) was created for the control condition and one for the partnered conditions. Both apps were identical in function, except as described. The apps were designed with basic walking measurement capabilities: date and time of use, distance walked, and geographic route indicated by Global Positioning Services (GPS) built in to the device. The distance walked was measured from the user initiation to the termination of the walk “session” with ongoing distance traveled provided to the user during the walk. Pace was interpreted by accelerometer capability on the device and also displayed to the user (updated every 20 s to simulate continuous average pace). Pace was a simple measure of distance traveled over time and included stops in the walk unless the app timer was paused by the user. The average walk pace was transmitted to the investigator in a data file after each walk. The principal investigator had the ability to monitor total walks each week for each participant via an online account, by tracking app data files that were automatically transmitted immediately after each walk (see Appendix B for examples of data transmitted after each walk was completed). Email reminders were sent to any participants who failed to walk at least once by the fourth day of each week.

The participant "active walk screen" consisted of a color graphic representation of the user moving on a map, along with immediate feedback data listed for his/her pace, elapsed time, and duration in miles (see Appendix A for images of all app screens). The SGP information was displayed in an alternate color, adjacent to the participant's data (Figure 3.1) to invoke a social comparison mechanism and was programmed from the user's actual performance so the SGP always appeared to perform moderately better (conforming to a conjunctive task structure).

The IC app was designed to simply monitor the subject's walking pace and distance and display this information graphically and numerically for the participant. By design, both partnered condition SGPs were programmed to be always moderately better than the user (i.e., walk more minutes, just ahead of the user). During an initial orientation session, users would be informed that the team performance was based upon the "weaker member" or whoever stops walking first as further manipulation of the conjunctive paradigm. In addition, syncSGP condition participants (but not those using SGP or IC) were provided simulated footsteps of their

SGP, during a 3-minute warm-up period at the beginning of every walk, creating the potential to nonconsciously activate interpersonal synchrony.

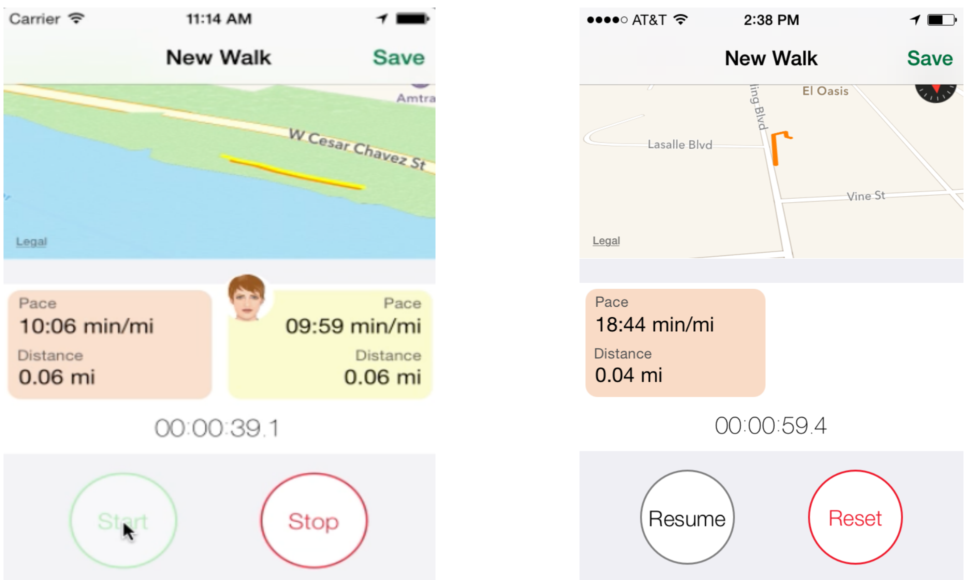

Figure 3.1 Active Walk Screens (Partnered & Control conditions)

To ensure each participant, in all conditions, met the minimum level of MVPA, BOOST monitored walks for a minimum pace (2.5-3.5 mph), reflecting a moderate-vigorous intensity level of activity by the participant. This pace would generally equate to a participant's energy expenditure of approximately 3.5-4.5 metabolic equivalents per kilogram per hour (MET/kg/hr). The lower intensity threshold of the recommended MVPA is 3.5 MET/kg/hr. Self-selected walking speeds have been shown to be sufficient to qualify as a moderate intensity (3-6 METS) physical activity, an important criterion for health benefits (Murtagh, Boreham, & Murphy, 2002). Similarly, a sample of formerly sedentary middle-aged women self-selected a physiologically effective walking intensity between 55–65%, although considerable inter-individual variability was noted (Lind, Joens-Matre, & Ekkekakis, 2008). Each time the participant fell below the minimum pace threshold, a BOOST pop-up screen and audible alarm appeared to encourage an increase in pace, and disappeared after 10-s or when the participant met the minimum pace. If the user temporarily stopped walking (e.g., street light, traffic, tie shoe), they could select the 'Stop' button to pause the timer and minimum pace monitoring. The 'Start' button would then change to 'Resume' and could be selected when the user was ready to resume walking. Otherwise, a reduction in pace, including any stops, would trigger the minimum pace alert after 1 minute below the pace threshold. The number of pauses was monitored and transmitted to the investigator with the other data once each walk was complete.

Pilot testing of the mobile app. A pilot iteration of the BOOST app was tested with six adult community members (25-49 years) and six college-aged (18-25 years) adults recruited via a university online research pool system. The users field-tested the app for one week (minimum of three walks), completed online surveys, and were interviewed as a group afterwards. The goal was to evaluate: device function, ease of use, app handling during walk, data transmission, reaction to and perceptions of the SGPs, and performance discrepancy data and perceptions provided on the walk screen for both the user and SGP. Testers evaluated two male and two female SGPs. A smartphone hand carrier was provided to participants for comfort and to encourage proper use. No significant problems were encountered and feedback was helpful to enhance initial participant instruction without requiring changes to the app.

Procedure

Participants. Once the app was pilot tested, male and female community members were recruited through a variety of flyers, online social media, and print advertisements for the

BOOST Walking Study. A general summary recruitment statement implied the study was designed to examine the use of smartphone technology on physical activity. Participants (*N* = 46, female = 38) provided their own iPhone (models 4s thru 6s) compatible with the exercise application. Recruitment incentives consisted of $30 cash, a smartphone hand strap carrying case (provided during the initial appointment), and a packet of healthy lifestyle walking information. An a priori power analysis was conducted with G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007). Results of the power analysis showed that a total sample size of 45 participants (3 groups; 3 measurement points) would be sufficient to obtain a moderate effect size of 0.60 with a power of 0.9 and an alpha level of 0.05.

The informed consent was completed during an orientation session, in the lab, for each participant prior to enrollment and subsequent to full Institutional Review Board approval. Recruitment and consent materials had informed participants that a minimum of three walks over each 7-day period would be required to remain 'active' in the study and this was reiterated during the orientation session. All participants were screened with the Physical Activity Readiness Questionnaire (PAR-Q: Shephard, 1988) to assess participation physical readiness. Volunteers would have been excluded (none were) if they answered 'yes' to any one of seven general health criteria (e.g., heart condition that precludes participating in moderate physical activity; feel chest pain during physical activity, etc.). Demographic data were collected via an online survey during the session, including: age, measured height and weight, years of education, estimated annual income, and marital status. Although there are potential limitations to self-report, levels of MVPA (including walking) over the preceding week were collected via an initial survey to provide a general baseline of walking and overall physical activity for ancillary analysis.

After random assignment, BOOST app installation and an instructional video were provided to participants in the lab. The partnered condition participants were provided the team dynamic manipulation: "*Remember, you are teammates and your walk result will be based upon the total time of the teammate who quits walking first. The pace for each of you may sometimes be slightly different, as any partners would be. The researchers have programmed your partner to be slightly more fit but, you should know that, your partner will also respond to exercise like anyone and can fatigue*." Later, in the orientation video, the manipulation was reinforced with the following instruction: "*As team partners, you are both yoked or linked in a way. That just means that, either of you should slow down when getting too far ahead of the other partner. It also means that, when one of you quits the walk, the other one must quit too – even if they could have walked farther. The walk display will show pace and distance for each of you, slightly different as one partner challenges the other to go a little faster or farther. Your partner may challenge you to walk faster or longer, but as a team partner, he or she will stay close – just as you should do if challenging him or her*."

The Köhler effect dynamics were reinforced by walk discrepancy feedback during the walk, as the SGP was programmed to always slightly lead the participant on BOOST's map display (grossly approximated to appear as no more than 3 meters), with the SGP's pace alongside the participant's pace as always faster. Variation in SGP pace was designed to create the visual effect of the partner gradually slowing and accelerating intermittently, yet always maintaining an averaged slight lead. This variability was to enhance the perception that the participant's ability was reasonable in comparison to his/her walk teammate, as well as provide a more realistic representation of walking with a human exercise partner. Unknown to the participants, the SGP was programmed to never stop before the participant stops.

Participants in all conditions were informed that they would be 'warming-up' by walking for the first 3-min of every walk at any pace, without concern for the minimum pace limit. In the partnered conditions, the SGP remained beside the participant for the 3 min. In the syncSGP condition, the 3-min period included an audible recording of the SGP's 'footsteps' at a moderate and consistent walking pace (3 mph). The audible cues were the only difference between the SGP and syncSGP app versions. The IC app version simply provided the participant's walking pace and distance but all warm-up and minimum pace features were identical to the partnered app version.

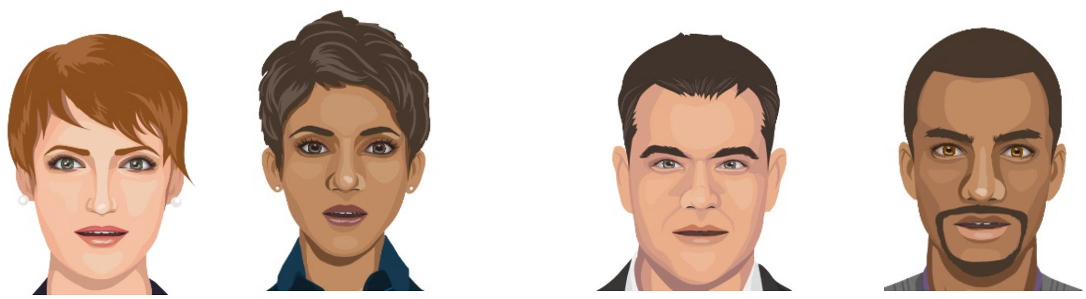

Figure 3.2 Software-generated partners

At the end of the orientation session survey, the participants were asked to choose between two same-sex partners (Figure 3.2): "*Please select which one of the two partners below you wish to be your walk partner. Select by clicking on the partner image*." The partner's age was then programmed into the app as similar (25-45 years) to the participant's age within 5 years. The age was visible to participant before each walk, along with a picture of the partner. After choosing the partner and watching an instructional video, a second brief animated introductory video of the chosen partner was presented, during which the SGP provided a few personal facts (name, hometown, favorite pastime): "*Hi, nice to meet you! I'm Chris. I'm from Lansing, Michigan. I love old movies and, ah, I like reading suspense novels.*" After the SGP introduction, the participant used the app home screen to type a brief introductory statement of his or her own directed to the SGP, with the instruction that they were free to say anything they wish to introduce themselves (See Appendix E for all participant to SGP greetings). Versions of this partner exchange were used in previous studies and the introduction exchange was thought to be important to the participant's team, group, and partner perceptions (Feltz et al, 2011; Forlenza et al, 2012; Samendinger et al., 2015). The chosen partner remained the same through out the study period.

A hand-strap carrying case for the phone was provided to encourage the participant to periodically view their performance data, without having to grasp the phone for an extended time or store the phone in a pocket. Phones were fitted in the hand-strap case during the orientation session to reinforce use and to demonstrate how the app button selection would work through the clear plastic. The participant was instructed to leave the volume on high to be able to hear app alerts (and footsteps in partnered conditions). The app screens and function were reviewed with each participant to verify understanding and app function on the participant's phone.

Participants in all conditions were free to walk for exercise in their environment of choice, whenever they wished, for the minimum of three times each week (they were told there was no maximum number of walks). This minimum number of walks was not enforced, as no participants were withdrawn unless they did not walk at least once in each week. The term "walk for exercise" was emphasized by the investigator when explaining that walks with the app should not be leisurely strolls, with frequent stops, or walks to a specific destination (e.g., walking to school or work, to the store). Issues related to walking indoors were discussed, including the possibility of the GPS and cellular service not functioning. Instructions were provided to be able to determine if the app would function in an indoor environment (e.g., mall, gym track), should they choose to do so. Along with this instruction, and to maintain experimental manipulation fidelity, we discouraged walking with others, dogs, and any use of alternative media (e.g. music, other phone apps) while using BOOST.

Tips for safe use during walking, an introduction to the PAG, and literature from the Every Body Walk! Collaborative promoting the positive effects of walking (Kaiser, 2013) were provided to each participant. At the end of 3 weeks, participants returned to the lab to have the app removed from their smartphone, complete surveys, and be debriefed.

Measures

Study "start dates" and subsequent week-long periods were tracked so that all weekly online surveys were completed by participants at the end of their specific 7-day period. See Appendix B for all measures.

Persistence. Persistence was defined as the average minutes walked per week and over the 3-week study period. Distance and pace were also collected for each walk, from app-recorded data, and averaged over each week and the 3-week study period.

Self-efficacy beliefs. Self-regulatory self-efficacy was measured at the end of each of the 3 weeks via an online survey. The measure consisted of a 3-item scale on which participants indicated how confident they are in their ability to maintain three different paces (Strolling, 30-min/mile; Walking, 20-min/mile, Brisk Walking, 15-min/mile) during 30-min walks on 5 out of the next 7 days. Responses ranged from *Not Confident At All* (0) to *Completely Confident* (7). Responses to how confident the participant would be maintaining each pace were averaged into a mean score for baseline (prior to Week1) and for the end of walk Weeks 1, 2, and 3. Mean self-efficacy scores across all 4 measurement points were also combined for an overall self-regulatory self-efficacy rating.

Enjoyment. Enjoyment perceptions of each walk were gathered within the app after the participant completed a walk using a modified 8-item Physical Activity Enjoyment Scale (PACES; Kendzierski & DeCarlo, 1991). Raedeke (2007) found the reduced 8-item measure highly correlated (r = .94) with the complete enjoyment scale. Each item was rated on a 7-point bipolar scale beginning with the stem "Please rate how you feel at the moment about the physical activity you have been doing according to the following scales" (e.g., 1= "*I loved it*"; 7 = "*I hated it*"). There is support for the construct validity of PACES in sedentary 25 to 75 year old adults (Heesch, Mâsse & Dunn, 2006). Enjoyment ratings for each walk were averaged into block scores: Week 1, Week 2, and Week 3 for analysis. A mean enjoyment rating, over the 3-week period of walks, was also calculated for an overall measure of walking enjoyment.

Perceived exertion. An app screen also prompted the participant to enter a perceived exertion rating at the end of each walk with the Borg Ratings of Perceived Exertion Scale (Borg, 1998). The participants recorded subjective perceptions of their overall level of intensity each time the measurement screen appeared, on a scale of 6 (*no exertion*) to 20 (*maximal exertion*). Instructions for this scale, including descriptive anchors for several exertion ratings, were provided in the orientation video. Mean exertion ratings, captured on the app immediately after each walk, were averaged into block exertion scores for each week. An overall, 3-week, exertion score was also calculated to provide a measure of exertion during the entire study period.

Partner relationship. To assess social and task-related (working as a team) perceptions, partnered condition participants completed additional measures each week (online) and at the end of the study period (in lab): team perceptions (Nass, Fogg, & Moon, 1996), group identification, and attitudes toward the SGP.

Upon return to the lab for debriefing, each participant also completed 1-time measures: perceptions of synchrony, Alternative Godspeed Indices (perceptions of SGP eeriness, humanness, and attractiveness; Ho & MacDorman, 2010), entitativity, or the perceptions of one's group being a social unit (based upon a similar scale utilized by Postmes, Brooke, and Jetten, in 2008; as cited in Lakens & Stel, 2011), and rapport (Bernieri, Davis, Rosenthal, & Knee, 1994; Manusov, 2014).

Previous physical activity. The International Physical Activity Questionnaire (IPAQ) was used to capture an estimate of the average physical activity for each participant prior to enrolling in the study. The IPAQ comprises a set 5 activity domains asked independently: walking and moderate-intensity and vigorous-intensity activity within each of the work, transportation, domestic chores and gardening (yard) and leisure-time domains (Craig et al., 2003). Each set measures the frequency and duration of activities during the previous 7-day period. Using recommended metabolic equivalents (MET), an average MET score was calculated for each type of activity: walking (3.3 METs), moderate-intensity activities (4 METs), and vigorous-intensity activities (8 METs). A sum value for all 3 types of activity was used as the total physical activity (MET-minutes/week) for each participant. The IPAQ was developed and tested in adults, aged 15-69 years of age.

Manipulation checks. In an attempt to indirectly measure participant perceptions of the two primary mechanisms thought to be responsible for the Köhler effect motivation gain, partnered condition participants were asked several questions regarding team indispensability and social comparison. These one-time measures were at the end of the participants' final survey.

Indispensability to the team was measured with a 1-item manipulation check (Hertel, Niemeyer, & Clauss, 2008): "*As you walked, how important was it to you to not let your partner down*?" (1: *not important*; 7: *very important*). As it is difficult to obtain direct measures of social comparison without biasing the participant, a new measure of relative ability was used to aid in identifying if social comparison of the SGP by the participant occurred. The participants were asked to rate, 1 to 7 on a semantic differential scale, how they felt in relation to their partner (1=*Inferior/Superior=7; 1=Weaker/Stronger=7; 1=Slower/Faster=7; 1=Less Fit/More Fit=7*). They could also answer "*Neither, I didn't think about it*," which may suggest comparison to the SGP did not occur. Finally, the perceived discrepancy between the participant's and the SGP's ability was measured with a single question. The question related to the participant's perceptions of the difference in task (walk) ability between them and the partner and asked participants to rate how they felt they compared to their partner over the past 3 weeks (1=*much less capable*; 7=*much more capable than my partner*).

Results

A preliminary analysis was conducted on multiple study variables to examine the effectiveness of the conjunctive paradigm implementation in a field setting and to ensure the study protocol was followed. These variables include manipulation checks and aspects of protocol monitoring. Descriptive data for demographic and participant characteristics is presented before the results for primary and secondary study variables. The main analysis included persistence effects and was defined as the mean minutes of walking per week, as well as over the 3-week study period. Analysis for the survey responses for enjoyment, exertion, self-efficacy, and partner relationship measures will also be presented. Given the exploratory nature of this field experiment, the p-value was set at .05 for all tests and no attempt was made to control the experiment-wise error rate.

Preliminary Analyses

Participant characteristics. Participant (M_{age} = 37.98, *SD* = 10.25) sex-composition by condition is provided in Table 3.1 and education levels and income levels are provided in Table 3.2. Of note, four others consented to the study but withdrew for scheduling conflict reasons and could not meet the minimum walk requirements. The groups did not substantially differ regarding any of the demographic variables for age, BMI, education level, or household income. Comparatively, the mean annual 2013 household income for the county including and nearest to the University was $62,161.

Table 3.1 Experimental condition participants

	Female N	Male N	Total N
IC	13	3	16
SGP	13	2	15
syncSGP	12	3	15
Total N	38	8	46

Table 3.2 Participant Income and Education Levels

Income	N	Percent	Degree	N	Percent
$10-19,999	4	8.7	High School/Equivalent	6	13.0
$20-29,999	2	4.3			
$30-39,999	3	6.5			
$40-49,999	7	15.2	Associate’s	3	6.5
$50-59,999	6	13.0			
$60-69,999	4	8.7	Bachelor’s	18	39.1
$70-79,999	2	4.3			
$80-89,999	2	4.3	Master’s	14	30.4
$90-99,999	4	8.7			
$100-149,999	10	21.7	Doctorate	5	10.9
$150,000 or more	2	4.3			

Walk manipulation checks. Several internal and external factors could have affected the results for persistence during the walks. These uncontrolled factors include: variation in pace, fidelity of the minimum pace threshold, and weather.

Pace. Data for walking pace was analyzed to examine whether differences between the conditions might affect persistence, and as a control measure to ensure all participants walked at the minimum moderate intensity. For walking pace, there were no significant effects for Condition: $F(2,45) = .74$, $p = .48$ or Weeks: $F(2,80) = 1.17$, $p = .32$. Males walked significantly faster on average (Males: $M = 17.85$, $SD = 2.61$; Females: $M = 15.56$, $SD = 2.40$), $F(1,40) = 4.98$, $p = .03$. There was no significant interaction between Condition and Gender, $F(2,40) = 1.25$, $p = .29$. Means for Pace walked (minutes/mile) by Condition and Week are plotted in Figure 3.3 *(Y-axis scale reduced for clarity of trends)* and means are presented in Table 3.3.

Table 3.3 Pace by Condition in minutes/mile – Means (Standard Deviations)

	Week1 Pace	Week2 Pace	Week3 Pace	Total Pace
IC	16.45 *(1.80)*	16.65 *(1.75)*	15.72 *(4.87)*	16.27 *(2.03)*
SGP	15.22 *(4.55)*	15.79 *(5.56)*	14.86 *(4.59)*	15.30 *(3.26)*
syncSGP	16.19 *(2.18)*	16.72 *(3.54)*	15.92 *(2.1)*	16.28 *(2.30)*

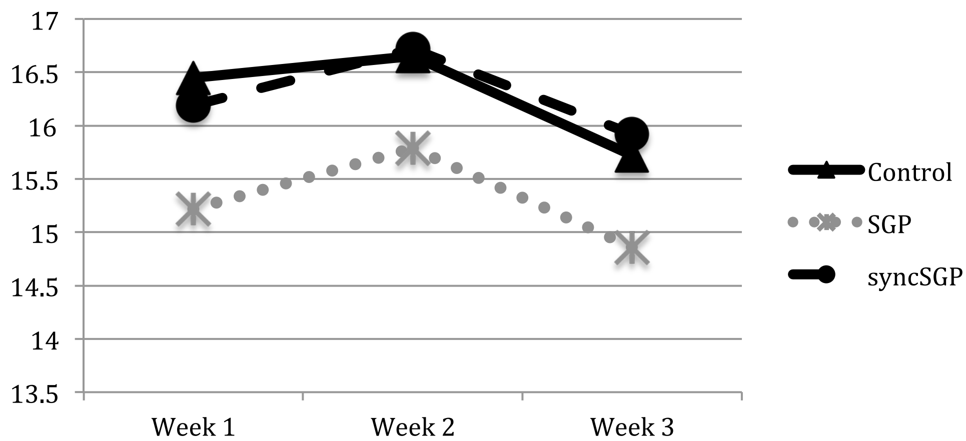

Figure 3.3. Plots for mean Pace walked (minutes/mile) x Condition x Week

Pace alerts. Participants were alerted of a slow pace by an automatic feature of the app, when walking pace fell below the minimal threshold for more than 1 min (3.5 mph). Participants were alerted of the slow pace by a pop-up warning and an audible tone, dismissed by touching the screen alert. The alert would reappear an unlimited number of times if the participant's pace did not reach the threshold. There were no significant differences between conditions for mean number of pace alerts for each of the 3 weeks, Week 1: $F(2,45) = .52$, $p = .60$; Week 2: $F(2,45) = .91$, $p = .41$; Week 3: $F(2,45) = 1.07$, $p = .35$.

Table 3.4 Pace alerts means (Standard Deviation)

	Week 1	Week 2	Week 3
IC	0.51	0.5	0.42
SGP	0.32	0.33	0.41
syncSGP	0.36	0.76	0.22
Alert Means	0.4 (.547)	0.54 (.889)	0.35 (.425)
Alert Sum	49	62	52

Weather. Although all participants were enrolled from March 27th through June 8th, weather did not appear to be a significant factor in the number of walks, or the distance and time walked (overall or by condition). Daytime high temperatures ranged from 30 to 85 degrees over the study period. There was a non-significant negative correlation between daytime high temperatures and the number of walks per participant (number of walks each day divided by participants enrolled on that day). Temperature also did not demonstrate a significant relationship with the distance of each walk ($r = -.01$, $p = .80$) or duration of each walk ($r = -.03$, $p = .54$) for all participants pooled (398 walks). Likewise, when each day of the study during which walks occurred was generally categorized as a 'rain day' or 'no rain day' (regardless of rainfall total or characteristics), neither distance ($r = .01$, $p = .78$) or duration ($r = .03$, $p = .55$) of the walk was correlated to the rain variable. The same was then true by condition, as no relationship emerged with running the correlations by condition.

Non-study walking. Each week, participants were surveyed regarding exercise not related to the walking app. During the baseline session, 10 people reported not taking part in any activity the prior week. At the end of Week 1, only three people reported no other physical activity, aside from the study-related walking. At the end of both Weeks 2 and 3, there were five participants who reported no 'other' exercise. Of those who reported some other exercise: 14 included walking as one of the physical activities the week before the study; 30 reported non-study walking at Week 1; 26 reported other walking at Week 2; and, 29 reported some other walking at the end of Week 3. There were no significant differences between conditions for self-reports of non-study walking.

Conjunctive paradigm manipulation checks. During the final survey, participants were asked to select the appropriate response to questions about the SGP and team partnership. These questions were designed to verify the paradigm manipulation based on an interdependent conjunctive task structure, in which the team score is defined as that of the weakest member. If effective, motivation gains are thought to arise from two primary mechanisms: team indispensability and upward social comparison.

Indispensability. Reported perceptions of the participant's importance to the team score did not differ from the mid-point (1= my performance is not important; 7= my performance is very important) for either of the partnered conditions (SGP: *M* = 4.3, *SD* = 1.8; syncSGP: *M* = 4.6, *SD* = 1.6). Partnered participants were also asked: "*How important was it to not let your partner down*?" On this question related to perceived indispensability, mean ratings for the syncSGP (*M* = 4.3, *SD* = 2.09) and the SGP (*M* = 3.67, *SD* = 1.68) were not significantly different from each other or the mid-point.

Ability discrepancy. Relative partner ability was examined with two questions. The questions related to the participant's perceptions of the difference in task (walk) ability between them and the partner. The questions may be an indirect measure of whether the participant compared their ability to that of the partner, not just to represent an understanding of the manipulation implemented within the study design. The first question asked participants to rate how they felt they compared to their partner over the past 3 weeks (1=*much less capable*; 7=*much more capable than my partner*). Ratings between groups did not differ and were slightly, but not significantly, below the scale mid-point (syncSGP: *M* = 3.63, *SD* = 1.46; SGP: *M* = 3.73, *SD* = 1.03).

The second question asked participants to rate how they felt in relation to their partner (1=*Inferior/Superior=7; 1=Weaker/Stronger=7; 1=Slower/Faster=7; 1=Less Fit/More Fit=7*) on a semantic differential scale. They could also answer "*Neither, I didn't think about it*," which may suggest explicit comparison to the SGP did not occur during the walks. Only one of the thirty-one respondents indicated they 'didn't think about it' on any of the four items, implying they did not compare themselves to the SGP. After all of the "Neither" responses were removed from the other scale responses for all participants, ratings were averaged for total rating of comparison. Again, there were no group differences (syncSGP: $M = 3.95$, $SD = 2.3$; SGP: $M = 3.1$, $SD = 1.2$), $t(17) = 1.03$, $p = .32$, and the ratings were not significantly different from the mid-point (4).

Conjunctive structure. In terms of whether the conjunctive manipulation was effective, participants were asked at the end of the study to choose how "your" total score was determined. The majority of participants responded that their total score was the time that they walked (Table 3.5). No participants chose the incorrect answer ("*My score was the team's score, defined as "the last team member to quit walking*"). Both of the other answers could be interpreted as correct. A one-way ANOVA did not demonstrate significant differences in average overall Time walked during the 3-week period between the "*Time I walked*" responders ($M = 32.5$, $SD = 13.8$) and the "*Quits walking first*" responders ($M = 29.01$, $SD = 13.2$), $F(1,30) = .478$, $p = .49$. Further more, participants who indicated that the team score was "*Quits walking first*" (conjunctive), rated his/her importance to the team score lower (M = 3.64, SD = 1.9) than the "*Time I walked*" responders ($M = 4.94$, $SD = 1.3$), $t(15.7) = 1.95$, $p = .07$. The scale for ratings of own importance to the team score ranged from 1 to 7 (1=*My performance is not important*, 4=*somewhat important*, 7=*My performance is very important*).

Table 3.5 Conjunctive structure manipulation perceptions

Condition	*"The amount of time I walked"*	*"My score was the team's score, defined as: The teammate who quits walking first"*	*"The last team member to quit walking"*
SGP	8	7	0
syncSGP	12	4	0
Total	20 *(65%)*	11 *(35%)*	0

Primary Analyses

Persistence Effects. As the primary dependent variable, time walked (mean minutes) and duration (mean distance) were analyzed for persistence effects. Results for pace, the number of pace alerts, the number of walks and other factors that may have affected the walks provided context for the persistence variables.

For means minutes of walking, a 3 (condition) x 2 (gender) x 3 (weeks) mixed ANOVA with repeated measures on the last factor was conducted to test whether mean minutes of walking per week differed by Condition or by Gender, and whether there was an interaction between Condition and Gender. Results showed no significant main effects for Condition: F (2, 40) = .96, p = .39, Gender: F(1,40) = .04, p = .85, nor Weeks: F(2,84) = .35, p = .70. No Condition-by-Gender interactions were identified. A linear trend analysis was non-significant, F(1,43) = 1.7, p = .19, for mean minutes of walking overall, such that participants in the syncSGP condition walked the most (M = 33.25, SD = 14.98) and walkers in the IC walked the least (M = 27.6, SD = 8.01), with those in the SGP condition falling in the middle (M = 29.19, SD = 11.86). A Dunnett's test was performed for total minutes walked using the IC condition as control but neither the syncSGP (p = .91) or the SGP (p = .33) condition mean differences were significant. However, the mean time differences for Condition demonstrated a moderate effect size between the syncSGP condition and the IC condition (d = 0.47).

To control for possible group differences in pre-study physical activity levels, responses from the IPAQ questionnaire were calculated and compared. There were no significant differences in total physical activity the week prior to study participation between conditions, $F(2,43) = 1.41$, $p = .26$. There was also no effect of condition type on average Time walked (3-week total) when controlling for physical activity the week prior to study participation, $F(2,42) = 1.05$, $p = .36$. Likewise, there were no group differences in average Time walked when controlling for just the IPAQ Total Walk MET score, $F(1,42) = 1.26$, $p = .27$, or the IPAQ Leisure Walk MET score, $F(1,42) = .64$, $p = .43$. See Figure 4 for plots of mean Time walked (minutes) by week.

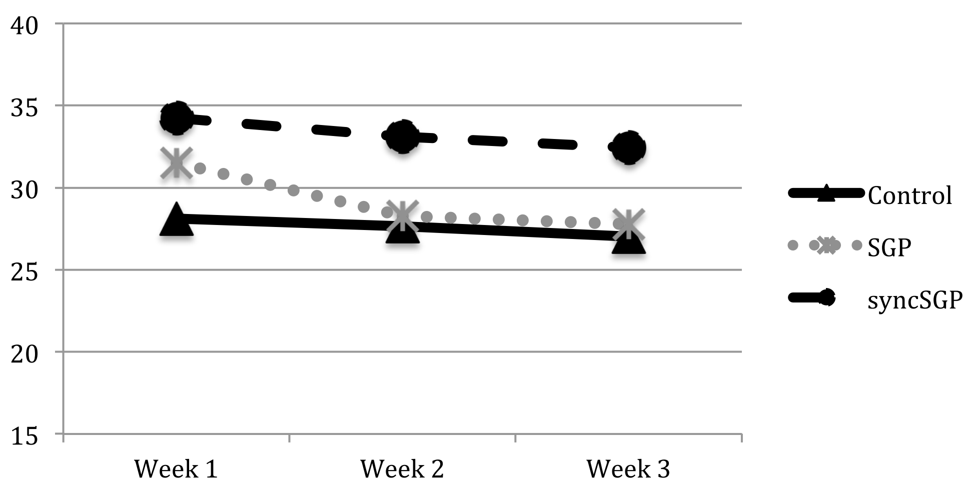

Figure 3.4 Plots for mean Time walked (minutes) x condition x week

No relationship was noted between which same-sex partner was chosen (of 2) and the mean time duration of walks for the 3 weeks (Time: $r_s = -.11$, $p = .56$).

As mean minutes walked were highly correlated with distance walked (*r* = .94, p = .01), the decision was made to continue with analyses only using time as the primary persistence variable (Table 3.6). Descriptive data for time and distance are presented in Table 3.7.

Table 3.6 Persistence Correlations – Time and Distance (means)

	Week1 Distance	Week2 Distance	Week3 Distance	Week1 Time	Week2 Time	Week3 Time	Total Time	Total Distance
Week1 Distance	1.00							
Week2 Distance	.75**	1.00						
Week3 Distance	.69**	.70**	1.00					
Week1 Time	.97**	.67**	.65**	1.00				
Week2 Time	.70**	.93**	.62**	.66**	1.00			
Week3 Time	.44**	.57**	.89**	.43**	.59**	1.00		
Total Time	.85**	.86**	.77**	.85**	.90**	.77**	1.00	
Total Distance	.92**	.94**	.86**	.86**	.88**	.83**	.94**	1.00

** Correlation is significant at the 0.01 level (2-tailed).

Table 3.7 Descriptive Data for Walk Distance (meters) and Time – Mean (Standard Deviations)

	Week1 Distance	Week2 Distance	Week3 Distance	3-Week Distance	Week1 Time	Week2 Time	Week3 Time	3-Week Time
IC	2930.22 *(1200.67)*	2774.01 *(922.57)*	2945.82 *(1149.15)*	2896.13 *(978.91)*	28.13 *(9.812)*	27.64 *(8.06)*	27.02 *(11.42)*	27.60 *(8.01)*
SGP	3409.90 *(1744.26)*	3270.05 *(2166.61)*	3082.97 *(1100.70)*	3204.51 *(1504.01)*	31.51 *(19.11)*	28.27 *(15.86)*	27.78 *(12.38)*	29.20 *(11.86)*
syncSGP	3453.07 *(1579.23)*	3371.5 *(1995.84)*	3348.93 (1438.53)	3391.20 *(1537.30)*	34.23 *(15.65)*	33.12 *(19.38)*	32.43 *(13.23)*	33.26 *(14.98)*

Ancillary Analyses

Variables included in this analysis included: Enjoyment (measured after each walk), ratings of perceived Exertion (measured after each walk), and Self-Efficacy perceptions (measured at the end of each week). Results for a set of participant-SGP relationship-focused variables, as well as manipulation checks, are also presented.

Enjoyment. There were no significant differences in 3-week mean Enjoyment rating between males ($M = 2.22$, $SD = .64$) and females ($M = 2.62$, $SD = .66$), $t(39) = 1.52$, $p = .14$. Therefore, male and female data were combined for the remainder of the analysis.

Enjoyment ratings for each walk were averaged into block scores: Week 1, Week 2, and Week 3. A 3 (Condition) x 3 (Time: Week 1, Week 2, Week 3) ANOVA with repeated measures on the last factor was conducted to test whether mean ratings of Enjoyment differed by Condition and whether there was an interaction between Condition and Time. An adequate Cronbach's α was obtained for each time point ($\alpha > .88$). Results showed no significant main effects for Condition: $F(2, 38) = .03$, $p = .97$, or Weeks: $F(2,76) = 1.8$, $p = .17$, as well as no interaction effect: $F(4,76) = .52$, $p = .72$. One-sample t-test results for overall Enjoyment scores were significantly positive from the scale midpoint (4; 1=*enjoy it*, 7=*hate it*) for all participants ($M = 2.54$, $SD = .67$), $t(40) = 14.04$, $p < .001$.

Enjoyment scores were positively related to average Time per walk ($r = .41$, $p = .008$), but not with walking pace ($r = .08$, $p = .64$). Mean enjoyment, over the 3-week period of walks, was positively correlated to overall 3-week ratings of self-efficacy ($r = .33$, $p = .047$).

Perceived Exertion. Mean Ratings of Perceived Exertion were not significantly different between females ($M = 11.57$, $SD = 2.1$) and males ($M = 10.25$, $SD = 1.8$), $t(42) = 1.64$, $p = .11$. Female and male data were then combined for the remainder of the analysis. Mean exertion ratings immediately measured after each walk were averaged into block scores for weeks. A 3 (Condition) x 3 (Time: Week 1, Week 2, Week 3) ANOVA with repeated measures on the Time was conducted to test whether blocked ratings of Exertion differed by Condition and whether there was an interaction between Condition and Time. Results showed no significant main effects for Condition: F (2, 41) = .31, p = .74, or Weeks: F(2,82) = .19, p = .83, nor an interaction: F(4,82) = .49, p = .74. Over the 3-week period, combined ratings of Exertion for all participants (M = 11.3, SD = 2.1) was associated with a "light" perception of exertion on the Borg scale. Exertion was not related to time spent walking per walk overall (r = .05, p = .77), nor to walking pace (r = .18, p = .25). No significant correlation was noted between self-report of exertion levels and enjoyment or self-efficacy for any of the 3-week averages (p >.05).

Self-Efficacy Effects. Perceptions of self-regulatory self-efficacy were measured at four time points and responses were averaged into a mean score for baseline (prior to Week1) and for the end of walk Weeks 1, 2, and 3. Prior to analyzing self-efficacy ratings over time, a preliminary one-way ANOVA was used to demonstrate that there were no significant differences between conditions at the baseline measurement point, F(2,45) = 1.2, p = .33. Subsequent to this result, a 3 (Condition) x 2 (Gender) x 4 (Time) ANOVA with repeated measures on Time was performed. Results indicated no significant main effect for Condition: F(2,37) = 1.14, p = .33, Gender: F(1,37) = .44, p = .51, or Time: F(3,111) = 1.06, p = .37. No Condition-by-Gender interactions were identified.

Table 3.8 Self-regulatory Self-efficacy overall mean ratings (Standard Deviations)

	Sex	Mean	SD
Week 1 (Baseline) Self-efficacy	Male	6.3	0.7
	Female	6.1	1.1
	Total	*6.1*	*1*
Week 2 Self-efficacy	Male	5.8	1.4
	Female	5.7	1.3
	Total	*5.7*	*1.3*
Week 3 Self-efficacy	Male	6.1	1.1
	Female	5.7	1.1
	Total	*5.8*	*1.1*
Week 4 Self-efficacy	Male	5.8	1.2
	Female	6	1
	Total	*6*	*1*

Significant relationships with persistence (Time walked) developed with self-efficacy ratings prior to Week 1 (baseline) and at the end of each week (Table 3.9). Likewise, mean self-efficacy scores across all four measurement points combined were related to average walk Time ($r = .52$, $p < .001$), but not with walking pace ($r = -.22$, $p = .15$).

Table 3.9 Correlation means: Self-efficacy and Persistence (Time)

	SE-baseline	SE-Week1	SE-Week2	SE-Week3	Week1 Time	Week2 Time	Week3 Time	Total Time
SE-baseline	1.00							
SE-Week1	.43**	1.00						
SE-Week2	.45**	.70**	1.00					
SE-Week3	0.14	.61**	.68**	1.00				
Week1 Time	0.09	.37*	.42**	.36*	1.00			
Week2 Time	0.23	.38**	.48**	.40**	.66**	1.00		
Week3 Time	.30*	0.23	.34*	.35*	.43**	.59**	1.00	
Total Time	0.24	.40**	.49**	.44**	.85**	.90**	.77**	1.00

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Partner Relationship. To determine the effect of the synchronization manipulation on partner relations, *t* tests were conducted between the SGP and syncSGP conditions for attitude toward partner, feeling of groupness, perceptions related to being part of a team, entatitivity, rapport, and synchrony. There were no significant differences between the two groups for any of these variables.

Furthermore, *t* tests were conducted to examine participant positive relationship with the partner (feeling of being part of team, groupness, partner attitude, entatitivity, rapport, and synchronization). Results indicated that for both the SGP and syncSGP conditions, participants did not score significantly different from the scale midpoints (Table 3.1.1).

Table 3.1.1 Overall mean ratings for Relationship Survey Measures

	Mean	Std. Deviation	Scale Mid-Point	Cronbach's α
Group	2.67	0.98	3	.91
Team	3.68	1.81	5	.95
Partner Attitudes	2.68	0.92	3	.78
Rapport	5.06	0.91	5	.71
Entatitivity	3.31	1.53	4	.92
Synchrony	3.59	1.78	4	---

Correlation coefficients among the partner relationship variables are displayed in Table 3.1.2. There were strong, positive relationships between most of the partner relationship measures. Similarly, repeated measures for Group, Team, and Partner Attitudes were significantly correlated to each other at each of the time points (>.001).

Table 3.1.2 Mean value correlations for Relationship Survey Measures

	Group	Team	Partner Attitudes	Rapport	Entatitivity	Synchrony
Group	1.00					
Team	.89**	1.00				
Partner Attitudes	.78**	.74**	1.00			
Rapport	.71**	.48*	0.44	1.00		
Entatitivity	.77**	.76**	.63**	.56**	1.00	
Synchrony	.70**	.62**	.50**	0.35	.58**	1.00

*** Correlation is significant at the 0.01 level (2-tailed).*
** Correlation is significant at the 0.05 level (2-tailed).*

Participants in the two conditions did not significantly differ in their evaluations of their partner's humanness: $F(1,29) = .78$, $p = .38$, eeriness: $F(1,28) = .01$, $p = .93$, or attractiveness: $F(1,28) = .05$, $p = .83$. An adequate Cronbach's α was obtained for the humanness (α = .77), eeriness (α = .78), and attractiveness (α = .76) subscales. Both conditions considered the SGP more attractive than the neutral mid-point, SGP: $t(15) = 4.43$, $p > .001$; syncSGP: $t(15) = 2.71$, $p = .016$ (SGP attractiveness: $M = 3.5$, $SD = .39$; syncSGP attractiveness: $M = 3.4$, $SD = .61$). The Alternative Godspeed Indices combined survey responses for both partnered conditions related to eeriness ($M = 2.1$, $SD = 0.51$) and humanness ($M = 1.7$, $SD = 0.68$) were significantly less from the scale mid-point (3). Thus, while participants in both partnered conditions perceived the partner to be artificial, they also did not find them eerie.

Discussion

Ubiquitous smartphone access and the explosion of popularity for software applications offers an attractive opportunity to harness these upward trends to lead people toward more physical activity. Initiatives utilizing active video games and mobile technology are increasing, as is recognition by government and professional organizations of the potential role of technology in achieving better health. Unfortunately, many of the physical activity applications do not take advantage of evidenced-based principles to achieve specific activity outcomes. The BOOST app was developed to adapt popular mobile device applications to one of the few proven paradigms in group performance to increase persistence with exercise. This project also sought to explore potential moderators of the group dynamics principles and their relationship with social and task variables.

However, in this study, the primary dependent variable (minutes spent walking) showed no significant benefit to using group dynamics principles with a software-generated partner compared to using the app in the alone condition. Although there was trend that favored the syncSGP condition (syncSGP > IC), which demonstrated a moderate effect size compared to the alone condition, the study was most likely under-powered to find statistical significance. It is unlikely that the SGP synchrony pace tone attributed to these differences in minutes walked by somehow initiating a difference in the desire to set off from the warm-up with a brisk pace, as all pace measures were variable and differed from the consistent 2.5 mph pace tone provided during that period. Considering the relatively short average time of the walks, it may be that the tone was simply an extra, novel feature that stimulated sufficient interest in the syncSGP participants to engage with the app enough to result in the group differences in minutes walked. It is also possible that simply hearing the footstep tone enhanced the nonconscious perception of realism, with the result of increasing engagement with the SGP.

Despite inherent limitations in accelerometer capabilities and without the ability to monitor each walk closely, the data collected for pace and low pace alerts suggested that all walks were at least at moderate intensity. As expected, distance and time walked were highly correlated and the overall pace for all conditions was faster than the minimal threshold set to ensure a moderate intensity walk. The number of walks each week were nearly the same across all conditions, with an increasing trend developing at the 3-week time point. Although the mean difference between the syncSGP and IC conditions was only 5.5 minutes, the group differences and trends do appear to provide initial support for the SGP app as a proof of concept motivational tool.

Overall, the specific Köhler motivation gain paradigm was compatible with mobile technology and free-living environments. The participant feedback for relative ability discrepancy, via real-time data and animated map graphic display, functioned with enough variability that all participants reported during debriefings that they were not aware that the SGP performance was based on their distance and pace. In a general measure of the success for a social user-SGP relationship, almost all participants chose to enter a response greeting after watching an animated video introduction from their partner. Similarly, in debriefing, no participant referred to the partner as anything other than 'Chris' or 'my partner' (versus using terms such as: the app, avatar, character).

In general, the low to moderate scores across the SGP relationship variables and conditions suggest that the participants did not feel they had a positive or negative relationship with the partner. All of the relationship variables (team, group, rapport, entatitivity, and synchrony) were correlated to each other, perhaps providing some construct validity for the measures. The consistency across these measures may be due to how much the participant accepted the SGP as a legitimate partner. In other words, if they accepted the SGP, it may be uniformly reflected across all of these "relationship" measures and vice versa. In this case, results indicated that for both the SGP and syncSGP conditions, participants did not score significantly above scale midpoints, suggesting that participants generally did not have strong, positive feelings about their relationship with the partner. As there were no clear differences between the partnered conditions, the findings suggest that the synchrony warm-up period manipulation did not seem to enhance social perceptions and foster a connection between partners. Despite the lack of a clear relationship between synchrony and persistence or perceptions of the partner relationship, the trend for the syncSGP condition outperforming the IC condition suggests that synchrony may be a phenomenon worthy of further study. It may be useful to introduce synchrony into a paradigm that has already been shown to better facilitate a connection between a human and software-generated exercise partner.

Self-efficacy ratings by all participants for walking at various intensity levels were high initially and remained so throughout the study. Self-efficacy demonstrated a positive correlation with distance and total time walked. This high efficacy may simply be due to the general perception that walking is not a difficult task and speaks to why it is the most popular form of physical activity. The lack of changes in self-efficacy ratings are likely related to the high initial confidence and the fact that little change would be expected over a 3-week period of walks. Importantly, self-efficacy ratings did not suffer in the partnered conditions (versus control or baseline) even though participants were provided feedback over the 3 weeks that they were the weaker member of the team and always quit before their partner stopped walking.

Exertion levels measured immediately after each walk were not correlated to the duration and pace of the walk and no differences in these ratings were observed at any of the time points for the 3 conditions. No relationship was noted between the level of exertion and ratings of enjoyment. Enjoyment perceptions for all combined conditions were significantly above the scale mid-point. So, regardless of the distance or time spent walking at a moderate intensity, participants enjoyed the walks and perceived the overall exertion level to be light.

Although this was an initial application of the Köhler motivation paradigm outside the lab, addressing the moderators and experimental weaknesses may improve outcomes in future research. In terms of this study's limitations, firstly, the sample size was small and largely female. Previous studies that assessed the Köhler effect under laboratory conditions, employed 20 to 25 participants per condition. The natural weaknesses in experimental fidelity of this free-living experiment will always pose challenges to capturing adherence, compliance, or deviance from the protocol, and thereby increasing the variance. Certainly, experimenter implementation can be addressed and have an impact on establishing and maintaining the key Köhler manipulation related to team outcomes and the moderately more capable attributes of the SGP. Although this experiment provided this instruction in multiple ways (orientation video, instructional take-home material, performance feedback), there may be other techniques to ensure the participant understands and accepts this information. For example, perhaps one area of focus could be in reinforcing that the team is focused on performance-outcome exercise, not social coactive physical activity. Some participants may not be familiar with partnered exercise in which the goal is primarily performance-based, not relationship-based. Although the relationship is important and should be positive, it is not the primary purpose of the activity (e.g., walking), unlike some physical activity relationships.

The social-psychological constructs at the core of the Köhler paradigm are upward social comparison and team indispensability. Both variables are difficult to measure directly and the dynamics required for establishing these perceptions are susceptible to limitations in using SGPs, as well as hosting the experiment outside of the lab. This study attempted to capture a measure of each variable by asking participants if they compared or felt indispensable to the team. Participants reported that they did not feel indispensable and did not seem to compare themselves to their partner. In other words, they did not rate their partner any better or any worse. It is possible that this study failed to create a superior partner. Yet, this seems unusual in that the participants were told in several formats that the SGP was moderately better and the SGP always out-performed the participant. To obtain a better idea of team indispensability and participant understanding of team-focused manipulations, future versions of the app may include questions after each walk in which the participant is asked how far they walked and how far the SGP walked. Again, even acknowledging the limitations of directly assessing these variables, the instruction and feedback should be reinforced. Other methods of capturing these perceptions should also be explored.

In terms of the conjunctive design manipulation, participants were asked to choose the statement that described "How your total score was determined during each walk." While 11 participants chose "the teammate who quits walking first" (the intended interpretation of the manipulation), 20 participants chose "my score was the amount of time I walked." No participants chose the incorrect response that would have clearly suggested a misunderstanding of the manipulation. Of course, it is possible that the participants misinterpreted the manipulation and this contributed to the lack of indispensability perceptions and, potentially, stronger team ratings and performance outcomes. It is also plausible that the participants misinterpreted the question and the answer choices or assumed, as the inferior member, that the score would always be based upon their time walked. One way to interpret these findings is that both of the chosen responses essentially represent the intended manipulation and indicate that study instructions and feedback were successful at this level of understanding. Finally, it is also quite possible that participants were unclear on the meaning and significance of a "team score", especially with an

SGP. Future use of this manipulation should improve the validity of this measure and seek a secondary method of determining how participants perceived feedback or manipulations.

Furthermore, procedures for providing and enforcing experimental parameters can be reviewed. Important parameter components to emphasize might include instruction to: walk alone (or only with the SGP), not be distracted by use of other phone apps or music, and to not walk with a defined end time or destination (e.g., don't walk from home to the store as an experimental walk with the app). Enforcing these parameters can be challenging, even with constant technological monitoring of the app walk files submitted after each walk. There were clear patterns for some walkers to indicate that they stopped walking after a set time (i.e., 30 minutes), as if they walked during a lunch hour or other limited period. The same is true for very brief walks observed, perhaps only to satisfy the study requirements but not to truly walk for exercise. These issues may be managed through appropriate handling of the data and missing data analyses by setting more detailed parameters for data exclusion before the study begins so that clear violations of these parameters are easier to identify and manage. However, an adequate sample size and ethical use of disqualifying data from the analysis is warranted. In this study, all of walks were used in the analysis unless the data were flawed in a way that was not compatible with natural human abilities (excessively fast pace or data that were not readable). The number of walks was monitored and emails were sent to participants if only one walk was noted in a 4-day period. If the walk time was very brief, upon inspection of the data file, the participant was contacted to inquire about potential problems with the app or difficulty achieving the study requirements. Care was taken to not influence the length of the walk when contacting participants for fear of potentially coercing participants into walking longer. Any potential issues were managed by re-instruction or, on occasion, reloading the app to ensure proper function.

Likewise, pace alerts were reviewed to determine if the user's pace frequently dropped below the threshold for moderate intensity exercise.

Function of the app occurred with very few problems reported or noted in the receipt of walk data files. The app included a back-up data transmission mechanism by which any data files not immediately sent to the DropBox account were stored in the phone and then sent automatically via email when service was restored. Although rare, issues reported to the experimenter included those most often related to the improper use of the app (e.g., initiating and then placing in a pocket for the entire walk) or issues with cellular service. Participants were provided a hand strap and instructed to not store the app in a pocket, checking the active walk screen periodically for walk performance data (and that of a partner). Feedback is important for the successful application of Köhler effect mechanisms (social comparison, team indispensability) and lack of attention to this performance data could pose a problem in free-living environments, beyond the control of the researcher. Without demanding constant attention (and unsafe distraction), other attractive features could be added to the app that might draw closer attention to the performance data and increase the likelihood of participants engaging with this feedback. As an alternative, non-immersive devices (such as with a eye-level display), may encourage more attention to feedback without the concern of pocketing the device. Audio cues of participant and partner performance might also lessen the dependency on visual attention to the app screens.

In light of the findings and limitations, future research should seek to further develop and test BOOST motivation design and features to strengthen the weaknesses mentioned here. There appears to be enough evidence to recommend that this experimental design and application of the Köhler effect motivation paradigm can proceed and build on the work from this study. User-SGP interaction characteristics can be explored to enhance the relationship and potentially affect the performance of the team exercise. Although increasing verbal and nonverbal interaction between the user and SGP can create problems (misinterpretations, bias, frustration, believability), Media Equation suggests that there are possible social norms and group dynamic responses that may be of benefit. The question of whether interpersonal synchrony can enhance the partner social and task relationship has not been answered. Suggestions for future research include: IPS may be tested further in a similar paradigm within the lab setting; the time period of initial synchrony may be expanded (without interfering in Köhler discrepancy manipulations); the introductory meeting might include synchronous activities between the partners; or, synchronous cues may need to be revisited during the walk. Recorded walks (and associated performance data) of a human partner embedded in the app might also be explored to potentially enhance the effect of Köhler mechanisms and those for the potential impact of synchrony features. Although playback of the human partner performance may be challenging for continuous engagement of the participant during the walk (versus immediate responsive features available with a SGP), human partners have demonstrated greater Köhler motivation gain effects compared to those with SGPs (Feltz et al., 2014; Samendinger et al., unpublished).

Future iterations of the Köhler paradigm to practical applications may need to stretch the limits of the conjunctive manipulation to include popular game features typical of non-experimental game designs. Features that may increase general appeal or SGP likeability can be woven into the design, such as: incorporating music; out-group competition; partner inter-game interaction; embed the exercise goals or partner interaction in a story or progressive narrative between the partners; skill level or reward attainment; and, adding actual game or sport elements to foster cooperation or competition. All of these features have the potential to interfere with key

Köhler effect mechanisms but there may be techniques to balance the known motivational group dynamic requirements with a popular, enjoyment-focused design.

Finally, the design can also be tested with other populations (perhaps younger people would respond differently), other mobile frameworks (Android), games, and popular console home-based technologies as a means of increasing physical activity. Weight loss and fitness measures can be combined with adaptable partner dynamics over longer periods. Ultimately, the long-term goal could be to develop easy to use, widely available exercise tools to help people achieve recommended levels of exercise and reduce health risks.

APPENDICES

Appendix A – App Screens and Descriptions

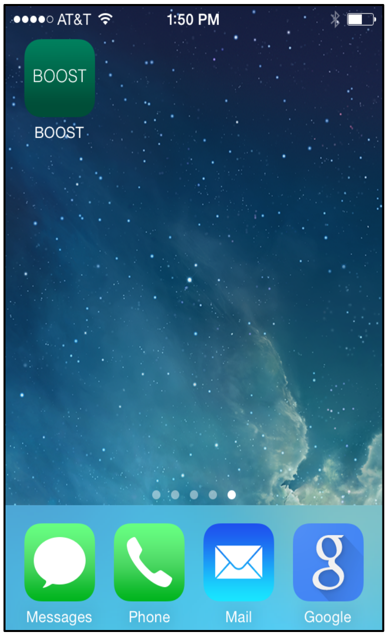

Figure 3.5 iPhone Home screen

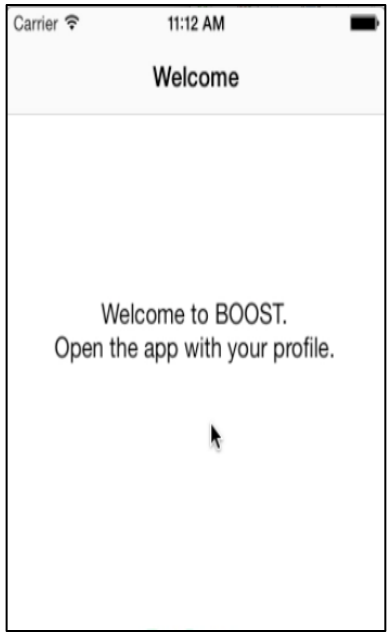

Figure 3.6 BOOST Home screen

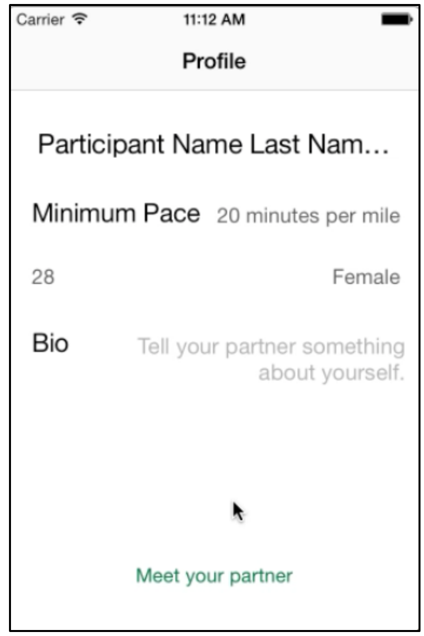

Figure 3.7 Initialization screen (1-time only); User introduction to partner; Partnered conditions

Figure 3.8 Initial walk partner greeting (1-time only); Partnered conditions

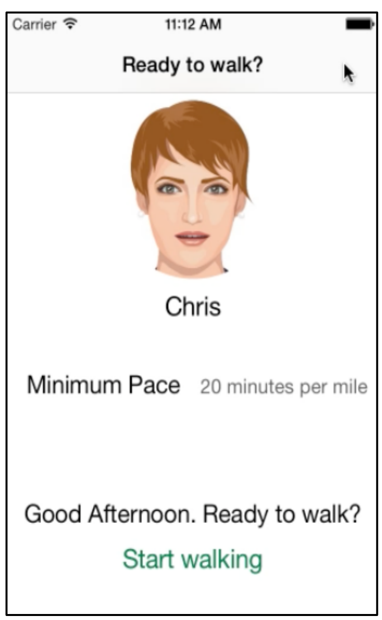

Figure 3.9 Walk partner greeting; Every walk; Time of day greeting; Partnered conditions only

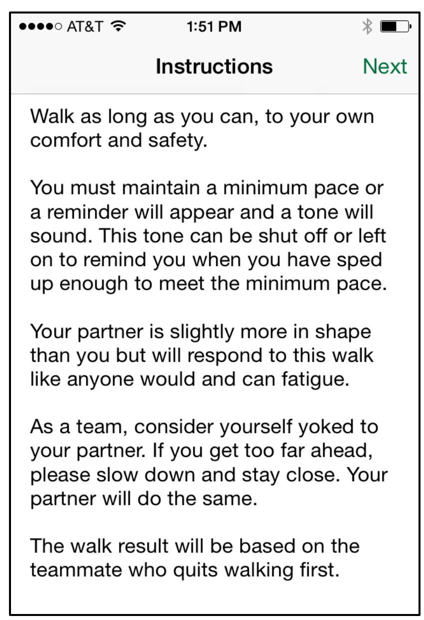

Figure 3.1.1 Reminders; Every walk; 10 seconds before 'Next' appears; Partnered conditions

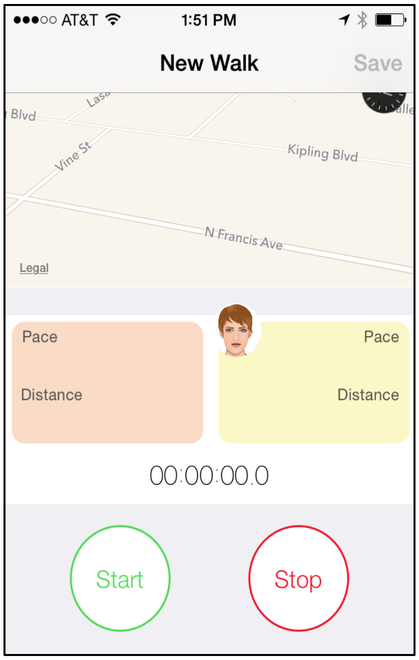

Figure 3.1.2 Active walk screen; Every walk; Partnered conditions; Control condition

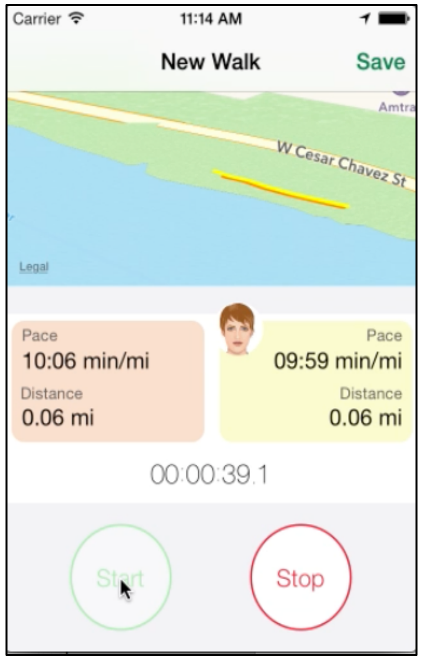

Figure 3.1.3 Active walk screen in use; Colored lines on map for user & SGP; Partnered conditions

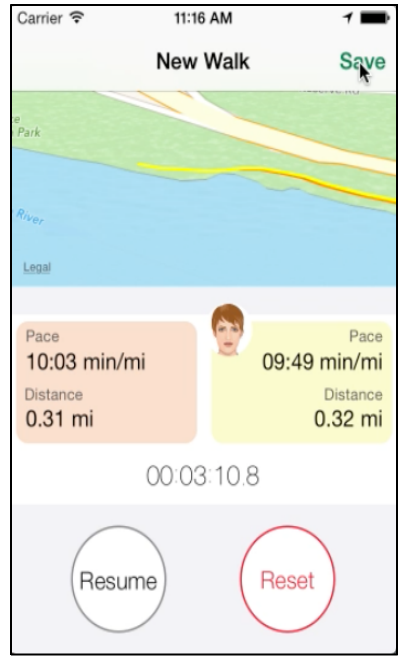

Figure 3.1.4 Active walk screen; Paused & 'Start' becomes 'Resume'; Select 'Save' (top, right); Partnered conditions

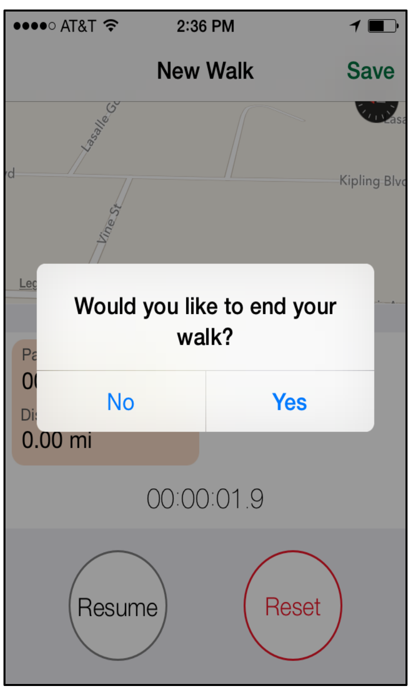

Figure 3.1.5 Active walk screen; After selecting 'Save'; Resume or save; All conditions

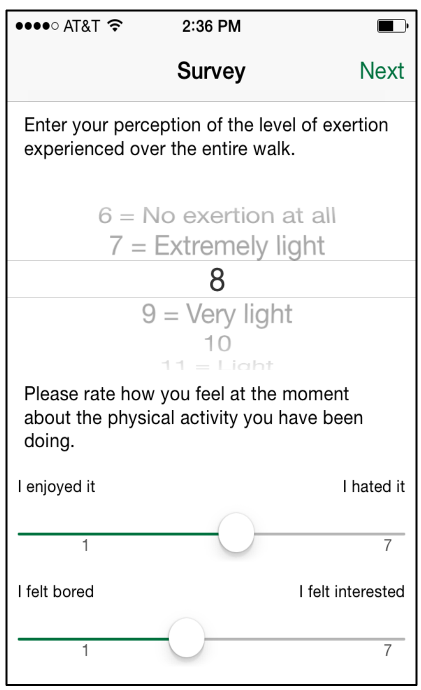

Figure 3.1.6 Survey screen Exertion & Enjoyment; Must move selector on each item; Every walk - All conditions

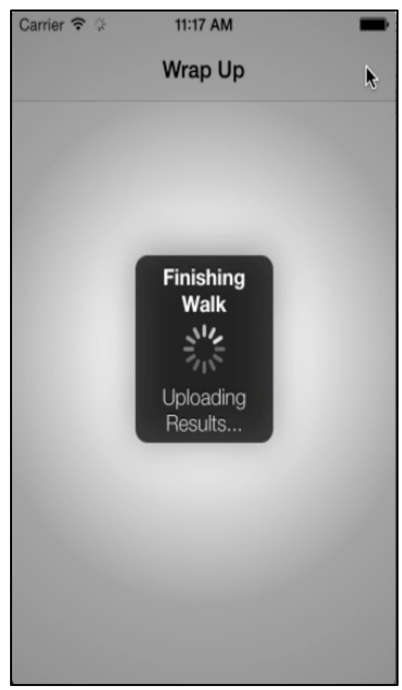

Figure 3.1.7 Upload of data upon completion of survey; Every walk; All conditions

Figure 3.1.8 Final, Thank you screen; May review walk; Every walk; All conditions

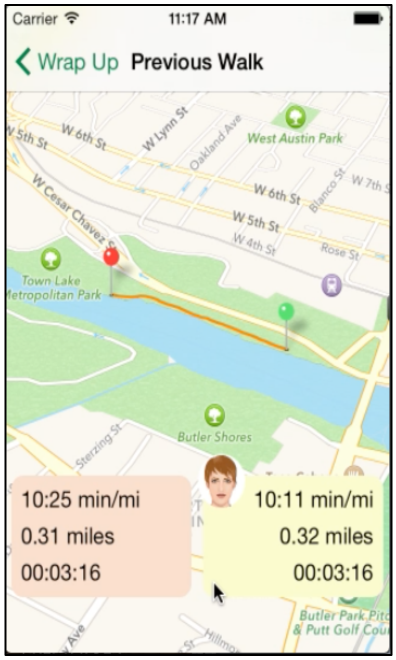

Figure 3.1.9 Review walk screen; Choose 'Wrap up' to return; Every walk; Partnered conditions

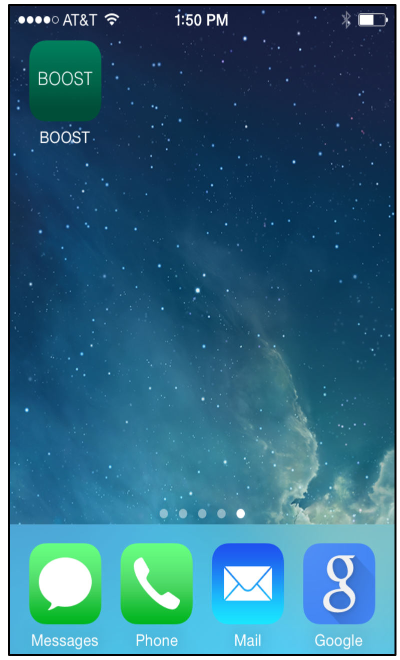

Figure 3.2.1 Close app by selecting iPhone Home screen; All conditions

Appendix B - Surveys

I. 'Initial Lab' Session online survey in lab (after consent)

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q) (Shephard, 1988)
1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
2. Do you feel pain in your chest when doing physical activity?
3. In the past month, have you had chest pain when you were not doing physical activity?
4. Do you lose your balance because of dizziness or do you ever lose consciousness?
5. Do you have bone or joint problems that could be made worse by a change in your physical activity?
6. Is your doctor currently prescribing medication for your blood pressure or heart condition?
7. Do you know of any other reason why you should not do physical activity?

PHYSICAL ACTIVITY QUESTIONNAIRE (Milton, Bull, & Bauman, 2011)
"In the past month, on how many days have you done a total of 30 minutes or more of physical activity, which was enough to raise your breathing rate. This may include sport, exercise, and brisk walking or cycling for recreation or to get to and from places, but should not include housework or physical activity that may be part of your job".
Days: 1-31

DEMOGRAPHIC QUESTIONS
Gender: Male/Female
Age: _________
Height (in feet and inches): _________
Weight (in pounds): _________

What is the highest degree or level of school you have completed? If currently enrolled, mark the previous grade or highest degree received.
*No schooling
*8th grade
*9th, 10th, 11th, or 12th grade
*High school diploma or the equivalent (for example: GED)
*Associate degree (for example: AA, AS)
*Bachelor's degree (for example: BA, BS)
*Master's degree (for example: MA, MS, MEng, MEd, MSW, MBA)
*Professional degree (for example: MD, DDS, DVM, LLB, JD)
*Doctorate degree (for example: PhD, EdD)

Marital Status:
*Married
*Single
What is your estimated annual household income?
Less than $10,000

$10,000 to $19,999
$20,000 to $29,999
$30,000 to $39,999
$40,000 to $49,999
$50,000 to $59,999
$60,000 to $69,999
$70,000 to $79,999
$80, 000 to $89,999
$90,000 to $99,999
$100,000 to $149,999
$150,000 or more

What is your race? (select one or more):
American Indian or Alaska Native
Asian
Black or African American
Native Hawaiian or other Pacific Islander
White
Other (please specify): _____________
I prefer not to respond

What is your ethnicity? (select one):
Hispanic or Latino
Not Hispanic or Latino
I prefer not to respond

SELF-REGULATORY SELF-EFFICACY SCALE
Instructions:
Physical Activity Guidelines suggest exercising at least 30 minutes a day, 5 days a week, at a moderate intensity. If you were to take walks on 5 of the next 7 days, how confident are you that you could maintain the following paces?

For each pace, please select how confident you are of maintaining that pace for 30 minutes.
0 = not confident at all 7 = completely confident

Pace and confidence:
1. Strolling: 2 mph or 30 min/mile *0 1 2 3 4 5 6 7*
2. Walking: 3 mph or 20 min/mile *0 1 2 3 4 5 6 7*
3. Brisk walking: 4 mph or 15 min/mile *0 1 2 3 4 5 6 7*

NON-STUDY PHYSICAL ACTIVITY
1. "Did you take part in any exercise this past week? Y/N"
2. "If yes, please briefly describe your exercise."

PHYSICAL ACTIVITY QUESTIONNAIRE (IPAQ; Craig et al., 2003)
We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** and **moderate** activities that you did in the last 7 days. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal.

Part 1: Job-related physical activity
The first section is about your work. This includes paid jobs, farming, volunteer work, course work, and any other unpaid work that you did outside your home. Do not include unpaid work you might do around your home, like housework, yard work, general maintenance, and caring for your family. These are asked in Part 3.

1. Do you currently have a job or do any unpaid work outside your home?

☐ Yes
☐ No → ***Skip to PART 2: TRANSPORTATION***

The next questions are about all the physical activity you did in the **last 7 days** as part of your paid or unpaid work. This does not include traveling to and from work.

2. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, heavy construction, or climbing up stairs **as part of your work**? Think about only those physical activities that you did for at least 10 minutes at a time.

_____ **days per week**

☐ No vigorous job-related physical activity → ***Skip to question 4***

3. How much time did you usually spend on one of those days doing **vigorous** physical activities as part of your work?

_____ **hours per day** _____ **minutes per day**

4. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads **as part of your work**? Please do not include walking.

_____ **days per week**

☐ No moderate job-related physical activity → ***Skip to question 6***

5. How much time did you usually spend on one of those days doing **moderate** physical activities as part of your work?

_____ **hours per day** _____ **minutes per day**

6. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **as part of your work**? Please do not count any walking you did to travel to or from work.

_____ **days per week**

☐ No job-related walking → ***Skip to PART 2: TRANSPORTATION***

7. How much time did you usually spend on one of those days **walking** as part of your work?

_____ **hours per day** _____ **minutes per day**

Part 2: Transportation physical activity

These questions are about how you traveled from place to place, including to places like work, stores, movies, and so on.

8. During the **last 7 days**, on how many days did you **travel in a motor vehicle** like a train, bus, car, or tram?

_____ **days per week**

☐ No traveling in a motor vehicle → ***Skip to question 10***

9. How much time did you usually spend on one of those days **traveling** in a train, bus, car, tram, or other kind of motor vehicle?

_____ **hours per day** _____ **minutes per day**

Now think only about the **bicycling** and **walking** you might have done to travel to and from work, to do errands, or to go from place to place.

10. During the **last 7 days**, on how many days did you **bicycle** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No bicycling from place to place → ***Skip to question 12***

11. How much time did you usually spend on one of those days to **bicycle** from place to place?

_____ **hours per day** _____ **minutes per day**

12. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No walking from place to place → ***Skip to PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY***

13. How much time did you usually spend on one of those days walking from place to place?

_____ **hours per day** _____ **minutes per day**

Part 3: Housework, house maintenance, and caring for family

This section is about some of the physical activities you might have done in the **last 7 days** in and around your home, like housework, gardening, yard work, general maintenance work, and caring for your family.

14. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, chopping wood, shoveling snow, or digging **in the garden or yard**?

_____ **days per week**

☐ No vigorous activity in garden or yard → ***Skip to question 16***

15. How much time did you usually spend on one of those days doing **vigorous** physical activities in the garden or yard?

_____ **hours per day** _____ **minutes per day**

16. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, sweeping, washing windows, and raking **in the garden or yard**?

_____ **days per week**

☐ No moderate activity in garden or yard → ***Skip to question 18***

17. How much time did you usually spend on one of those days doing **moderate** physical activities in the garden or yard?

_____ **hours per day** _____ **minutes per day**

18. Once again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, washing windows, scrubbing floors and sweeping **inside your home**?

_____ **days per week**

☐ No moderate activity inside home → ***Skip to PART 4: RECREATION, SPORT AND LEISURE-TIME PHYSICAL ACTIVITY***

19. How much time did you usually spend on one of those days doing **moderate** physical activities inside your home?

_____ **hours per day** _____ **minutes per day**

Part 4: Recreation, sport, and leisure-time physical activity

This section is about all the physical activities that you did in the **last 7 days** solely for recreation, sport, exercise or leisure. Please do not include any activities you have already mentioned.

20. Not counting any walking you have already mentioned, during the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **in your leisure time**?

_____ **days per week**

☐ No walking in leisure time → ***Skip to question 22***

21. How much time did you usually spend on one of those days **walking** in your leisure time?

_____ **hours per day** _____ **minutes per day**

22. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like aerobics, running, fast bicycling, or fast swimming **in your leisure time**?

_____ **days per week**

☐ No vigorous activity in leisure time → ***Skip to question 24***

23. How much time did you usually spend on one of those days doing **vigorous** physical activities in your leisure time?

_____ **hours per day** _____ **minutes per day**

24. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like bicycling at a regular pace, swimming at a regular pace, and doubles tennis **in your leisure time**?

_____ **days per week**

☐ No moderate activity in leisure time → ***Skip to PART 5: TIME SPENT SITTING***

25.How much time did you usually spend on one of those days doing **moderate** physical activities in your leisure time?

_____ **hours per day** _____ **minutes per day**

Part 5: Time spent sitting

The last questions are about the time you spend sitting while at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading or sitting or lying down to watch television. Do not include any time spent sitting in a motor vehicle that you have already told me about.

26. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekday**?

_____ **hours per day** _____ **minutes per day**

27. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekend day**?

_____ **hours per day** _____ **minutes per day**

II. Available via online survey: reminder email sent at the end of each calendar week 1 & 2

iPHONE WALK APPLICATION FUNCTION (email response only)
Is the iPhone walk app functioning as explained during your introduction to it in the lab? Yes/No
If no, please describe the problem.

SELF-REGULATORY SELF-EFFICACY SCALE (See Initial Survey)

TEAM PERCEPTION INDEX (Nass, Fogg, & Moon, 1996)
Partnered conditions only
Instructions:
For each of the following statements, rate how much you agree or disagree with them.
1 = Strongly Disagree, 9 = Strongly Agree

I felt I was part of a team.
I thought of my partner as a teammate.
I felt I worked collaboratively with my partner.
I felt my partner and I worked together.
I felt I was working separately from my partner.

GROUP IDENTIFICATION (Brown, Condor, Matthews, Wade, & Williams, 1986)
Partnered conditions only
Instructions:
For each of the following statements, "exercise group" refers to yourself and the person you walked with, your partner whom you met.
1 = Strongly Disagree, 5 = Strongly Agree

I considered this exercise group to be important.

I identified with this exercise group.
I felt strong ties with this exercise group.
I was glad to belong to this exercise group.
I saw myself as belonging to this exercise group.
I would be annoyed to say that I was a member of this exercise group.

ATTITUDES TOWARDS PARTNER
Partnered conditions only
How well does each of these statements describe your feelings toward your partner?
1 = Strongly Disagree, 5 = Strongly Agree

I liked my partner
I would be glad to exercise with my partner again in the future
I felt comfortable with my partner
I would like to get to know my partner better

NON-STUDY PHYSICAL ACTIVITY
1. "Did you take part in any exercise this past week, other than walks with the iPhone app? Y/N"
2. "If yes, please briefly describe your exercise."

III. 'Study Complete' Lab Session online survey in lab (at of 3 weeks)

SELF-REGULATORY SELF-EFFICACY SCALE (See Initial Survey)

TEAM PERCEPTION INDEX (See Above; *Partnered conditions only*)

GROUP IDENTIFICATION (See Above; *Partnered conditions only*)

ATTITUDES TOWARDS PARTNER (See Above; *Partnered conditions only*)

MANIPULATION CHECKS
What, in your own words, do you think the purpose of this experiment was?
What did you like and not like about this experiment?
Did you change anything related to healthy lifestyle during this study (diet, physical activity habits, sleep, etc.)? If yes, describe it briefly here:

How was your total score determined during each walk? *Partnered conditions only*

- My score was the amount of time I walked.
- My score was the team's score, defined as "the teammate who quits walking first"
- My score was the team's score, defined as "the **last** team member to quit walking"

During the walks, over the past 3 weeks, how do you feel you compared to your partner?
1 = Much less capable than my partner, 7 = Much more capable than my partner

As you were preparing to walk, how important did you think your performance would be to the team score?
1 = My performance is not important, 7 = My performance is very important

Think about all of your walks over the past week. In general, why did you stop walking each time?

I walked as long or as far as I planned to walk.
I didn't go as far or as long as I had planned to walk.
I stopped but I didn't have a specific plan before setting out to walk.
Please explain your answer to the previous question regarding why you stopped walking.

MANIPULATION CHECK-SOCIAL COMPARISON
Partnered conditions only
Please answer the following question as how you felt overall, looking back over the entire 3-week period.

In relationship to my walk partner, I felt:

Inferior	1	2	3	4	5	6	7	Superior	☐	Neither, I didn't think about it
Weaker	1	2	3	4	5	6	7	Stronger	☐	Neither, I didn't think about it
Slower	1	2	3	4	5	6	7	Faster	☐	Neither, I didn't think about it
Less Fit	1	2	3	4	5	6	7	More Fit	☐	Neither, I didn't think about it

INDISPENSABILITY (*Hertel, Niemeyer, & Clauss, 2008)*
Partnered conditions only
As you were preparing to walk, how important was it to you not to let your partner down?
1 = Not important, 7 = Very important

NON-STUDY PHYSICAL ACTIVITY
1. "Did you take part in any exercise this past week, other than walks with the iPhone app? Y/N"
2. "If yes, please briefly describe your exercise."

ALTERNATIVE GODSPEED INDICES (Ho & MacDorman, 2010)
Partnered conditions only
Rate your partner according to the following scale

Humanness
1 = Artificial, 5 = Natural
1 = Human-made, 5 = Human-like
1 = Without definite lifespan, 5 = With definite lifespan

1 = Inanimate, 5 = Animate
1 = Mechanical movement, 5 = Biological movement
1 = Synthetic, 5 = Real
Eeriness
1 = Reassuring, 5 = Eerie
1 = Numbing, 5 = Freaky
1 = Ordinary, 5 = Superordinary
1 = Bland, 5 = Uncanny
1 = Unemotional, 5 = Hair-raising
1 = Uninspiring, 5 = Spine-tingling
1 = Predictable, 5 = Thrilling
1 = Boring, 5 = Shocking
Attractiveness
1 = Unattractive, 5 = Attractive
1 = Repulsive, 5 = Agreeable
1 = Ugly, 5 = Beautiful
1 = Messy, 5 = Sleek
1 = Crude, 5 = Stylish

SYNCHRONY
Partnered conditions only
Think about walking with your partner over the past 3 weeks. Overall, how synchronized were you with your partner?
(1-Less synchronized; 7-More synchronized)

ENTITATIVITY (Postmes, Brooke, & Jetten, 2008)
Partnered conditions only
When thinking about walking with your partner over the past 3 weeks, please rate how you felt about the following statements: (1 = Strongly Disagree, 7 = Strongly Agree)

I felt like my partner & I were a unit
I experienced a feeling of togetherness when walking with my partner
I have the feeling the walking partners can work together
I feel like my partner and I were like one
I felt similar to my partner
My partner and I shared the same goals

RAPPORT (Manusov, 2014; Bernieri, Davis, Rosenthal, & Knee, 1994)
Partnered conditions only
Over the past 3 weeks walking, please rate the interaction you experienced between you and your partner for each of the characteristics listed. Your rating will not be disclosed to your partner.
(1 = Not at all, 9 = Extremely)

The interaction was:
1. Well-coordinated

2. Boring
3. Cooperative
4. Harmonious
5. Satisfying
6. Comfortably paced
7. Cold
8. Awkward
9. Engrossing
10. Focused
11. Involving
12. Intense
13. Friendly
14. Active
15. Positive
16. Dull
17. Worthwhile
18. Slow

IV. In-app surveys (repeated end of each walk)

EXERTION (The Borg Scale; Borg, 1998)
Instructions:
Enter your perception of the level of exertion experienced over the entire walk.

6	No exertion at all
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard (heavy)
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

ENJOYMENT (Physical Activity Enjoyment Scale; PACES; Kendzierski & DeCarlo, 1991; Raedeke (2007)
Instructions:
Please rate how you feel at the moment about the physical activity you have been doing.

1. I enjoyed it	*I hated it*
2. I felt bored	*I felt interested*
3. I liked it	*I disliked it*
4. I found it pleasurable	*I found it unpleasurable*
5. It was a lot of fun	*It was no fun at all*
6. It was very pleasant	*It was very unpleasant*
7. I felt as though there was nothing else I'd rather be doing	*I felt as though I would rather be doing something else*
8. I was very absorbed in the activity	*I was not at all absorbed in the activity*

REFERENCES

REFERENCES

Ainsworth, B. E., Haskell, W. L., Leon, A. S., Jacobs, D. R., Montoye, H. J., Sallis, J. F., & Paffenbarger, R. S. (1993). Compendium of physical activities: classification of energy costs of human physical activities. *Medicine and Science in Sports and Exercise*, *25*(1), 71–80.

Atlantis, E., Barnes, E. H., & Ball, K. (2007). Weight status and perception barriers to healthy physical activity and diet behavior. *International Journal of Obesity*, *32*(2), 343–352. http://doi.org/10.1038/sj.ijo.0803707

Bell, J. A., Hamer, M., Batty, G. D., Singh-Manoux, A., Sabia, S., & Kivimaki, M. (2014). Combined effect of physical activity and leisure time sitting on long-term risk of incident obesity and metabolic risk factor clustering. *Diabetologia*, *57*(10), 2048–2056. http://doi.org/10.1007/s00125-014-3323-8

Bernieri, F. J. (2014). The Expression of Rapport. In *The Sourcebook of Nonverbal Measures: Going Beyond Words*. Psychology Press.

Bernieri, F. J., Davis, J. M., Rosenthal, R., & Knee, C. R. (1994). Interactional Synchrony and Rapport: Measuring Synchrony in Displays Devoid of Sound and Facial Affect. *Personality and Social Psychology Bulletin*, *20*(3), 303–311. http://doi.org/10.1177/0146167294203008

Borg, G. (1998). *Borg's perceived exertion and pain scales* (Vol. viii). Champaign, IL, US: Human Kinetics.

Bricker, S. (2012, December 8). *Comments on National Physical Activity Report: Midcourse Report.* Retrieved from http://americawalks.org/america-walks-comments-on-the-national-physical-activity-plan-midcourse-report/

Centers for Disease Control and Prevention (CDC). (2012). Vital signs: walking among adults--United States, 2005 and 2010. *MMWR. Morbidity and Mortality Weekly Report*, *61*(31), 595–601.

Chartrand, T. L., & Bargh, J. A. (1999). The chameleon effect: the perception-behavior link and social interaction. *Journal of Personality and Social Psychology*, *76*(6), 893–910.

Craig, C. L., Marshall, A. L., Sjostrom, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., … Oja, P. (2003). International Physical Activity Questionnaire: 12-Country Reliability and Validity: *Medicine & Science in Sports & Exercise*, *35*(8), 1381–1395. http://doi.org/10.1249/01.MSS.0000078924.61453.FB

Delaherche, E., Chetouani, M., Mahdhaoui, A., Saint-Georges, C., Viaux, S., & Cohen, D. (2012). Interpersonal synchrony: A survey of evaluation methods across disciplines. *Affective Computing, IEEE Transactions on*, *3*(3), 349–365.

Ekkekakis, P., & Lind, E. (2005). 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. http://doi.org/10.1038/sj.ijo.0803052

Ekkekakis, P., Lind, E., & Vazou, S. (2010). Affective Responses to Increasing Levels of Exercise Intensity in Normal-weight, Overweight, and Obese Middle-aged Women. *Obesity*, *18*(1), 79–85. http://doi.org/10.1038/oby.2009.204

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*, 175-191.

Feltz, D. L., Forlenza, S. T., Winn, B., & Kerr, N. L. (2014). Cyber Buddy Is Better than No Buddy: A Test of the Köhler Motivation Effect in Exergames. *Games for Health Journal*, *3*(2), 98–105. http://doi.org/10.1089/g4h.2013.0088

Feltz, D. L., Irwin, B., & Kerr, N. (2012). Two-player partnered exergame for obesity prevention: using discrepancy in players' abilities as a strategy to motivate physical activity. *Journal of Diabetes Science and Technology*, *6*(4), 820–827.

Feltz, D. L., Kerr, N. L., & Irwin, B. C. (2011). Buddy up: the Köhler effect applied to health games. *Journal of Sport & Exercise Psychology*, *33*(4), 506–526.

Forlenza, S. T., Kerr, N. L., Irwin, B. C., & Feltz, D. L. (2012). Is My Exercise Partner Similar Enough? Partner Characteristics as a Moderator of the Köhler Effect in Exergames. *Games for Health Journal*, *1*(6), 436–441. http://doi.org/10.1089/g4h.2012.0047

Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I.-M., Swain, D. P. (2011). Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise. *Medicine & Science in Sports & Exercise*, *43*(7), 1334–1359. http://doi.org/10.1249/MSS.0b013e318213fefb

Gellert, P., Ziegelmann, J. P., Warner, L. M., & Schwarzer, R. (2011). Physical activity intervention in older adults: does a participating partner make a difference? *European Journal of Ageing*, *8*(3), 211–219. http://doi.org/10.1007/s10433-011-0193-5

Hamilton, D. L., & Sherman, S. J. (1996). Perceiving persons and groups. *Psychological Review*, *103*(2), 336–355. http://doi.org/http://dx.doi.org.proxy2.cl.msu.edu/10.1037/0033-295X.103.2.336

Heesch, K. C., Mâsse, L. C., & Dunn, A. L. (2006). Using Rasch modeling to re-evaluate three scales related to physical activity: enjoyment, perceived benefits and perceived barriers. *Health Education Research*, *21*(suppl 1), i58–i72. http://doi.org/10.1093/her/cyl054

Hertel, G., Kerr, N. L., & Messé, L. A. (2000). Motivation gains in performance groups: paradigmatic and theoretical developments on the Köhler effect. *Journal of Personality and Social Psychology*, *79*(4), 580–601.

Hertel, G., Niemeyer, G., & Clauss, A. (2008). Social Indispensability or Social Comparison: The Why and When of Motivation Gains of Inferior Group Members1. *Journal of Applied Social Psychology*, *38*(5), 1329–1363. http://doi.org/10.1111/j.1559-1816.2008.00350.x

Ho, C.-C., & MacDorman, K. F. (2010). Revisiting the uncanny valley theory: Developing and validating an alternative to the Godspeed indices. *Computers in Human Behavior*, *26*(6), 1508–1518. http://doi.org/10.1016/j.chb.2010.05.015

Hove, M. J., & Risen, J. L. (2009). It's all in the timing: Interpersonal synchrony increases affiliation. *Social Cognition*, *27*(6), 949–960.

Irwin, B. C., Scorniaenchi, J., Kerr, N. L., Eisenmann, J. C., & Feltz, D. L. (2012). Aerobic exercise is promoted when individual performance affects the group: a test of the Köhler motivation gain effect. *Annals of Behavioral Medicine: A Publication of the Society of Behavioral Medicine*, *44*(2), 151–159. http://doi.org/10.1007/s12160-012-9367-4

Kahn, E. B., Ramsey, L. T., Brownson, R. C., Heath, G. W., Howze, E. H., Powell, K. E., Corso, P. (2002). The effectiveness of interventions to increase physical activity. A systematic review. *American Journal of Preventive Medicine*, *22*(4 Suppl), 73–107.

Kaiser Permanente. (2013, October). *EveryBody Walk! Collaborative*. Retrieved from http://www.everybodywalk.org

Karau, S. J., & Williams, K. D. (1993). Social loafing: A meta-analytic review and theoretical integration. *Journal of Personality and Social Psychology*, *65*(4), 681–706. http://doi.org/10.1037/0022-3514.65.4.681

Karau, S. J., & Williams, K. D. (1997). The effects of group cohesiveness on social loafing and social compensation. *Group Dynamics: Theory, Research, and Practice*, *1*(2), 156–168. http://doi.org/10.1037/1089-2699.1.2.156

Kassavou, A., Turner, A., & French, D. P. (2013). Do interventions to promote walking in groups increase physical activity? A meta-analysis. *The International Journal of Behavioral Nutrition and Physical Activity*, *10*,18. http://doi.org/10.1186/1479-5868-10-18

Kendzierski, D., & DeCarlo, K. J. (1991). Physical Activity Enjoyment Scale: Two Validation Studies. *Human Kinetics Journals*, *13*(1), 50–64.

Kerr, N. L., Forlenza, S. T., Irwin, B. C., & Feltz, D. L. (2013). "… been down so long …": Perpetual vs. intermittent inferiority and the Köhler group motivation gain in exercise groups. *Group Dynamics: Theory, Research, and Practice*, *17*(2), 67–80. http://doi.org/10.1037/a0031588

Kerr, N. L., & Hertel, G. (2011). The Köhler Group Motivation Gain: How to Motivate the "Weak Links" in a Group. *Social and Personality Psychology Compass*, *5*(1), 43–55. http://doi.org/10.1111/j.1751-9004.2010.00333.x

Kerr, N. L., Messé, L. A., Seok, D.-H., Sambolec, E. J., Lount, R. B., Jr, & Park, E. S. (2007). Psychological mechanisms underlying the Köhler motivation gain. *Personality & Social Psychology Bulletin*, *33*(6), 828–841. http://doi.org/10.1177/0146167207301020

Kruger, J., Ham, S. A., Berrigan, D., & Ballard-Barbash, R. (2008). Prevalence of transportation and leisure walking among U.S. adults. *Preventive Medicine*, *47*(3), 329–334. http://doi.org/10.1016/j.ypmed.2008.02.018

Lakens, D., & Stel, M. (2011). If they move in sync, they must feel in sync: Movement synchrony leads to attributions of rapport and entitativity. *Social Cognition*, *29*(1), 1–14.

Lakin, J. L., & Chartrand, T. L. (2003). Using nonconscious behavioral mimicry to create affiliation and rapport. *Psychological Science*, *14*(4), 334–339.

Launay, J., Dean, R. T., & Bailes, F. (2013). Synchronization Can Influence Trust Following Virtual Interaction. *Experimental Psychology (formerly Zeitschrift Für Experimentelle Psychologie)*, *60*(1), 53–63. http://doi.org/10.1027/1618-3169/a000173

Launay, J., Dean, R. T., & Bailes, F. (2014). Synchronising movements with the sounds of a virtual partner enhances partner likeability. *Cognitive Processing*, *15*(4), 491–501. http://doi.org/10.1007/s10339-014-0618-0

Lee, I.-M., & Buchner, D. M. (2008). The Importance of Walking to Public Health. *Medicine & Science in Sports & Exercise*, *40*(Supplement), S512–S518. http://doi.org/10.1249/MSS.0b013e31817c65d0

Lind, E., Joens-Matre, R. R., & Ekkekakis, P. (2005). What intensity of physical activity do previously sedentary middle-aged women select? Evidence of a coherent pattern from physiological, perceptual, and affective markers. *Preventive Medicine*, *40*(4), 407–419. http://doi.org/10.1016/j.ypmed.2004.07.006

Max, EJ, Samendinger, S, Spencer, B, Winn, B, Kozma, G, Jeffery, W, Kerr, NL, Pfeiffer, KA, Forlenza, ST, & Feltz, DL; Examining the Koehler Motivation Effect with Software-Generated Partners in Repeated Sessions of Aerobic Exercise. Unpublished paper, East Lansing, MI 2015

Murtagh, E. M., Boreham, C. A. G., & Murphy, M. H. (2002). Speed and Exercise Intensity of Recreational Walkers. *Preventive Medicine*, *35*(4), 397–400. http://doi.org/10.1006/pmed.2002.1090

Nass, C., Fogg, B. J., & Moon, Y. (1996). Can computers be teammates? *International Journal of Human-Computer Studies*, *45*(6), 669–678. http://doi.org/10.1006/ijhc.1996.0073

Nielsen (2014). *Hacking health: How consumers use smartphones and wearable tech to track their health*. Retrieved from: http://www.nielsen.com/us/en/insights/news/2014/hacking-health-how-consumers-use-smartphones-and-wearable-tech-to-track-their-health.html

Parise, S., Kiesler, S., Sproull, L., & Waters, K. (1999). Cooperating with life-like interface agents. *Computers in Human Behavior*, *15*(2), 123–142.

Peterson, M. D., Al Snih, S., Stoddard, J., Mcclain, J., & Lee, I.-M. (2014). Adiposity and Insufficient MVPA Predict Cardiometabolic Abnormalities in Adults: *Medicine & Science in Sports & Exercise*, *46*(6), 1133–1139. http://doi.org/10.1249/MSS.0000000000000212

Pew Internet (2014). *Smartphone ownership 2013*. Retrieved from: http://www.pewinternet.org/fact-sheets/mobile-technology-fact-sheet/

Raedeke, T. D. (2007). The Relationship Between Enjoyment and Affective Responses to Exercise. *Journal of Applied Sport Psychology*, *19*(1), 105–115. http://doi.org/10.1080/10413200601113638

Rafferty, A. P., Reeves, M. J., McGee, H. B., & Pivarnik, J. M. (2002). Physical activity patterns among walkers and compliance with public health recommendations. *Medicine and Science in Sports and Exercise*, *34*(8), 1255–1261.

Reeves, B., & Nass, C. (1996). *The media equation: how people treat computers, television, and new media like real people and places*. New York, NY, USA: Cambridge University Press.

Samendinger, S., Beckles, J., Forlenza, S. T., Pfeiffer, K. A., & Feltz, D. L. (2015). Partner Weight as a Moderator of Exercise Motivation in an Obese Sample. *Medical Research Archives*, (3). http://doi.org/10.18103/mra.v0i3.277

Samendinger, S, Max, EJ, Winn, B, Kozma, G, Jeffery, W, Kerr, NL, Forlenza, ST, & Feltz, DL. Interactive Dialogue is Important in Software-Generated Workout Partners. Unpublished paper, East Lansing, MI 2015

Services, H. (2008). *Two Thousand Eight Physical Activity Guidelines for Americans: Be Active, Healthy, and Happy*. Government Printing Office. Retrieved from http://www.health.gov/paguidelines/guidelines/default.aspx

Shephard, R. J. (1988). PAR-Q, Canadian Home Fitness Test and exercise screening alternatives. *Sports Medicine (Auckland, N.Z.)*, *5*(3), 185–195.

Smith, A. (2013). *Smartphone Ownership 2013*. Retrieved from http://www.pewinternet.org/2013/06/05/smartphone-ownership-2013/

Stephens, J., & Allen, J. (2013). Mobile phone interventions to increase physical activity and reduce weight: a systematic review. *The Journal of Cardiovascular Nursing*, *28*(4), 320–329. http://doi.org/10.1097/JCN.0b013e318250a3e7

Treasure, D. C., Lox, C. L., & Lawton, B. R. (1998). Determinants of physical activity in a sedentary, obese female population. *Journal of Sport & Exercise Psychology*, *20*(2), 218.

Tucker, J. M., Welk, G. J., & Beyler, N. K. (2011). Physical Activity in U.S. Adults: Compliance with the Physical Activity Guidelines for Americans. *American Journal of Preventive Medicine*, *40*(4), 454–461. http://doi.org/10.1016/j.amepre.2010.12.016

US Burden of Disease Collaborators. (2013). The state of US health, 1990-2010: burden of diseases, injuries, and risk factors. *JAMA: The Journal of the American Medical Association*, *310*(6), 591–608. http://doi.org/10.1001/jama.2013.13805

CHAPTER 5

GENERAL DISCUSSION

The Three Experiments

The three manuscripts presented in this dissertation expanded previous Köhler motivation gain research with exergames by examining potential moderators of a dyadic conjunctive paradigm to boost motivational effort. The Köhler effect is a conjunctive task paradigm in which the team outcome is dependent upon the least capable member's performance and performance gains are thought to be the result of increased levels of motivation that stem from being indispensable to the group and making an upward comparison to one's moderately higher-ability partner (Köhler, 1926; Kerr & Hertel, 2011). This motivation gain effect is unique in that it is derived from a group task structure that restricts potential group motivation losses, such as social loafing (Latane, Williams, Harkins, 1979), free-riding (Kerr & Bruun, 1983), and the sucker effect (Kerr, 1983). A host of moderators for this motivation paradigm were outlined previously and help to describe the theoretical boundaries for the continued success of this effect. The group dynamics approach was chosen because of evidence that exercise companions increase time engaged in regular physical activity (Gellert, Ziegelmann, Warner, & Schwarzer, 2011; Kahn et al., 2002; Kassavou, Turner, & French, 2013). With evidence that exercising in groups may be popular and also capable of maintaining one's exercise effort, one valid strategy is to move forward exploring group dynamics and by further defining the boundaries of their influence on motivation.

In Experiment 1, the human partner's weight (same or lighter) was examined as a potential moderator of the Köhler effect with adult obese participants. Weight of one's exercise partner may distort social comparisons of partner ability, deterring the other partner from competing or accepting an upward goal worth achieving. Participants completed two blocks of abdominal planks, one alone and one with the partner's simultaneous (and manipulated) performance presented over a video connection during a single lab session. Results indicated that the Köhler motivation effect increased persistence with abdominal isometric exercises in obese adults but this effect was not moderated by the relative weight of one's partner.

Although these results provide proof of concept for the flexibility in partner characteristics to enhance motivational effort for a set of abdominal exercises, the one-session test does not address the issue of whether the Köhler motivation effect can be used to increase the physical activity levels over time for this population to have a public health impact. Additionally, even though the use of a virtually-presented partner had the practical advantages for this population of overcoming the challenges of finding an ideally-matched exercise partner who could be available at any given time and location, the use of a real person as partner involves providing false feedback and, thus, may be impractical or unethical in exercise settings or games (Feltz, Forlenza, Winn, & Kerr, 2014). Experiment 2 used software-generated partners whose appearances, movements, and ability discrepancies could be manipulated to solve this problem but still used a single-session paradigm to provide proof of concept for software-generated partners.

Experiment 2 sought to develop the Köhler paradigm further by introducing software-generated partners (SGPs). Success adapting the motivation gain effect to a design substituting SGPs would permit a practical utilization (e.g., portable technologies, game consoles), reduce limitations posed by using human partners, and extend the reach of this positive group dynamic effect. In this experiment, participants were exclusively partnered with a same-sex SGP, in a similar one-session lab design. A primary purpose of Experiment 2 was to explore whether exercise participants would willingly team up with an SGP, or view the SGP as an incomparable *other* with the effect of weakening the Köhler motivation gain. With some evidence that the Köhler effect may diminish with the use of an SGP, partner introductory conditions were compared as a possible method of enhancing perceptions of the SGP-human social relationship. Enhancing the relationship may offset any motivation losses in the Köhler effect paradigm when no longer using human partners.

Results showed that participants partnered with an SGP persisted with plank exercises longer than non-partnered controls but the difference was not significant. Differences between introductory dialogue methods were also not significant but tended to favor the dialogue tree technique. However, when the data were combined with data from Feltz et al. (2014), the result produced a significant overall difference between individual controls and SGP conditions, suggesting that Study 2 was under-powered. Thus, the motivation gain achieved so far with SGPs seems to be real, comparable for younger and older people, but smaller in magnitude than has been observed with a human partner. Thus, there seemed to be enough evidence for the Köhler motivation effect to pursue the issue of whether it could be effectively used to increase the physical activity levels of adults over time.

Experiment 3, therefore, extended prior Köhler motivation gain research to a field study, for the first time, using a mobile phone application and tested the use of SGPs on a physical exertion task (walking) in free-living conditions over 3 weeks. Again, to counter potential reductions in the Köhler effect when moving away from using human partners, an experimental manipulation was introduced with one of the conditions to examine the effect on the participants' perceptions of the SGP (interpersonal synchronization SGP footstep cues). Experiment 3 successfully implemented a free-living mobile application of an SGP-based Köhler effect exercise paradigm. There was non-significant difference in mean minutes of walking per week, taken across all 3 weeks, favoring the *synchronized* conjunctive condition.

Results from each of the three experiments support the Köhler effect on the motivation to persist with exercise in community adults. However, if the effect is responsible for the persistence gains, it weakened as the study design shifted to SGPs and moved outside the lab. In the discussion that follows, there are multiple considerations that may explain why this pattern may have occurred that have to do with the SGP-participant relationship, paradigm manipulations, the effects of long-term inferiority on motivation, and the uncontrolled factors that come with field studies.

Media Equation and the Partner Relationship

Of primary importance to the success of the Köhler motivation effect within exergames is the SGP-participant relationship. Although it may be possible to work or exercise together as a team at a low-social relationship level, there is compelling evidence that social aspects of the team can affect productivity. Commitment, cooperation, and task monitoring have been identified as mediators between group relationship level and performance (cognitive or motor) of the group (Jehn & Shah, 1996). At the crux of efforts to pair humans and SGPs is the assumption that a relationship can occur and function as it would between humans and other humans. Media Equation predicts that humans will interact naturally and unconsciously with media, as if the content represented reality and that the social dynamics of human interaction with computers can be similar to human interactions (Reeves & Nass, 1996). Similar to Feltz et al. (2014), Study 2 and 3 utilized SGPs, bringing the participant and SGP together for an introduction and, then pairing them together as an exercise team. Across these studies, there was no indication that the participants were unwilling to interact or accept a software-generated partner. While there may be some demand or observer effect (expectations of a researcher nearby) preventing participants from overtly objecting to interacting with an SGP, qualitative data in this study support the willingness of people to enter into a human-SGP relationship. For example, Study 3 collected SGP greetings entered into the app by participants that very few skipped, even when the instruction was such that they could have entered nothing or rather meaningless phrases ("*choose to enter a greeting; whatever you wish to say*"). In terms of partner ratings, measures of likeability and rapport were neutral in Study 2, but Study 3 participants rated their attitude toward the partner higher than the scale mid-point. When collecting participants' perceptions of the SGP humanness, attractiveness, and eeriness (Alternative Godspeed Indices), results from both studies showed that participants perceived the partner to be not exactly like a human but also not eerie. The index for attractiveness in both studies suggested the participants found the partners to be more attractive than not. None of these measures seem to indicate that participants were adverse to the SGP, even though the SGP out-performed the participant prior to when the ratings were collected.

Perceptions of being in a group, team, and social unit (entativity) were also neutral for both Study 2 and 3. However, males in Study 2 rated perceptions of being a group negatively, lower than the scale mid-point. Overall, combining genders, ratings were neutral after a single session in Study 2, as well as when walking with the SGP after 3 weeks in Study 3. When condition manipulations (interactive dialogue and interpersonal synchronization) were introduced in an attempt to enhance the participant-SGP relationship, no differences in partner ratings appeared across all 'relationship' variables. Non-significant performance differences favored the conditions in which these relationship-enhancing manipulations were applied in both studies.

It is possible that an indifferent level of personal feelings for one's partner is all that is required to perform in a team setting. However, findings from many different disciplines point to the importance of the social relationship in team performance, including those from Köhler effect studies (Kerr & Seok, 2010; Kerr, Seok, Poulsen, Harris, & Messé, 2008). How much one likes and values one's partner will, in part, determine feelings of obligation to the team outcome. Further, increasing the participant's perception of the value of the partner, the team, and the outcome should increase motivation (Karau & Williams, 1993; Vroom, 1964). Lessons learned from use of relational agents may also be examined in future Köhler research to potentially enhance the human-SGP relationship in exercise groups. Relational agents are designed to provide long-term, social-emotional engagement between the computer agent and the user by exhibiting such relational behaviors as: social dialog, empathy, and nonverbal liking behavior (Bickmore, Schulman, & Yin, 2010). In work testing the benefit of relational agents, Bickmore and colleagues define engagement as the degree of involvement between user and agent (or, system). Directly relevant to exergame research, there is evidence that relational agents (in the role of advisor or coach) may increase walking in older adults (Bickmore, Caruso, Clough-Gorr, & Heeren, 2005; Ellis et al., 2013). Previously studied potential characteristics embodied in relational agents that might be incorporated into the user-SGP exercise relationship include: flattery, humor, social deixis (ratify and check-in on the status of the relationship); continuity behaviors (greetings and farewells and talk about the time spent apart); and, personality matching behaviors (Bickmore & Picard, 2005). Without continuous interactive elements in the human-SGP relationship, many expectations of a typical relationship are missing. For example, participants may feel as though the SGP is not engaged or interested in the relationship or that the superior SGP has given up on them as a weaker partner. Verbal and non-verbal interaction may be necessary to maintain the illusion of the relationship. Experience with relational agents may help identify which communication or interaction features to explore when working to improve the exercise social relationship and task outcome.

Increasing user responses to the SGP, and to being a member of a human-SGP team, may come about as a result of augmenting the participant's identity in the virtual relationship. Using an avatar to represent the participant, either through projection (at home or in the lab) or on-screen (mobile devices) from a 3rd-person perspective (as was used to a minor degree in Study 3) could serve to reinforce virtual group identity (Yee, Bailenson, & Ducheneaut, 2009; Van Der Heide, Schumaker, Peterson, & Jones, 2013). In this way, the relationship is shared in the virtual world, as much as it is in the real world. Asking participants to identify as a team or group by posting their SGP team membership may also enhance their perceptions of being in the group (Van Der Heide et al., 2013). It is also possible that allowing the participant to share in the creation of their SGP and team characteristics (team name, identifying features) may also enhance the relationship.

A complex relationship, closer to those with other humans, may also improve SGP likeability and perceptions of group and team. Simple task-based exercise with a non-human may not be enough to engage the user and promote upward social comparison and team indispensability. The relationship and shared task may benefit from being enriched in detail, by enveloping the task in a story (similar to video games), leading the partners through an evolving narrative, or infusing a small degree of unpredictability or instability between the partners. A stagnant or low-interaction relationship may be perceived as boring, causing the user to never truly engage or lose interest, regardless of partner likeability. Immersive, story-like video games are popular and may also set expectations for the user of what is typical in virtual relationships.

These game-like features may help reduce the long-term perception that the exercise task and goal are boring or prescriptive. Serious, manipulative, or prescribed content, that dictates what one must do or is perceived as an attempt to control behavior, may distract from attractive features of a game (Buday, 2014).

Enriching the relationship may also invoke some of the benefits of social support and group cohesion. Social support processes may include the use of emotional, informational, or instrumental resources or those supportive processes that generally come about as a result of social participation in groups (Cohen et al., 2000). Usual social support factors (e.g., intimacy, nurturing, advice, tangible resources), responsible for influencing behavior, may not be as easy to convey through a virtual relationship than a human relationship but an enriched SGP relationship may engender perceptions of support in other ways. It is plausible that increasing the complexity of the relationship may increase the perception of social support through feelings of attachment, esteem support, reciprocity, offering of group norms, or satisfying a need to belong (Baumeister & Leary, 1985).

Interpersonal synchronization (IPS) was theorized as a potential mechanism by which the participant's unconscious feelings for the SGP might be enhanced, thereby increasing the participant's willingness to cooperate and work toward a team goal. This manipulation was applied to one condition in Experiment 3 based on evidence that external synchronization cues, such as rhythmic sounds generated from another person, may improve ratings of likeability and trust (Launay, Dean, & Bailes, 2014; Launay, Dean, & Bailes, 2013). Synchrony and rhythmic movement is more likely to occur with audible tones versus visual cues (Repp & Penel, 2004). Automatic synchrony to audible pacing has been widely used in rehabilitation and recognized to occur in walkers (Repp & Su, 2013). Likeability ratings of one's partner have improved after synchrony to sound, including when a computer generated the tone and participants were told the sounds were actually made by another human (Launay et al., 2014). Launay et al. also showed, in the same experiment, that likeability did not increase when participants were shown a picture of a computer as the source of the tone. However, there were no attempts at anthropomorphizing the computer, no other means of relationship building were included, and the human-computer interaction did not involve a team task. These natural adaptive synchronous processes have been found to boost liking and cohesion in groups, collaboration, and rapport (Chartrand & Bargh, 1999; Lakens & Stel, 2011; Lakin & Chartrand, 2003; Delaherche et al., 2012; Hove & Risen, 2009).

In Experiment 3, a rhythmic footstep tone, set at a moderate pace, was audible to all participants in this condition during each 3-minute pre-walk warm-up period. The idea was that if IPS is indeed a fundamental behavioral and physiological mechanism (Delaherche et al., 2012), then this novel adaptation might invoke a similar response from non-human counterparts as well. The brief, 3-minute period of synchrony was chosen to prevent any interference with the illusion of performance discrepancy or SGP realism. Offering a consistent rhythmic sound any longer than the 3-minute warm-up may have acted as a pacer tone for the entire walk and dissociated the SGP's variable pace (observed on the app screen) from the pace of an extended and consistent tone. Yet, the audible tone period may have been too brief to encourage the participant to synchronize with the SGP (if the tone elicits this desire at all). It may be worthwhile to pursue testing of an extended duration SGP footstep tone into or throughout the actual walk period. If the tone can be simulated to match the SGP's variability and does not cause participants to simply align their performance to the tone, asynchronous rhythms may also be of benefit. That is, if the participant does synchronize with the footsteps in the initial consistent period, deviations between SGP rhythm later in the walk may cause the human partner to automatically strive to re-synchronize his/her motor responses. Perhaps adding a separate, initial baseline walk with the syncSGP (without differences in pace or distance), during which the footstep tone is audible throughout the entire walk, may allow for a longer period of potential synchrony and positively effect future discrepant Köhler paradigm walks. The result of synchrony may be increased affective responses to the SGP and, potentially, improved performance. Testing this potential synchronization manipulation in the lab will help determine feasibility of this mechanism with future iterations. In hindsight, deploying this synchrony feature in Study 3 may have been premature. Care will need to be taken to ensure the SGP footsteps match the graphic and data display so believability does not suffer.

Finally, the measures by which the participants' perceptions of the relationships are gathered require attention. Research testing SGPs in a team exercise task structure is relatively uncommon and often relies on newly created scales or those adapted from human behavioral, game design, or computer research. Consideration must also be taken when using portable devices, free-living environments, or temporal differences in the experimental design. Context, timing of the question to the activity, and the orientation of scale questions could significantly alter responses. Lack of experimenter control and the unwillingness of participants to repeat instructions or problem solve may decrease reliability. In addition, constructs, such as social comparison and interpersonal synchrony, are inherently difficult to measure without introducing bias or a priming effect. Asking individuals if they compared themselves to another may elicit an unreliable response because social comparison is not always an obvious process or one of which most people are fully aware. It is also possible that alternative measures need to be developed that better capture moderators of the SGP-participant relationship. It may be that items related to trust, partner similarity, virtual identity, or character attraction (interest) better capture potential relationship moderators in group performance with an SGP.

As discussed, the participant-SGP relationship is ripe for continued testing and refinement. The limitations of the participant-SGP relationship in the current studies were reviewed, as well as suggestions for future iterations. Results from Study 2 and 3 support predictions from the Media Equation but much needs to be tested if motivation gains are to be realized when using SGPs in Köhler effect paradigms.

Prior Köhler effect experiments (Feltz et al., 2014; Moss, 2015), that have used SGPs, have demonstrated significant differences in persistence, versus control. However, those studies examined the Köhler effect in college-aged samples. Feltz et al. (2014) enrolled 120 students with a mean age of 19.4 years, while Moss (2015) also utilized a college-aged sample of 90 students. Experiment 2 and 3 in this dissertation examined the Köhler effect and SGPs with community adults (M_{age} = 38.8 and 37.9) and this difference in age may signal another boundary of using SGPs in this paradigm. It may be that younger people are more likely to accept the SGP and engage more in virtual relationships than those in middle age. Although reasons for this may include higher levels of comfort with technology or virtual environments in people of younger ages, games and computer applications are widely used by middle-aged people as well. However, the means in Experiments 2 and 3 were in the same direction as Feltz et al. and Moss, but their sample sizes were somewhat higher. Thus, rather than a boundary issue, the effect for middle-aged people may just be more subtle and require a larger sample size to detect the effect.

One feature unique to the Moss (2015) study and not used in Feltz et al. (2014) or the studies in this dissertation was the manipulations of team identity. In Moss' experiment, both partnered groups were told to wear same-colored t-shirts and were assigned team names.

Although persistence difference did not exist between the experimental-partnered conditions, both groups outperformed the control group. Perhaps motivation gains using SGPs in the Moss study may be partially explained by this simple but powerful manipulation. Otherwise, differences in the subjective data collected across these similar studies make any other speculation difficult and further research is required to explore age differences when using SGPs.

Paradigm Manipulation Limitations

The experimental paradigm used to test the Köhler effect has proven very successful for eliciting motivation gains in lab settings. For the Köhler motivation gain to occur, the conjunctive task design must be such that the participant readily understands the team structure, interdependence, and function. Factors critical to successful implementation include those that the participant must be made to believe: they and the partner are exercising as a team; the result of team performance is based on the weaker member (the term 'weaker' defined by the task); the partner is moderately superior in a manner relevant to the task; and, that the ability discrepancy is moderate (not equal or too much stronger; attainable). In order to achieve an adequate level of understanding, the design includes reinforced instruction related to the teammates being 'yoked', so that when one can no longer continue, the other partner must also stop (contingent, of course, on the partner wanting to continue). Feedback regarding the performance discrepancy and interdependence is provided, either as performance data and/or through inferences the participant can make when exercising in the presence of the superior partner. Although continuous feedback about the participant's relative performance is not essential (Kerr, Messe, Park, & Sambolec, 2005), there is a positive relationship between partner-related information availability and higher effort by the participant (Weber & Hertel, 2007). Of course, this group-structure design and feedback must be easily interpreted to be effective. The conjunctive structure is rather unique in an exercise setting and may be difficult to distinguish between intragroup competition, something that may be more familiar to people. Although competition with the partner may be a common and useful response to the task structure (and a result of upward social comparison), its predominance may mitigate team interdependence and perceived indispensability, unless there is some common external reward or outside group competition. It makes sense that these design features must be conveyed appropriately and reinforced when the experiment continues over time.

Manipulation checks after Experiment 3 may suggest that the participants may not have understood the structure after 3 weeks or simply did not understand the question related to the team's structure. Participants are particularly at risk for this complication when the research is carried out in free-living settings, where less experimenter control is possible. Anticipating this issue, the BOOST app was programmed with a 'reminders' screen, on which key points about the team task structure were available for review before each walk. The 'Next' tab was not active for several seconds to encourage review of this screen. Participants were also informed that there may or may not be new information on the screen over the 3 weeks to discourage dismissal of the reminders before reviewing them. During the initial orientation session, information about the team structure and partner ability was provided in a narrated video (to ensure consistency across all participants) that also included key points written out for the viewer while the narrator spoke. All instructions (with conjunctive task information) were also sent home in a packet of information after the forms were reviewed with the participant. However, none of the participants chose the incorrect response indicating the believed the score was based on the last team member to quit walking. Therefore, it may be that the participants misinterpreted the question after the 3-week study period (always being the inferior partner) and answered in a way that reflected the score would always be based upon *their* time walked. As there was a choice to select an answer that most accurately represents the intended manipulation, it is not clear if consistently being the inferior team member would be enough to cause them to respond that the result was based on the time *they* walked. Comparing these responses to a question related to how they perceived their own importance to the team score seemed to indicate confusion with the team structure or survey questions, or both. In light of precautions meant to avoid this problem, further conjunctive paradigm research will be tasked with finding alternative reinforcement and measurement techniques.

In contrast to those who are spurred to compete with the exercise partner, some may perceive the partnership as primarily social in nature. This may occur when partnered over longer periods of time. For example, many people walk or perform other physical activities with friends and do so for the social benefits of this companionship. In fact, this attraction to and support from others is fundamental to the argument that groups may enhance motivation to initiate and maintain physical activity. However, to increase intensity and persistence with exercise, it may be necessary to emphasize the performance aspect of the group, ideally without disrupting the social relationship. The Köhler effect paradigm places such performance demands on the weaker member, capitalizing on a feeling of obligation to the partner and the interdependent team outcome. During Experiment 3 debriefings, several participants remarked on how the partner always walked ahead, making them feel as if they were not partners, expressing the idea that they thought the walks would be with a friendly companion. This idea or expectation of 'social partners' versus 'exercise task partners' may arise from the fact that the team is meant to function as both a social unit, as well as a performance (or, task-based) unit. This group role and goal confusion may be a barrier to successful implementation of the conjunctive task structure manipulations. To remedy this issue, the gamification (game-like) features and partner interaction mentioned previously, that are meant to enhance the social and affective nature of the group exercise, may also be used to emphasize the shared task goals. Along with developing an acceptable SGP relationship, the performance-based outcome must be valued and the participant must feel as if his/her contributions to that outcome are instrumental. Among other techniques of increasing the value perception of the team outcome, one interesting method of doing so might be to tie the SGP future to the team result. For example, the SGP informs the participant that, if the team does not perform well, they may be dropped from the team and replaced with a different software-generated partner.

One potential method of increasing the participant's performance salience, while boosting the desire to cooperate with the partner, is to frame the exercise task as a competition against another team. In an exercise setting, the desire to 'win' an outgroup competition represents a more tangible outcome than the simple result of the team activity between partners. Comparing one's team performance to that of another team is thought to be a natural consequence of identifying with one's group and perceiving those not within the group as an 'out-group' (Tajfel, 1982; Tajfel & Turner, 1979). Tajfel and Turner suggested that simply recognizing and valuing membership in a group establishes a social identity and the instinctive need to maintain a positive sense of self is also reflected in the need to view the group in which they belong as positive. A natural comparison and desire for differentiation occurs between the group one identifies with and other groups. Motivation gains have been demonstrated in inferior members of non-exercise groups when given the opportunity to compare to a superior outgroup (Lount & Phillips, 2007). Also, utilizing a previous Köhler paradigm (holding a weight above a trip-wire) with the addition of intergroup competition, Kerr and Seok (2008) demonstrated a motivation gain in weaker group members when the outgroup was known to be moderately more capable at the competitive task. No motivation gain was demonstrated when the outgroup was of lower or equal ability.

In contrast, a Köhler paradigm exergame experiment compared abdominal plank persistence differences (between Block 1 and Block 2 times) for a no-partner control to a conjunctive condition with no competition and a conjunctive condition with outgroup competition (Moss, 2015). Although both Köhler conditions performed significantly better than control overall, the outgroup competition group did not differ in performance from the standard conjunctive task group. The results may reflect the complexity of participant feedback required to establish intragroup and intergroup comparisons during the plank exercises. In this experiment, no Block 1 performance information (baseline) for the outgroup was provided to the participant, nor was there immediate outgroup performance feedback provided during the completion of Block 2. So, participants were simply aware that there was a moderately superior outgroup performing the exercises simultaneously but unaware of the status or level of that performance. As noted, eliminating feedback regarding partner performance resulted in a mitigation of the Köhler effect in a previous study (Kerr et al., 2005). Although researchers concluded that continuous feedback of both members' performance was not necessary, considering the complexity of potential comparison processes when adding an outgroup, it may be that continuous feedback is most helpful. The researchers noted that, if knowledge of the superior outgroup had a motivating effect at all, it might have been manifest in the participants' persistence during Block 1 of the exercises. In other words, the outgroup competition condition participants held the planks longer during the first block than the other groups (after being told there was an outgroup), potentially approaching a ceiling for persistence prior to any partnered exercise. This may have been an issue but the competition condition did go on to demonstrate persistence gains longer than the other groups so it may be more likely that Block 1 differences reflect fitness differences between the groups (despite randomization). The competitive condition participants in Moss' study also rated perceptions of team higher than the other conditions. This finding may provide further support for future outgroup research with conjunctive task groups.

In summary, there is a compelling body of work on social identity and motivation gains in the presence of an outgroup. Despite mixed findings when applied to an exercise setting, the addition of an outgroup to the Köhler paradigm holds some promise in strengthening intragroup cooperation and value of the team goal.

One other point of discussion related to limitations of the Köhler paradigm involves the participant's perception of the discrepancy in the partner's relative ability. There is evidence that a moderate relative discrepancy is optimal for a motivation gain to occur within the Köhler paradigm. In Experiments 1, 2, and 3, participants were informed of the partner superiority but were also provided information that implied the discrepancy may be overcome (affording an opportunity to match or surpass the partner). During Experiment 2, participants were told that the SGP was unable to hold the exercises forever and would tire, just like a real person. In Experiment 3, participants were informed: "*The researchers have programmed your partner to be designed as slightly more fit but, you should know that your partner also will respond to exercise like anyone and can fatigue.*" Additionally, in Experiment 3, the distance graphic displayed on the app screen between the SGP and the participant varied to provide the illusion of reality but also to indicate that the SGP was not always so far ahead that their performance could not be matched. Concerns about the effect of consistent failure to match or beat the superior partner led Lount and colleagues (2008) to examine if working with multiple different superior partners would help maintain the hope of one's increased efforts finally meeting that of their partner. In fact, the researchers demonstrated that a series of new partners (all superior) was more motivating than performing as the weaker member in a stable partner group. A second Köhler study did not find that varying superiority of performance (but using the same partner) in an exercise setting moderated the motivation gain effect (Kerr, Forlenza, Irwin, & Feltz, 2013). However, in a virtual relationship, even with acceptance of a software-generated character as a legitimate exercise partner, the participant may consider the non-human nature of the SGP to be indefatigable. It is plausible that after performing as the weaker partner on one or two abdominal planks, that the participant loses confidence in the ability to match the performance on the final three or four planks. During a multiple session exercise partnership, Experiment 3 was designed so that the participant never matched or surpassed the SGP's performance over 3 weeks. It is even more plausible that "losing" to a moderately superior SGP over several sessions confirms any suspicion the participant may have that it is not possible to match the performance. While it may not be necessary to meet the performance level of the superior partner on every challenge, motivation to compare and increase one's effort may be optimal if the participant's effort is rewarded with tangible comparison-based results. Matching or surpassing the SGP's performance may also serve to maintain the illusion that the discrepancy is indeed moderate, and not too great to overcome. The technology exists to incorporate outgroup comparisons on a console or mobile device link, within a game setting, or through social media (FaceBook or online group postings). As motivation gains have been less robust as this line of research has moved away from human partners, it may be worth revisiting the reliability of the SGP ability discrepancy manipulation, especially over multiple trials or exercise sessions.

Field Studies

It is vital to maintain the core Köhler manipulations through feedback of performance for both partners, as well as maintain the perception of the moderate ability discrepancy. Experiment 3 results are naturally limited by the fact that the Köhler paradigm was implemented in a low-control, community field study. The BOOST app functioned appropriately, during walks and in gathering data, but experimental conditions were difficult to assure outside of the lab. Any participant deviance from the intended function of the app and data collection were difficult to monitor. Obviously, protocol compliance issues will always exist without methods of direct observation or enforcement. However, electronic device technology continues to advance so that there may be ways by which the application can sense and correct errors in data collection (both objective performance data or subjective responses entered into the app). Currently, there are ancillary devices embedded in shoes and clothing that communicate with mobile devices to improve the accuracy and amount of available data. Console game units already have the ability to sense, simulate, and respond to actual movement. These technologies may enhance execution of protocols, game function, the amount of data available to the researcher, and the fidelity of the data.

In terms of achieving all aspects of the study design in free-living environments, it also may be that, as the paradigm evolves, researchers find some of the boundaries can be relaxed. With further testing of the Köhler effect paradigm parameters, findings may indicate that listening to music or gamification do not interfere with the motivation mechanisms and can be incorporated into the design. It may be possible to include music preferred by the participant that does not distract from interpretation of partner or participant performance feedback. Music tempo or selection may be restricted to conform to parameters that are an acceptable compromise to Köhler effect dynamics. Likewise, walking with a friend and a superior SGP, in a 3-member Köhler task structure, has also not been tested. Exercising with this structure may improve compliance to the protocol, provide social support, and elicit group dynamic motivation processes. Depending on the comparable abilities and relationship status of the friends, the conjunctive structure may fluctuate over multiple sessions and be motivating for one friend while other processes motivate the other (e.g., social facilitation). Managing the challenges of implementing Köhler research, and ultimately a Köhler-based product, in free-living conditions will necessitate further examination of this proven paradigm, adapting it to technology and stretching the boundaries of its effectiveness. With a pragmatic perspective, Köhler application versions may eventually be able to benefit from multiple motivational elements. It does not appear as if the application will need to be all or nothing.

Individual Differences

Just as the Köhler paradigm is not the solution to all inadequacies in physical activity, not all individuals are well suited for the motivation mechanisms or will readily respond to the specific conjunctive task structure. There may be personality differences that influence whether or not upward social comparison or group indispensability are likely to be motivating. Kerr and Hertel (2011) suggest that characteristics such as loyalty beliefs, agreeableness, and social value orientations may alter responses to the Köhler effect. Likewise, one can see how competitiveness, achievement goals, need to belong, and exercise setting preferences (group versus individual) may color how one responds to Köhler mechanisms (Baumeister & Leary, 1995; Gill & Deeter, 1988; Karau & Elsaid, 2009). For example, in a Köhler abdominal plank paradigm, using college students, Moss (2015) noted that students with competitive orientations persisted with exercise longer than other conditions when subjected to an outgroup competition manipulation. In contrast, those with high competitive orientations decreased persistence times when in an individual control condition, with no such competition available. It is also reasonable to believe that some people may not verbally acknowledge specific traits or goals, or simply not overtly recognize personal characteristics, such as the dislike for exercising with a partner or just how competitive they really are. Identifying these characteristics may help in the analysis of variance in study variables and guide further changes in study design. The flexibility of software applications also make it possible that individual characteristics may help create adaptable elements of the app or game so that some components are personalized for the user.

Conclusions

This dissertation provides further understanding of group dynamics in conjunctive exercise task settings. By examining the utilization of software-generated exercise partners and adapting the conjunctive task paradigm to free-living conditions, Experiments 2 and 3 moved this line of research closer to practical interventions aimed at increasing levels of physical activity. Persistence differences between partnered groups and control resulted in moderate effect sizes, suggesting there is some evidence for Köhler motivation gains with SGPs and in free-living settings. The studies concurrently explored moderators of the Köhler effect: weight, introductory dialogue, and interpersonal synchronization. Partner weight in Experiment 1 did not moderate the effect in an obese sample and non-significant but positive differences point to the potential for further research on introductory dialogue and interpersonal synchronization as methods to enhance team social and task outcomes. This series of studies added to the knowledge on the Köhler effect, as one of a few motivation gain dynamics available in a group setting.

APPENDIX

Appendix- IRB Approval Letters

MICHIGAN STATE
UNIVERSITY

Initial IRB Application Approval

March 20, 2013

To: Deborah L. Feltz
130 IM Sports Circle
Dept. of Kinesiology
MSU

Re: **IRB#** 13-213 Category: EXPEDITED 4, 7
Approval Date: March 20, 2013
Expiration Date: March 19, 2014

Title: Exergames, Kohler Effect, and Obesity

The Institutional Review Board has completed their review of your project. I am pleased to advise you that **your project has been approved**.

The committee has found that your research project is appropriate in design, protects the rights and welfare of human subjects, and meets the requirements of MSU's Federal Wide Assurance and the Federal Guidelines (45 CFR 46 and 21 CFR Part 50). The protection of human subjects in research is a partnership between the IRB and the investigators. We look forward to working with you as we both fulfill our responsibilities.

Renewals: IRB approval is valid until the expiration date listed above. If you are continuing your project, you must submit an ***Application for Renewal*** application at least one month before expiration. If the project is completed, please submit an ***Application for Permanent Closure***.

Revisions: The IRB must review any changes in the project, prior to initiation of the change. Please submit an ***Application for Revision*** to have your changes reviewed. If changes are made at the time of renewal, please include an ***Application for Revision*** with the renewal application.

Problems: If issues should arise during the conduct of the research, such as unanticipated problems, adverse events, or any problem that may increase the risk to the human subjects, notify the IRB office promptly. Forms are available to report these issues.

Please use the IRB number listed above on any forms submitted which relate to this project, or on any correspondence with the IRB office.

Good luck in your research. If we can be of further assistance, please contact us at 517-355-2180 or via email at IRB@msu.edu. Thank you for your cooperation.

Sincerely,

H. McGee

Harry McGee, MPH
Vice Chair, Biomedical and Health Institution Review Board (BIRB)
Human Research Protection Program

c: Joelle Beckles, Samuel Forlenza

Office of Regulatory Affairs
Human Research Protection Programs

Biomedical & Health Institutional Review Board (BIRB)

Community Research Institutional Review Board (CRIRB)

Social Science Behavioral/Education Institutional Review Board (SIRB)

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MICHIGAN STATE
UNIVERSITY

Initial IRB Application Approval

March 1, 2012

To: Deborah L. Feltz
130 IM Sports Circle
Dept. of Kinesiology
MSU

Re: **IRB#** 11-849 Category: EXPEDITED 2-7
Approval Date: February 29, 2012
Expiration Date: February 28, 2013

Title: Cyber Partners: Harnessing Group Dynamics to Boost Motivation to Exercise

The Institutional Review Board has completed their review of your project. I am pleased to advise you that **your project has been approved**.

The committee has found that your research project is appropriate in design, protects the rights and welfare of human subjects, and meets the requirements of MSU's Federal Wide Assurance and the Federal Guidelines (45 CFR 46 and 21 CFR Part 50). The protection of human subjects in research is a partnership between the IRB and the investigators. We look forward to working with you as we both fulfill our responsibilities.

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Please use the IRB number listed above on any forms submitted which relate to this project, or on any correspondence with the IRB office.

Good luck in your research. If we can be of further assistance, please contact us at 517-355-2180 or via email at IRB@msu.edu. Thank you for your cooperation.

Sincerely,

H. McGee

Harry McGee, MPH
SIRB Chair

c: Brian Winn, Norbert Kerr, Karin Pfeiffer, Brandon Irwin, Samuel Forlenza

Michigan State University Founded 1855

Office of Regulatory Affairs
Human Research Protection Programs

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MICHIGAN STATE
UNIVERSITY

Initial IRB Application Approval

September 29, 2014

To: Deborah L. Feltz
130 IM Sports Circle
Dept. of Kinesiology
MSU

Re: **IRB#** 14-312 Category: EXPEDITED 7
Approval Date: September 29, 2014
Expiration Date: September 28, 2015

Title: BOOST: Virtual Partner APP to Boost Walk Motivation (CGA135610)

The Institutional Review Board has completed their review of your project. I am pleased to advise you that **your project has been approved**.

The committee has found that your research project is appropriate in design, protects the rights and welfare of human subjects, and meets the requirements of MSU's Federal Wide Assurance and the Federal Guidelines (45 CFR 46 and 21 CFR Part 50). The protection of human subjects in research is a partnership between the IRB and the investigators. We look forward to working with you as we both fulfill our responsibilities.

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Problems: If issues should arise during the conduct of the research, such as unanticipated problems, adverse events, or any problem that may increase the risk to the human subjects, notify the IRB office promptly. Forms are available to report these issues.

Please use the IRB number listed above on any forms submitted which relate to this project, or on any correspondence with the IRB office.

Good luck in your research. If we can be of further assistance, please contact us at 517-355-2180 or via email at IRB@msu.edu. Thank you for your cooperation.

Sincerely,

Ashir Kumar, M.D.
BIRB Chair

c: Stephen Samendinger

Office of Regulatory Affairs
Human Research Protection Programs

Biomedical & Health Institutional Review Board (BIRB)

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REFERENCES

REFERENCES

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.

Bickmore, T. W., Caruso, L., Clough-Gorr, K., & Heeren, T. (2005). "It's just like you talk to a friend' relational agents for older adults. *Interacting with Computers*, *17*(6), 711–735. http://doi.org/10.1016/j.intcom.2005.09.002

Bickmore, T. W., & Picard, R. W. (2005). Establishing and maintaining long-term human-computer relationships. *ACM Transactions on Computer-Human Interaction (TOCHI)*, *12*(2), 293–327.

Bickmore, T., Schulman, D., & Yin, L. (2010). Maintaining engagement in long-term interventions with relational agents. *Applied Artificial Intelligence*, *24*(6), 648–666.

Buday, R. (2014). Games for Health: An Opinion. *Games for Health Journal*, *4*(1), 38–42. http://doi.org/10.1089/g4h.2014.0083

Chartrand, T. L., & Bargh, J. A. (1999). The chameleon effect: the perception-behavior link and social interaction. *Journal of Personality and Social Psychology*, *76*(6), 893–910.

Cohen, S., Underwood, L. G., & Gottlieb, B. H. (2000). Social relationships and health. In S. Cohen, L.G. Underwood, & B.H. Gottlieb (Eds.), *Social support measurement and intervention: A guide for health and social scientists*. Oxford University Press.

Delaherche, E., Chetouani, M., Mahdhaoui, A., Saint-Georges, C., Viaux, S., & Cohen, D. (2012). Interpersonal synchrony: A survey of evaluation methods across disciplines. *Affective Computing, IEEE Transactions on*, *3*(3), 349–365.

Ellis, T., Latham, N. K., DeAngelis, T. R., Thomas, C. A., Saint-Hilaire, M., & Bickmore, T. W. (2013). Feasibility of a Virtual Exercise Coach to Promote Walking in Community-Dwelling Persons with Parkinson Disease. *American Journal of Physical Medicine & Rehabilitation / Association of Academic Physiatrists*, *92*(6), 472–485. http://doi.org/10.1097/PHM.0b013e31828cd466

Forlenza, S. T., Kerr, N. L., Irwin, B. C., & Feltz, D. L. (2012). Is My Exercise Partner Similar Enough? Partner Characteristics as a Moderator of the Köhler Effect in Exergames. *Games for Health Journal*, *1*(6), 436–441. http://doi.org/10.1089/g4h.2012.0047

Gellert, P., Ziegelmann, J. P., Warner, L. M., & Schwarzer, R. (2011). Physical activity intervention in older adults: does a participating partner make a difference? *European Journal of Ageing*, *8*(3), 211–219. http://doi.org/10.1007/s10433-011-0193-5

Hove, M. J., & Risen, J. L. (2009). It's all in the timing: Interpersonal synchrony increases affiliation. *Social Cognition*, *27*(6), 949–960.

Jehn, K. A., & Shah, P. P. (1997). Interpersonal relationships and task performance: An examination of mediation processes in friendship and acquaintance groups. *Journal of Personality and Social Psychology*, *72*(4), 775.

Kahn, E. B., Ramsey, L. T., Brownson, R. C., Heath, G. W., Howze, E. H., Powell, K. E., & Corso, P. (2002). The effectiveness of interventions to increase physical activity. A systematic review. *American Journal of Preventive Medicine*, *22*(4 Suppl), 73–107.

Karau, S. J., & Elsaid, A. M. M. K. (2009). Individual differences in beliefs about groups. *Group Dynamics: Theory, Research, and Practice*, *13*(1), 1–13. http://doi.org/10.1037/a0013366

Karau, S. J. & Williams, K. D. (1993). Social loafing: A meta-analytic review and theoretical integration. *Journal of Personality and Social Psychology*, *65*(4), 681–706. http://doi.org/10.1037/0022-3514.65.4.681

Kassavou, A., Turner, A., & French, D. P. (2013). Do interventions to promote walking in groups increase physical activity? A meta-analysis. *The International Journal of Behavioral Nutrition and Physical Activity*, *10*,18.

Kerr, N. L. (1983). Motivation losses in small groups: A social dilemma analysis. *Journal of Personality and Social Psychology*, *45*(4), 819.

Kerr, N. L., & Bruun, S. E. (1983). Dispensability of member effort and group motivation losses: Free-rider effects. *Journal of Personality and Social Psychology*, *44*(1), 78.

Kerr, N. L., Forlenza, S. T., Irwin, B. C., & Feltz, D. L. (2013). "… been down so long …": Perpetual vs. intermittent inferiority and the Köhler group motivation gain in exercise groups. *Group Dynamics: Theory, Research, and Practice*, *17*(2), 67–80. http://doi.org/10.1037/a0031588

Kerr, N. L. & Hertel, G. (2011). The Köhler Group Motivation Gain: How to Motivate the "Weak Links" in a Group. *Social and Personality Psychology Compass*, *5*(1), 43–55. http://doi.org/10.1111/j.1751-9004.2010.00333.x

Kerr, N. L., Messé, L. A., Park, E. S., & Sambolec, E. J. (2005). Identifiability, performance feedback and the Köhler effect. *Group Processes & Intergroup Relations*, *8*(4), 375–390.

Kerr, N. L., & Seok, D.-H. (2008). *Intergroup Competition and the Köhler Effect*. Presented at the Third Annual INGRoup Conference, Kansas City, MO.

Kerr, N. L., & Seok, D.-H. (2010). "... with a little help from my friends": friendship, effort norms, and group motivation gain. *Journal of Managerial Psychology*, *26*(3), 205–218. http://doi.org/http://dx.doi.org.proxy2.cl.msu.edu.proxy1.cl.msu.edu/10.1108/02683941111112640

Kerr, N. L., Seok, D.-H., Poulsen, J. R., Harris, D. W., & Messé, L. A. (2008). Social ostracism and group motivation gain. *European Journal of Social Psychology*, *38*(4), 736–746. http://doi.org/10.1002/ejsp.499

Lakens, D. & Stel, M. (2011). If they move in sync, they must feel in sync: Movement synchrony leads to attributions of rapport and entitativity. *Social Cognition*, *29*(1), 1–14.

Lakin, J. L. & Chartrand, T. L. (2003). Using nonconscious behavioral mimicry to create affiliation and rapport. *Psychological Science*, *14*(4), 334–339.

Latane, B., Williams, K., & Harkins, S. (1979). Many hands make light the work: The causes and consequences of social loafing. *Journal of Personality and Social Psychology*, *37*(6), 822.

Launay, J., Dean, R. T., & Bailes, F. (2013). Synchronization Can Influence Trust Following Virtual Interaction. *Experimental Psychology (formerly Zeitschrift Für Experimentelle Psychologie)*, *60*(1), 53–63. http://doi.org/10.1027/1618-3169/a000173

Launay, J., Dean, R. T., & Bailes, F. (2014). Synchronising movements with the sounds of a virtual partner enhances partner likeability. *Cognitive Processing*, *15*(4), 491–501. http://doi.org/10.1007/s10339-014-0618-0

Lount, R. B., Kerr, N. L., Messé, L. A., Seok, D.-H., & Park, E. S. (2008). An examination of the stability and persistence of the Köhler motivation gain effect. *Group Dynamics: Theory, Research, and Practice*, *12*(4), 279–289. http://doi.org/10.1037/1089-2699.12.4.279

Lount Jr., R. B., & Phillips, K. W. (2007). Working harder with the out-group: The impact of social category diversity on motivation gains. *Organizational Behavior and Human Decision Processes*, *103*(2), 214–224. http://doi.org/10.1016/j.obhdp.2007.03.002

Moss, O. M. (2015). *The Kohler effect - Intergroup competition using software-generated partners*. Michigan State University. Retrieved from http://gradworks.umi.com/15/88/1588502.html

Reeves, B. & Nass, C. (1996). *The media equation: how people treat computers, television, and new media like real people and places*. New York, NY, USA: Cambridge University Press.

Repp, B. H., & Penel, A. (2004). Rhythmic movement is attracted more strongly to auditory than to visual rhythms. *Psychological Research*, *68*(4), 252–270. http://doi.org/10.1007/s00426-003-0143-8

Repp, B. H., & Su, Y.-H. (2013). Sensorimotor synchronization: A review of recent research (2006–2012). *Psychonomic Bulletin & Review*, *20*(3), 403–452. http://doi.org/10.3758/s13423-012-0371-2

Tajfel, H. (1982). Social Psychology of Intergroup Relations. *Annual Review of Psychology*, *33*(1), 1–39. http://doi.org/10.1146/annurev.ps.33.020182.000245

Tajfel, H., & Turner, J. C. (1979). An integrative theory of intergroup conflict. In Worchel, Stephan and Austin, William G. (Eds.), *The social psychology of intergroup relations* (pp. 33-47) Monterey, CA.

Van Der Heide, B., Schumaker, E. M., Peterson, A. M., & Jones, E. B. (2013). The Proteus Effect in Dyadic Communication: Examining the Effect of Avatar Appearance in Computer-Mediated Dyadic Interaction. *Communication Research*, *40*(6), 838–860. http://doi.org/10.1177/0093650212438097

Vroom, V. H. (1964). Work and motivation. 1964. *NY: John Wiley &sons*, 47-51.

Weber, B. & Hertel, G. (2007). Motivation gains of inferior group members: a meta-analytical review. *Journal of Personality and Social Psychology*, *93*(6), 973–993. http://doi.org/10.1037/0022-3514.93.6.973

Yee, N., Bailenson, J. N., & Ducheneaut, N. (2009). The Proteus Effect: Implications of Transformed Digital Self-Representation on Online and Offline Behavior. *Communication Research*, *36*(2), 285–312. http://doi.org/10.1177/0093650208330254