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Does Walking Mitigate Affective and Cognitive Responses to Social Exclusion?

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Social exclusion can produce harmful affective and cognitive responses that undermine healthy functioning. Physical activity is known to have acute affective and cognitive effects that are adaptive and therefore may mitigate these responses. The purpose of this study was to assess walking as a strategy to reduce the effects of social exclusion on affect and working memory performance. Healthy female college students ($N = 96$, $M_{age} = 19.2 \pm 0.8$ years) were randomly assigned to one of four experimental conditions: (a) sedentary plus neutral feedback, (b) sedentary plus exclusion feedback, (c) walking plus neutral feedback, or (d) walking plus exclusion feedback. Pre- and postactivity and pre- and postfeedback measures of affect and working memory performance were recorded. Excluded participants had a significant negative shift in affect following feedback, $p < .05$. Those who were sedentary prior to exclusion had lower affect scores following exclusion than the walking plus exclusion and neutral feedback conditions, $p < .05$. There were no direct effects of walking or social exclusion on working memory. However, perceptions of being ignored predicted smaller improvements in working memory performance for participants who were sedentary prior to exclusion, $p < .05$. The findings suggest that walking prior to social exclusion may mitigate the affective response to social exclusion as well as social perceptions that can undermine working memory. More broadly, this work supports continued examination of physical activity as a potential strategy for helping individuals cope with negative social experiences.

Keywords: affect, cognitive control, physical activity, rejection, social relationships

People have a fundamental need to form and maintain stable, meaningful, and lasting relationships (Baumeister & Leary, 1995). Indeed, people strongly desire acceptance and social bonds with others, frequently devote attention to the status of their relationships, and behave in ways to maintain and protect their relationships (Baumeister & Leary, 1995). Yet social life is dynamic, and exclusion experiences are common. New college students often feel left out of social opportunities, text messages go unanswered, students leave classmates out of group work, and romantic partners break up. These and other experiences reflect social exclusion, a process where a person is put into a condition of being alone or is denied social contact, thwarting that person's inherent need to belong (Blackhart, Nelson, Knowles, & Baumeister, 2009).

Social exclusion is harmful to psychological, physical, and interpersonal functioning (Baumeister, DeWall, Ciarocco, & Twenge, 2005; Cacioppo & Hawkley, 2009; Hawkley, Thisted, & Cacioppo, 2009; Twenge, Baumeister, DeWall, Ciarocco, & Bartels, 2007). Often underpinning such negative outcomes are transient effects on self-regulation systems (Baumeister et al., 2005; Baumeister, Twenge, & Nuss, 2002). Social exclusion is hypothesized to influence self-regulatory systems through affective and cognitive responses to social exclusion. For instance, people who are excluded typically report "hurt feelings" (MacDonald & Leary, 2005) and demonstrate impairments to cognitive functioning (Baumeister et al., 2002). Using proactive strategies that target transient affective and cognitive responses may be an important first step to reduce harmful outcomes. Currently, there exist few proactive strategies that target these responses (Baumeister, Brewer, Tice, & Twenge, 2007).

One approach to using proactive strategies is to find ways to enhance affect and cognitive performance prior to an event of social exclusion. Accumulating evidence shows that acute bouts of aerobic physical activity enhance affect and cognitive performance, making physical activity a potentially attractive proactive strategy (Chang, Labban, Gapin, & Etnier 2012; Reed & Ones, 2006). The present study specifically investigated the utility of walking, a widely accessible form of physical activity, to mitigate both affective and cognitive responses to social exclusion.

Affect is a simple, nonreflective feeling that is consciously accessible (Barrett, Mesquita, Ochsner, & Gross,

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2007; Russell, 2003; Russell & Barrett, 1999). Affective states range along a continuum from pleasant to unpleasant valence, with pleasant feelings tied to helpful or rewarding events and unpleasant feelings tied to hurtful or threatening events (Panksepp, 1998, 2005). Research suggests that social exclusion generally leads to less pleasant and more unpleasant affective states compared with neutral social interactions (Blackhart et al., 2009). The immediate effect of social exclusion is characterized by a shift away from pleasant toward unpleasant valence, with this shift not extending past a neutral state of affect. One rationale for why social exclusion does not produce a shift beyond neutral affect is that individuals immediately begin a process of coping after being excluded (Blackhart et al., 2009; Williams, 2009).

Coping with an affective state is a form of self-regulation that is cognitively demanding, requiring an individual to continuously monitor and use corrective action to manage the affective state (Gross, 2013). A higher order self-regulatory system known as cognitive control enables this regulation (Gray, 2004; Ochsner & Gross, 2005), with working memory being a component of this system that is particularly salient following social exclusion events. Working memory is the process of manipulating information when it is no longer perceptually present (Baddeley, 1992; Diamond, 2013), which is critical for making sense of events that unfold over time and in formulating plans of action. Ideally, plans of action that afford the best chances of regaining acceptance should be helpful and prosocial. Unfortunately, this may be difficult after social exclusion because helpful plans of action are effortful and require working memory to be unabated. Following social exclusion, impairments to working memory may be responsible for poor plans of action such as behaving aggressively (Twenge, Baumeister, Tice, & Stucke, 2001), being less prosocial (Twenge et al., 2007), and otherwise acting in self-defeating ways (Twenge, Catanese, & Baumeister, 2002).

Baddeley and Hitch's (1974) conceptual model posits that working memory is of limited capacity. Events that capture and direct attention require cognitive control systems (i.e., the central executive) in working memory to either amplify or inhibit perception, attention, and plans of action for these specific events (Baddeley, 2013). In the moments following social exclusion, working memory capacity is taxed from the self-regulation resource demands of managing affect, attention, perceptions, and potential plans of action. Thus, these increased demands draw from a finite pool of self-regulatory resources. This impairs cognitive control performance (Baumeister et al., 2002), with recent work showing working memory-specific decrements (Buelow, Okdie, Brunell, & Trost, 2015).

Strategies to mitigate the impact of social exclusion may serve to reduce demands on self-regulatory resources. Given that social exclusion experiences are common in daily life, such strategies should be applicable to a wide range of people to incorporate into their daily lives with little burden. Accumulating evidence shows that short bouts of aerobic physical activity increase pleasant affect and enhance cognitive performance (Chang et al., 2012; Lambourne & Tomporowski, 2010; Reed & Ones, 2006), making physical activity a potentially attractive strategy for addressing the affective and cognitive responses to social exclusion.

Extant work shows that short (10–40 min) bouts of light to brisk walking are associated with shifts from baseline affective states toward pleasant affect (Ekkekakis, Hall, VanLanduyt, & Petruzzello, 2000; Ekkekakis & Petruzzello, 1999; Reed & Ones, 2006). Immediately after a short bout of walking, individuals report feeling more pleasant and energized, whereas recovery from walking has a calming and relaxing effect (Ekkekakis & Petruzzello, 1999). Research also suggests that single bouts of walking and cycling of similar intensity are associated with positive effects on working memory performance (Martins, Kavussanu, Willoughby, & Ring, 2013; Pontifex, Hillman, Fernhall, Thompson, & Valentini, 2009; Weng, Pierce, Darling, & Voss, 2015). Meta-analytic evidence shows short bouts of aerobic exercise to have significant positive effects on short-term memory, a subprocess of working memory (Roig, Nordbrandt, Geertsen, & Nielsen, 2013). Moreover, one study exploring both affective and cognitive responses to a short bout of cycling found increases in pleasant affect and working memory performance (Hogan, Mata, & Carstensen, 2013). Altogether, findings indicate that short bouts of aerobic physical activity may positively impact both affect and working memory performance.

In light of these findings, walking might be useful in addressing the effects of social exclusion. By enhancing affect and working memory prior to an event of social exclusion, an acute bout of walking may mitigate the demands for self-regulatory resources by limiting effort expenditure for managing the effects of social exclusion. Accordingly, the purpose of this study was to assess the effect of 20 min of walking prior to social exclusion on affect and working memory performance. We hypothesized that social exclusion would decrease affect and working memory performance. We also hypothesized that walking prior to social exclusion would mitigate the effects of social exclusion on affect and working memory, resulting in a more pleasant affective state and higher working memory performance than social exclusion without walking.

Method

Participants

Ninety-six female college-aged adults (24 per condition, $M_{age} = 19.2 \pm 0.8$ years) from kinesiology classes in a large Midwestern U.S. university completed the study. The sample was delimited to female participants to hold the sex composition of the experimental sessions constant, a strategy that is in line with previous social exclusion research (Maner, DeWall, Baumeister, & Schaller, 2007). During recruitment, prospective participants were informed that they would be involved in a study investigating the link between exercise and aspects of team building. Employing a cover story is in line with previous work (Maner et al., 2007; Nezlek, Kowalski, Leary, Blevins, & Holgate, 1997) and is necessary to ensure that natural responses to social exclusion are observed. There were 127 enrollees; however, those reporting contraindications to physical activity or a history of depression, neurological health issues, brain trauma, or concussion with loss of consciousness were excluded from participation in the study ($n = 31$). Most participants identified as not Hispanic (94.8%), White (85.4%), and right-handed (91.7%) with normal (52.1%) or corrected-to-normal vision (47.9%). A portion (26%) of participants reported knowing another participant during the same visit (i.e., out of the four participants per data collection visit). Participants who identified knowing another participant reported their relationship as 12.5% infrequently/acquaintances, 8.3% frequently/regular acquaintances, and 4.2% very frequent/close friends. One participant did not disclose the type of relationship. The distribution of familiar or unfamiliar participants was not significantly different among experimental conditions, $X^2(3) = 1.89$, $p = .60$, and the distribution of the nature of the reported relationship did not differ among experimental conditions, $X^2(9) = 7.11$, $p = .63$.

Measures

Affective valence. In line with previous investigations of affective responses to social stimuli (Armstrong, McClenahan, Kittle, & Olatunji, 2014), we utilized the empirical valence scale (EVS; Lishner, Cooter, & Zald, 2008) to measure affective valence. The EVS is a one-item 200-mm bipolar scale that assesses affective valence. Participants were asked to place a mark along a continuous visual analog scale corresponding to how they currently felt, ranging from "*most unpleasant imaginable*" to "*most pleasant imaginable*." EVS scores range from −100 to 100, corresponding to a millimeter away from the center *neutral* point. Negative scores indicate unpleasant valence, and positive scores indicate pleasant valence. The EVS contains the following descriptors in both valence directions from the *neutral* 0-point: *barely* (7 mm), *slightly* (12 mm), *mildly* (24 mm), *moderately* (38 mm), *strongly* (70 mm), *extremely* (85 mm), and *most imaginable* (100 mm). Two independent raters using a metric ruler scored responses in millimeters. When two raters were discrepant (e.g., differing by 1 mm), a third independent rater was used to determine the appropriate score between the two raters. Initial interrater agreement between two independent raters was 91.4%.

Working memory. In line with previous investigations of working memory, we utilized a serial *n*-back task (Drollette et al., 2016). The *n*-back task asks participants to identify if the current stimulus matches or does not match a stimulus presented *n* trials previously (Carlson et al., 1998; Kirchner, 1958). Trials contained one of six 3.4 × 3.4-cm uniquely colored shape stimuli (i.e., green circle, red crescent, blue cross, purple star, orange square, and yellow triangle). Shapes were presented on a 15.4-in. laptop screen (Dell Vostro 3500, Round Rock, TX) against a black background for 250 ms with a 2,500-ms intertrial interval. Participants completed a 1-back block followed by a 2-back block containing a random order of 24 matching and 47 nonmatching trials per block. Matching trials in the 1-back block were trials containing a shape that matched the shape immediately preceding it. Matching trials in the 2-back block were trials containing a shape that matched the shape two trials preceding it. Participants responded on a two-button response pad (X-keys XK-24 keypad, Williamston, MI) with a left button press if the current shape did not match or a right button press if the shape did match the shape presented *n* trials previously. The 2-back block places greater demands on working memory than the 1-back block. Analyses were conducted using d' (D prime) as a measure of memory sensitivity. This performance measure was calculated by taking the difference between the standardized hit rate (the number of matching trials correctly identified relative to the total number of matching trials) and the standardized false alarm rate (the number of nonmatching trials incorrectly identified as matching relative to the total number of nonmatching trials); z (hit rate) – z (false alarm rate). Prior to standardization, a constant of .5 was added to the number of hits and false alarms and a constant of 1 was added to the total number of matching and nonmatching trials (e.g., hit rate = [hits + .5]/[total matching trials + 1]) to remove the potential for undefined values (Verde, MacMillan, & Rotello, 2006). Larger d' values indicate a greater ability to discriminate between matching and nonmatching stimuli, suggestive of better working memory performance.

Experimental Conditions

Activity. Participants assigned to the sedentary activity were asked to sit quietly at a table for 20 min. Participants assigned to the walking activity completed a 5-min warm-up on a motor-driven treadmill and were asked to continue walking at or above 60% of their age-predicted heart rate (HR) max (220 – age) on a 1.0% incline for an additional 15 min. This intensity is of light to moderate physical activity (i.e., a brisk walk) and is in line with exercise research showing positive effects on affect and cognition (Chang et al., 2012; Ekkekakis & Petruzzello, 1999; Lambourne & Tomporowski, 2010; Roig et al., 2013). All participants watched a neutral educational video clip (Cooter, Holt, & Lachmann, 2011) on a 15.4-in. laptop (Dell Vostro 3500) at eye level during the assigned activity to remove the potential for psychosocial confounds between sedentary and walking activities (Pontifex, Parks, Henning, & Kamijo, 2015). As a manipulation check, HR was recorded at 2-min intervals throughout each activity.

Feedback. For the social exclusion manipulation, four participants engaged in a group meeting adapted from the get-acquainted paradigm (Nezlek et al., 1997). First, participants with name tags met together in a room to get to know one another by taking turns orally answering a list of basic questions presented on a sheet of paper (e.g., name, hometown, academic major). After the meeting, research assistants separated participants into private rooms. For each respective participant, a research assistant instructed her to choose two other participants from the group that she would most like to work with for a subsequent partner task. The research assistant briefly left the room and the participant wrote the names on a worksheet. The research assistant then returned to retrieve the names and then again left the room under the guise of comparing responses of the other participants and determining partner groups. Upon returning to the room, the research assistant gave false feedback to the participant about the partner task. Participants receiving neutral feedback were told, *"We won't be doing the partner task for a while. In the meantime, I'm going to have you complete some additional tests and questionnaires."* Participants receiving social exclusion feedback were told, *"I hate to tell you this, but no one chose you as someone they wanted to work with. So because of that you will have to independently complete additional tests and questionnaires.*" This manipulation took approximately 15 min from the start of the group meeting to the end of feedback. As in previous investigations assessing the effectiveness of social exclusion manipulations (Zadro, Williams, & Richardson, 2004), a two-item questionnaire (Williams, 2009) was administered at the end of the study as a manipulation check for experimental feedback. This questionnaire assesses perceptions of social exclusion. That is, participants reported the degree to which they perceived being ignored and excluded, respectively, on a scale of 1 (*not at all*) to 5 (*extremely*).

Design and Procedure

A mixed design was utilized with one between-subjects independent variable (i.e., experimental condition: sedentary plus neutral feedback, sedentary plus exclusion feedback, walking plus neutral feedback, and walking plus exclusion feedback) and one repeated-measures independent variable (i.e., time). This design allowed for the analysis of changes in affect and working memory performance over the course of the study as well as condition comparisons. Although a within-subject design for condition comparisons possesses certain advantages, between-subjects designs are preferred in social exclusion research because repeated exposures to social exclusion conditions in a lab setting can reveal the purpose of the study and undermine natural responses to social exclusion.

After providing informed consent, participants completed demographics, health screening, and physical activity readiness questionnaires online. Qualifying participants received an email to confirm their visit for data collection. Under the cover of an exercise and team building study, four participants were concurrently scheduled with participants randomly distributed to the four experimental conditions. All data were collected with four participants per experimental session. If fewer than four participants arrived for a scheduled data collection visit (due to individual participant cancellations or no shows, $n = 6$ scheduled data collection sessions), all participants were rescheduled for a later visit. A team of research assistants greeted participants upon arrival and individually escorted each participant to a randomly assigned private room. Upon entering the room, participants were fitted with a Polar HR monitor (model H7, PolarElectro, Kempele, Finland), and baseline HR was recorded after being seated for 2 min. HR was also measured at 2-min intervals across the activity portion of the study as well as prior to completing each block of the *n*-back task (to ensure within 10% of baseline HR value). After baseline HR was recorded, the first of eight EVS reports was completed (time point 1). Remaining EVS reports were provided at key study benchmarks: after the practice *n*-back tasks (time point 2), after the pretest 1-back task (time point 3), after the pretest 2-back task (time point 4), halfway through the activity portion of the study (time point 5), after the activity portion (time point 6), after the posttest 1-back task (time point 7), and after the posttest 2-back task (time point 8). After the first EVS, participants completed one block each of the 1-back and 2-back versions of the *n*-back task for practice. This was repeated two additional times, once prior to the activity portion (pretest) and again following the activity portion and feedback (posttest). Each block of the *n*-back task took approximately 5 min to complete with instruction and breaks between blocks. Figure 1 displays the procedural timeline for an experimental session.

Following the walking or sedentary activity, participants were escorted to a separate room for the group meeting. After the group meeting, research assistants individually escorted participants back to their original private rooms, left the room for 60 s after asking participants to select partners on the worksheet, returned to gather the worksheet, left the room again for 60 s, and then returned to the room to deliver false feedback. After participants received false feedback about the partner task, participants immediately completed postassessment *n*-back tasks and the final EVS measures (once after 1-back block and once after 2-back block).

Following administration of the final EVS, each participant independently completed the social exclusion manipulation check, was verbally debriefed, and was provided the opportunity to ask any questions. After verbal debriefing, participants signed an additional debriefing and consent to use data form. The full experimental session lasted approximately 90 min.

Statistical Analysis

Data were screened in line with best practice using IBM SPSS v22.0 (Armonk, NY; Tabachnick & Fidell, 2013).

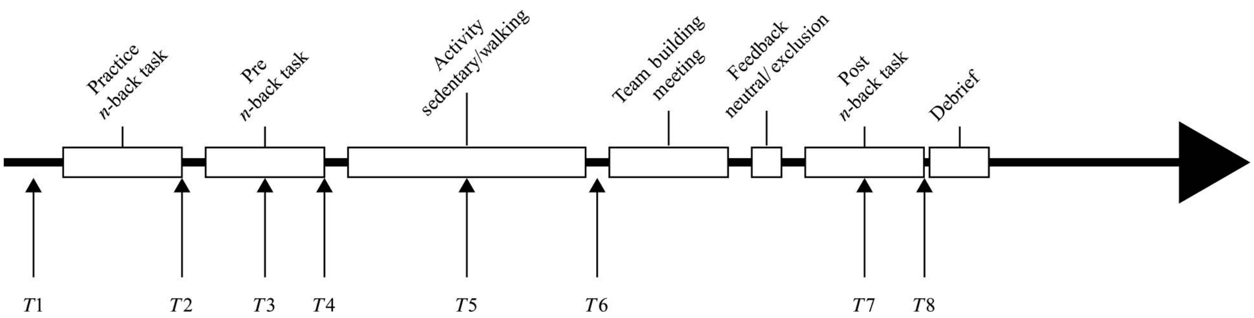

Figure 1 — Procedural timeline. T = time point corresponding to affect assessment. Labels above rectangles indicate specific events. Heart rate was measured immediately prior to T1, at 2-min intervals across the activity portion of the study, and prior to completing each block of the *n*-back task. Scale of events and spacing of time points are roughly consistent with time of an overall session.

As a check for random assignment, we analyzed differences among experimental conditions on affect at time point 1 and performance on the pretest 1-back and 2-back working memory tasks with three separate one-way analysis of variance (ANOVA) models. As a manipulation check for the activity portion of the study, we analyzed differences among experimental conditions on mean HR with a one-way ANOVA. As a manipulation check for the feedback portion of the study, we analyzed differences among experimental conditions on perceptions of being ignored and excluded, respectively, with one-way ANOVA models. Feedback manipulation checks were further analyzed to assess any influence of familiarity among participants within an experimental session. All significant effects were followed up with post hoc pairwise comparisons.

To measure differences in affect among experimental conditions across the experiment, we conducted a 4 × 8 mixed ANOVA with experimental conditions (sedentary neutral, sedentary exclusion, walking neutral, and walking exclusion) as the between-subject factor and time (time points 1 through 8) as the within-subject factor. Because our a priori interests were in differences across activity and feedback portions of the experiment, we focused subsequent analyses on affective measures during those portions (time points 5 through 8). First, we computed a composite measure by averaging initial, practice, and pretest affect scores (time points 1, 2, 3, and 4) to reduce the influence of multicollinearity among these baseline measures of affect. We included the composite measure in subsequent follow-up models as a covariate. This was to control for any potential influence of initial affect or testing reactivity (Holdwick & Wingenfeld, 1999) prior to the activity manipulation. Thus, the following models control for these baseline measures of affect to provide a clearer observation of the experimental manipulation effects. The primary follow-up model was a 4 × 4 mixed analysis of covariance (mixed ANCOVA) with experimental conditions (sedentary neutral, sedentary exclusion, walking neutral, and walking exclusion) as the between-subject factor and time as the within-subject factor (time points 5, 6, 7, and 8) after controlling for baseline affect.

Secondary follow-up models dissected the experimental condition by time interaction from the primary follow-up model with a series of ANCOVA models. To assess pairwise within-subject effects (i.e., shifts in affect), we conducted three 4 × 2 mixed ANCOVA models with experimental conditions (sedentary neutral, sedentary exclusion, walking neutral, and walking exclusion) as the between-subject factor and time (time points 5 vs. 6, 6 vs. 7, and 7 vs. 8) as the within-subject factor after controlling for baseline affect. To assess differences among experimental conditions for each time point, we conducted four one-way ANCOVAs with experimental conditions (sedentary neutral, sedentary exclusion, walking neutral, and walking exclusion) as the between-subject factor after controlling for baseline affect. All models used a family-wise α level of .05, Greenhouse–Geisser correction for nonsphericity, and partial eta squared (η_p^2)—a measure of effect size that is useful for research using covariates as control variables (Cohen, 1973; Tabachnick & Fidell, 2013).

We used two mixed 4 × 2 ANOVA models to examine performance in 1-back and 2-back working memory tasks, respectively, with experimental conditions (sedentary neutral, sedentary exclusion, walking neutral, and walking exclusion) as the between-subject factor and time (pre vs. post) as the within-subject factor. Last, we explored associations among affect, perceptions of being ignored and excluded, and pre-to-post changes in working memory performance with bivariate correlations.

Given the number of hypothesis-driven and exploratory analyses, we utilized the Benjamini and Hochberg (1995) false discovery rate control method (BH-FDR) to adjust for Type I error and identify potential false-positive results (see Glickman, Rao, & Schultz, 2014). There were 98 total probability tests conducted for the study. We used a false discovery rate of .05 (i.e., acknowledging that five in 100 significant findings may be potential false positives). Findings that did not pass the BH-FDR control method are noted in the results.

Table 1 Means and Standard Deviations for Manipulation Check Variables

Variable	Sedentary Neutral *M* (*SD*)	Sedentary Exclusion *M* (*SD*)	Walking Neutral *M* (*SD*)	Walking Exclusion *M* (*SD*)
Heart rate (BPM)	73.7 (15.0)[a]	71.9 (11.6)[a]	126.5 (5.4)[b]	127.0 (4.7)[b]
Ignored	1.0 (.2)[a]	2.2 (1.1)[b]	1.0 (.2)[a]	2.5 (1.5)[b]
Excluded	1.1 (.3)[a]	2.7 (1.2)[b]	1.0 (.2)[a]	2.5 (1.4)[b]

Note. BPM = beats per minute. Different superscripts across row indicate significant pairwise difference at $p < .001$.

Results

Randomization and Manipulation Checks

Affect upon entering the study, $F(3, 92) = .7$, $p = .53$, $\eta_p^2 = .02$, working memory performance on the pretest 1-back task, $F(3, 92) = .9$, $p = .43$, $\eta_p^2 = .03$, and working memory performance on the pretest 2-back task, $F(3, 92) = 1.4$, $p = .25$, $\eta_p^2 = .04$, were not significantly different among experimental conditions, suggesting successful random assignment.

Mean HR during the activity portion was significantly different among experimental conditions, $F(3, 92) = 226.9$, $p < .001$, $\eta_p^2 = .88$. Participants recorded a mean HR of 126.5 ± 5.4 beats per minute (BPM) (63% HR_{max}) in the walking neutral, 127.0 ± 4.7 BPM (63% HR_{max}) in the walking exclusion, 73.7 ± 15.0 BPM (37% HR_{max}) in the sedentary neutral, and 71.9 ± 11.6 BPM (36% HR_{max}) in the sedentary exclusion conditions. Participants in both walking conditions walked at the prescribed intensity, and participants in both sedentary conditions remained within 10% of baseline HR. Post hoc tests (see Table 1) revealed that participants in both walking conditions recorded higher mean HR than participants in both sedentary conditions.

Perceptions of being ignored were significantly different among experimental conditions, $F(3, 92) = 15.7$, $p < .001$, $\eta_p^2 = .34$. Post hoc tests revealed that participants in both exclusion conditions reported higher perceptions of being ignored than participants in both neutral conditions. Perceptions of being excluded were significantly different among experimental conditions, $F(3, 92) = 21.9$, $p < .001$, $\eta_p^2 = .42$. Post hoc tests revealed participants in both exclusion conditions reported higher perceptions of being excluded than participants in both neutral conditions. There was no evidence that knowing another participant had a main effect on reports of being ignored, $F(1, 95) = .04$, $p = .83$, or moderated the effect of experimental condition on reports of being ignored, $F(3, 88) = .03$, $p = .99$. There was also no evidence that knowing another participant had a main effect on reports of being excluded, $F(1, 95) = 1.1$, $p = .26$, or moderated the effect of experimental condition on reports of being excluded, $F(3, 88) = .4$, $p = .70$.

Affective Valence

The omnibus test revealed a significant main effect of time, $F(7, 86) = 13.3$, $p < .001$, $\eta_p^2 = .13$, and a significant experimental conditions by time interaction, $F(21, 264) = 3.6$, $p < .001$, $\eta_p^2 = .11$ (see Figure 2). The primary follow-up model revealed a significant experimental condition by time interaction, $F(9, 273) = 3.2$, $p < .01$, $\eta_p^2 = .09$. Thus, reports of affective valence were significantly different over activity and feedback portions of the study among experimental conditions after controlling for baseline affect. Secondary follow-up models focusing on time point shifts revealed a significant experimental condition by time interaction for the shift in affect from before to after the feedback (i.e., from time point 6 to 7) after controlling for baseline affect, $F(3, 91) = 4.1$, $p < .01$, $\eta_p^2 = .12$. Post hoc pairwise comparisons (see Table 2) revealed a significant shift in affect for participants in the sedentary exclusion condition and in the walking exclusion condition, $p < .05$. Participants in the sedentary exclusion condition reported a large shift, $d = -.80$, from an affective state corresponding to between slightly and mildly pleasant toward neutral affect. Participants in the walking exclusion condition reported a moderate shift, $d = -.62$, from an affective state corresponding to just above mildly to above slightly pleasant. However, the

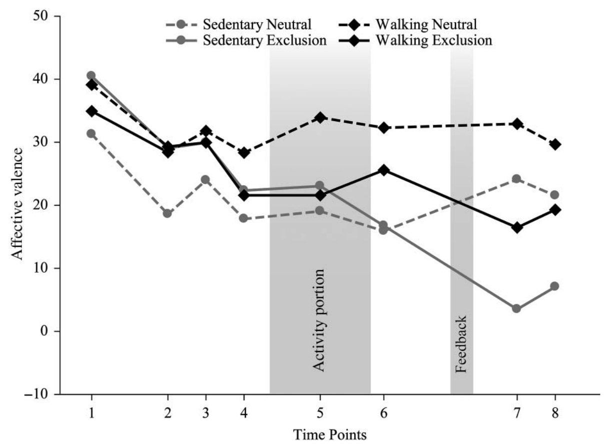

Figure 2 — Affective valence by experimental condition over time. Positive values for affective valence reflect pleasant valence, negative values reflect unpleasant valence, and neutral is zero. Neutral and social exclusion feedback occurred between time points 6 and 7. Spacing of time points is roughly consistent with timing of an overall session.

Table 2 Means and Standard Deviations for Affective Valence Scores in Follow-Up Models

Model Time Point(s)	Sedentary Neutral *M* (*SD*)	Sedentary Exclusion *M* (*SD*)	Walking Neutral *M* (*SD*)	Walking Exclusion *M* (*SD*)	*F*	*p*	η_p^2
Shifts in affect across adjacent time points							
Time 5–6	−3.1 (10.9)	−6.3 (16.9)	−1.6 (10.6)	4.0 (16.4)	2.24	.089	.07
Time 6–7	8.2 (25.1)	−13.3 (23.6)*	.6 (19.5)	−9.1 (20.9)*	4.14**	.009	.12
Time 7–8	−2.5 (9.7)	3.5 (8.8)	−3.3 (23.7)	2.8 (12.5)	1.26	.292	.04
Between conditions at individual time points							
Time 5	19.0 (28.1)	23.0 (27.9)	33.9 (24.9)	21.6 (33.1)	1.65	.183	.05
Time 6	15.9 (30.5)	16.8 (32.1)	32.3 (30.6)	25.6 (31.9)	1.77	.158	.06
Time 7	24.1 (21.6)[c]	3.5 (28.4)[a]	32.9 (24.2)[c]	16.5 (31.0)[b]	11.67***	.000	.28
Time 8	21.5 (22.8)[b]	7.0 (30.2)[a]	29.7 (29.0)[b]	19.3 (31.0)[b]	6.23***	.000	.17

Note. η_p^2 = variance accounted for in follow-up models. For shifts models, positive values reflect movement toward more pleasant valence and negative values reflect movement toward more unpleasant valence. For individual time point models, different superscripts across a row indicate significant between-condition pairwise differences at $p < .05$. Time point 5 was during, and time point 6 followed, the sedentary or walking activity. Neutral and social exclusion feedback occurred between time points 6 and 7.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 3 Means and Standard Deviations for Working Memory Performance

	Sedentary Neutral		Sedentary Exclusion		Walking Neutral		Walking Exclusion	
Task	Pre *M* (*SD*)	Post *M* (*SD*)	Pre *M* (*SD*)	Post *M* (*SD*)	Pre *M* (*SD*)	Post *M* (*SD*)	Pre *M* (*SD*)	Post *M* (*SD*)
1-back	3.2 (1.0)	3.2 (.9)	3.2 (.6)	3.3 (.5)	3.1 (.6)	3.3 (.7)	2.9 (1.0)	2.8 (.8)
2-back	2.2 (.8)	2.8 (1.0)	2.3 (.6)	2.6 (.9)	2.3 (.6)	2.5 (.9)	2.0 (.7)	2.3 (.9)

Note. Units are d' values. Higher values indicate greater working memory performance.

walking exclusion condition finding should be interpreted with caution because it did not pass the BH-FDR.

Secondary follow-up models (controlling for baseline affect) focusing on specific time points after feedback revealed differences in affective valence among experimental conditions at both time points 7, $F(3, 91) = 11.7$, $p < .001$, $\eta_p^2 = .28$, and 8, $F(3, 91) = 6.2$, $p < .001$, $\eta_p^2 = .17$. Post hoc pairwise comparisons for time point 7 revealed participants in the sedentary exclusion condition reported the lowest affect (just above neutral), followed by the walking exclusion condition (between slightly and mildly pleasant), and, last, both the sedentary neutral and walking neutral conditions (between mildly and moderately pleasant). Findings at time point 7 should be interpreted with caution because comparisons of the walking exclusion condition with the sedentary exclusion condition and the sedentary neutral condition, respectively, did not pass the BH-FDR. For time point 8, participants in the sedentary exclusion condition reported lower affect (at barely pleasant) than participants in all other experimental conditions (around mildly pleasant). However, the comparison of the sedentary exclusion condition with the walking exclusion condition did not pass the BH-FDR and should be interpreted with caution.

Working Memory

For the 1-back task, there was no evidence of a main effect of time, $F(1, 92) = .2$, $p = .62$, $\eta_p^2 = .00$, condition, $F(3, 92) = 1.6$, $p = .20$, $\eta_p^2 = .05$, or of a condition by time interaction, $F(3, 92) = .66$, $p = .57$, $\eta_p^2 = .02$. For the 2-back task, there was no evidence of a main effect of condition, $F(3, 92) = 1.2$, $p = .30$, $\eta_p^2 = .04$, or of a condition by time interaction, $F(3, 92) = .8$, $p = .49$, $\eta_p^2 = .03$. However, a main effect of time, $F(1, 92) = 21.9$, $p < .001$, $\eta_p^2 = .19$, indicated that all participants improved their working memory performance for the 2-back task regardless of experimental condition. Table 3 displays the mean performance for *n*-back tasks across the experiment.

Associations of Affect and Exclusion Perceptions With Changes in Working Memory Performance

There was no evidence that the affective shift from time points 6 to 7 or affective states at time point 7 or 8 correlated to pre-to-post changes in 1-back or 2-back working memory performance in any experimental condition (see Table 4). In addition, there was no evidence

Table 4 Associations of Affect and Exclusion Perceptions with Changes in Working Memory Performance

Condition	Task	Affective Shift	Affect T7	Affect T8	Ignored	Excluded
Sedentary Neutral	Δ 1-back	−.34	−.31	−.27	.20	−.02
	Δ 2-back	.21	−.02	.06	.03	.25
Sedentary Exclusion	Δ 1-back	−.37	−.06	−.06	−.15	−.02
	Δ 2-back	.05	.20	.24	−.50*	−.14
Walking Neutral	Δ 1-back	.27	−.19	−.08	−.01	−.01
	Δ 2-back	.20	−.07	.14	−.15	−.15
Walking Exclusion	Δ 1-back	.02	.05	.11	−.22	−.03
	Δ 2-back	.02	.14	.18	−.17	−.06

Note. Affective shift = difference in affect valence from time 6 to time 7; affect T7 = affective valence at time point 7; affect T8 = affective valence at time point 8; Δ = changes in task performance (post–pre).
*$p < .05$.

of perceptions of being excluded being associated with pre-to-post changes in working memory performance. However, higher perceptions of being ignored were associated with smaller pre-to-post changes in 2-back working memory performance for participants in the sedentary exclusion condition, $r = -.50$, $p < .05$, bootstrapped bias-corrected 95% CI [−.73, −.13]. Thus, perceptions of being ignored account for 25% of the variance in pre-to-post changes in 2-back working memory performance.

Discussion

The goal of the present study was to assess the effect of engaging in a short (20-min) bout of walking prior to social exclusion on affect and working memory performance. Extant work shows social exclusion to stimulate maladaptive affective and cognitive responses, whereas short bouts of physical activity afford affective and cognitive benefits (Baumeister et al., 2002; Chang et al., 2012; Reed & Ones, 2006; Roig et al., 2013). We found that social exclusion results in a shift away from pleasant affect and walking appears to mitigate this affective response. Social exclusion did not directly influence working memory performance; however, perceptions of being ignored were associated with smaller improvements in working memory performance for those in the sedentary social exclusion condition.

We hypothesized that social exclusion would decrease affect and working memory performance. Participants in the exclusion conditions reported a noteworthy shift from pleasant toward neutral affect, aligning with extant meta-analytic findings (Blackhart et al., 2009). The majority of previous research used single time point assessments of affect following social exclusion (Baumeister et al., 2002, 2005), whereas the present investigation captured affective shifts using repeated measures. By examining shifts within individuals, a rich understanding of affective responses to social exclusion was attained. For example, affect reported by participants in the sedentary exclusion condition declined following feedback and remained lower through time point 8. When comparing across conditions, affect following feedback was the lowest among those in the sedentary exclusion condition. These findings suggest that social exclusion has a substantive negative impact on pleasant affect and that affect may remain lower for several minutes following an event of social exclusion.

Although this investigation provided support for the affective portion of the first hypothesis, the direct effect of social exclusion on working memory was not supported. Social exclusion is hypothesized to place greater resource demands on higher order cognitive systems that manage affect and cognition, resulting in impairments to working memory performance (Baumeister et al., 2002; Buelow et al., 2015). The use of a high-functioning college-aged sample may explain this finding. These participants may possess a variety of automated self-regulation strategies based on experiencing social exclusion over their school-aged years. Automated self-regulation strategies may reduce resource demands following exclusion (DeWall et al., 2011; Ochsner & Gross, 2005), potentially explaining why working memory performance was not directly impacted by social exclusion in the present study.

Despite this outcome, the results show that social perceptions may be tied to working memory performance, introducing an additional conceptual pathway for social exclusion effects on working memory. Reports of being ignored were negatively associated with changes in working memory performance for participants in the sedentary exclusion condition. Thus, impairments to working memory may vary to the degree an individual perceives being ignored. Increases in perceptions of social exclusion may stimulate intrusive thoughts, which could increase resource demands from the same finite pool of resources as working memory. Related research utilizing stereotype threat manipulations demonstrates intrusive thoughts and rumination to be associated with poorer working memory performance (Beilock, Rydell, & McConnell, 2007). Thus, a pathway to explore regarding cognitive effects is how social exclusion stimulates exclusion-related perceptions that may produce intrusive thoughts.

It is important to situate this finding relative to the magnitude of the reported social perceptions. Reports of being ignored and excluded did not cross the midpoint of the scale for participants who received exclusion feedback. The getting to know you paradigm used in the present study likely constitutes a mild form of social exclusion. This noted, these levels of being ignored and excluded may also reflect underreporting of social exclusion perceptions. Underreporting could be a defensive psychological strategy to blunt the averseness of social exclusion and to preserve self-worth (Twenge et al., 2007; Twenge, Catanese, & Baumeister, 2003). Indeed, previous research suggests that excluded participants tend to avoid self-awareness and report a neutral affective state (Twenge et al., 2003). Impaired working memory performance may require a degree of social exclusion that overpowers this defensive strategy.

Results also demonstrated no evidence of associations of affective states or shifts with working memory performance. This finding aligns with previous reports of no association between affective responses and behavioral outcomes of social exclusion (Twenge et al., 2001, 2003). The absent associations suggest that affective responses are an independent effect of social exclusion. The shift toward neutral affect may be an automatic and natural response to social exclusion, thereby placing little demand on self-regulation systems. The present results instead suggest that social exclusion perceptions may place resource demands on self-regulatory systems.

We also hypothesized that walking would mitigate the effects of social exclusion on affect and working memory, resulting in a more pleasant affective state and higher working memory performance than social exclusion without walking. Participants who walked prior to exclusion reported more pleasant affect following exclusion feedback than those who did not walk. Thus, a short bout of walking prior to social exclusion may have utility in reducing affective responses to social exclusion. Increases in calmness and relaxation have been observed during the period following physical activity, which might explain a potential mitigating role of walking prior to social exclusion (Ekkekakis et al., 2000). Furthermore, walking prior to exclusion feedback may have dampened the association between perceptions of being ignored and working memory performance. Based on the BH-FDR results, it is important to view the key study findings as tentative and preliminary. This caution acknowledged, there appears to be value in further exploring the potential for walking and other forms of physical activity in addressing social exclusion. Replication of findings will be necessary, and this exploration will be enhanced by directly addressing limitations of the present work.

Limitations and Future Research Directions

Though the present investigation shows that walking may help mitigate the effects of social exclusion, there are limitations that must be considered. For example, in the interest of not revealing the purpose of the study, we did not administer an assessment of affect directly upon providing the exclusion feedback. Rather, we administered our most proximal affect assessment following a block of the working memory task. When using deception in experimental research, researchers must decide on the appropriate time points to capture affective states without sacrificing the integrity of experimental manipulations. In light of these concerns, one solution for future research is to use implicit measures of affect (DeWall et al., 2011). These may be particularly useful to avoid revealing the purpose of the study to participants.

Also, as noted previously, the use of a high-functioning college-aged sample likely produces a conservative estimate of effects. College-aged students may have already developed efficient coping strategies that buffer the impact of social exclusion. Future research may benefit from using a developing sample, such as adolescents, where social relationships with peers are of particular salience and self-regulation skills are developing.

An additional consideration in future work is that responses to exclusion may not be uniform, even if humans generally maintain a desire to feel included and share social bonds with others (Baumeister & Leary, 1995). Though we employed random assignment in the present study such that individual differences would be represented similarly across the conditions, there is value in attempting to directly assess individual difference variables that may moderate effects. Individual differences in affect regulation strategies (Gross & John, 2003), attachment styles (DeWall et al., 2012), loneliness (Cacioppo & Hawkley, 2009), need to belong (Beekman, Stock, & Marcus, 2016), and rejection sensitivity (Berenson et al., 2009) are examples that warrant exploration in future research.

Another consideration pertinent to all laboratory social exclusion research is if documented effects are the result of threats to the need to belong or a deprived sense of control. The social exclusion feedback in the current study is more controlling in tone than the neutral feedback and may have manipulated a participant's locus of control more so than the need to belong. Social exclusion comes in many forms, and some involve feeling a loss of control (e.g., ostracism). Though certainly challenging because they are easily confounded, future research may benefit if the effects of social exclusion as a result of threats to the need to belong can be distinguished from those stemming from a deprived sense of control.

The present investigation did not replicate previous findings showing effects of single bouts of aerobic physical activity on working memory (Martins et al., 2013; Pontifex et al., 2009; Weng et al., 2015). This may be due to the amount of time that passed following the cessation of walking and the posttest assessment of working memory. Positive effects on working memory have been observed up to 30 min following the cessation of exercise and our posttest assessments were within this time window (Pontifex et al., 2009). However, this time window is not absolute due to the heterogeneity of research designs, exercise intensities, timing of administration, and type of cognitive assessment that make up the current literature base. Additional evidence is needed to understand if the effects of walking specific to working memory diminish as time passes.

As is common in budding research areas when there is interest in exploring an array of possible effects, a large number ($n = 98$) of probability tests were conducted in this study. Accordingly, results must be cautiously interpreted because of the potential for Type I errors. In light of the large number of tests, we used the BH-FDR control method to control for Type I error and identify potential false-positive results. We found four potential false-positive results out of 33 (12.1%) probability tests that satisfied the uncorrected criterion (i.e., $p < .05$). The findings will be important to attempt to replicate before drawing firm conclusions.

Last, the present work examined pre-emptive walking. When the potential for social exclusion is predictable, as with auditions for school plays, rushing a fraternity or sorority, or band or sport tryouts, walking may be particularly useful before an individual is potentially excluded. However, social exclusion events are not necessarily predictable. Examining the potential for physical activity to mitigate negative responses following a social exclusion event is also important. Physical activity could be useful as both a pre-emptive strategy and a reactive strategy for coping with social exclusion. In moving forward with this work, it will be critical to consider issues of timing and dose of physical activity, contextual factors, and other possible moderators of any effects.

Strengths and Conclusion

There are several notable strengths of the present study. Importantly, we demonstrated significant effects of social exclusion on affect even though we used a high-functioning college-aged sample and a mild form of social exclusion. Moreover, we used a true control condition (i.e., neutral feedback), which is uncommon in social exclusion research. Social exclusion is typically juxtaposed with social inclusion (i.e., acceptance) in this research area. Comparing social exclusion with inclusion likely magnifies condition differences. The use of a repeated-measures design is another unique study strength, enabling assessment of shifts in affect and changes in working memory. Manipulating social exclusion in a controlled laboratory setting captures the direct effects of social relationships and addresses some of the weaknesses of correlational designs more typically used in social relationships research. Finally, we investigated walking, a behavior with potential to address the effects of social exclusion. The practicality and feasibility of a walking intervention to assist in coping with social exclusion warrants continued consideration. Walking is a common form of physical activity that most individuals can incorporate into their daily lives with little burden. Considered together, we believe these study strengths have enabled us to provide a novel contribution to the respective exercise psychology and social relationships literatures.

In conclusion, this study suggests that walking prior to social exclusion may mitigate the affective response to social exclusion as well as social perceptions with potential to undermine working memory. More broadly, this work supports continued examination of physical activity as a strategy for helping individuals cope with negative social experiences. Walking is a common form of active transport, especially on college campuses. Short bouts of walking throughout the day may mitigate subsequent affective consequences of social exclusion. However, the findings reported here are preliminary and tentative, requiring replication and attention to study limitations. Important future avenues of research include exploring samples beyond university students, assessment issues, consideration of individual differences, and other matters surrounding how and when physical activity may mitigate maladaptive effects of social exclusion.

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