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Momentary Assessment of Contextual Influences on Affective Response During Physical Activity

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Abstract

Objective: Higher positive and lower negative affective response during physical activity may reinforce motivation to engage in future activity. However, affective response during physical activity is typically examined under controlled laboratory conditions. This research used ecological momentary assessment (EMA) to examine social and physical contextual influences on momentary affective response during physical activity in naturalistic settings.

Method: Participants included 116 adults (mean age = 40.3 years, 73% female) who completed 8 randomly prompted EMA surveys per day for 4 days across 3 semiannual waves. EMA surveys measured current activity level, social context, and physical context. Participants also rated their current positive and negative affect. Multilevel models assessed whether momentary physical activity level moderated differences in affective response across contexts controlling for day of the week, time of day, and activity intensity (measured by accelerometer).

Results: The Activity Level × Alone interaction was significant for predicting positive affect ($\beta = -0.302$, $SE = 0.133$, $p = .024$). Greater positive affect during physical activity was reported when with other people (vs. alone). The Activity Level × Outdoors interaction was significant for predicting negative affect ($\beta = -0.206$, $SE = 0.097$, $p = .034$). Lower negative affect during physical activity was reported outdoors (vs. indoors).

Conclusions: Being with other people may enhance positive affective response during physical activity, and being outdoors may dampen negative affective response during physical activity.

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Keywords

positive affect; negative affect; social context; physical context; ecological momentary assessment

Physical inactivity has been declared a global public health problem by the World Health Organization (2008). Approximately 65% of U.S. adults report a combination of moderate- and vigorous-intensity physical activity totaling at least 150 min per week (Centers for Disease Control and Prevention, 2010), yet objective evidence from accelerometers indicates that this rate may be as low as 5% (Troiano et al., 2008). The public health significance of the problem is underscored by evidence showing that low physical activity increases risk of many serious health conditions, including coronary heart disease, Type 2 diabetes, and breast and colon cancers (Lee et al., 2012). Identifying modifiable correlates and determinants of physical activity is critical for the development of effective programs and policies.

To address the problem of physical inactivity, much research attention has been directed toward understanding cognitive, social, and environmental influences on this behavior (Bauman et al., 2012). However, many of these variables (e.g., attitudes, intentions, outcome expectancies, social support, recreational facilities) have been found to have only modest associations with physical activity in adults (Trost, Owen, Bauman, Sallis, & Brown, 2002). More recent models of physical activity engagement suggest that the affect experienced during physical activity may trigger key processes underlying the reinforcing properties of the behavior. This work is based on theories of hedonic motivation (Higgins, 2006) and operant conditioning (Skinner, 1953) on the role of affect in behavioral decision making. Behaviors that generate desirable affective states (i.e., high positive affect, low negative affect) have a greater likelihood of being performed in the future (Loewenstein, 2000). Positive affective states experienced during health-relevant behaviors may increase appetitive motivation (Updegraff, Gable, & Taylor, 2004). In contrast, negative affect experienced during health behaviors may trigger a motivational state of behavioral avoidance (Leone, Perugini, & Bagozzi, 2005). Along these lines, a small but growing number of studies have shown that experiencing a greater reward response (e.g., positive affect) and lower aversive response (e.g., negative affect) during bouts of exercise predicts greater current and future physical activity participation (Magnan, Kwan, & Bryan, 2013; Williams et al., 2008; Williams, Dunsiger, Jennings, & Marcus, 2012).

Studies on affective responses during physical activity are typically conducted in controlled laboratory settings where participants perform a standardized exercise task such as riding a stationary cycle or running on a treadmill for a specific intensity for a prescribed duration (Rose & Parfitt, 2007). This body of work has yielded the dual-mode model of affective responses to exercise (Ekkekakis, Hall, & Petruzzello, 2005), suggesting that individuals experience homogeneous pleasure responses at low-intensity physical activity and homogenous displeasure responses at high-intensity physical activity. However, there is considerable variability in positive and negative affective response at moderate-intensity levels (Ekkekakis, Parfitt, & Petruzzello, 2011). In these situations, contextual features of the physical activity setting may enhance or diminish the affective response.

Two core contextual dimensions that may play a particularly important role in modulating mechanisms involved in affective response are the physical and social features of a setting. Attention restoration theory (Kaplan, 1995) suggests that outdoor and natural settings offer engaging stimuli that can restore attentional fatigue and bolster concentration, leading to positive affective responses. Supporting this hypothesis, studies have shown that exercising outdoors is associated with greater feelings of revitalization and positive engagement; decreases in tension, confusion, anger, and depression; and increased energy as compared with indoor exercise (Thompson Coon et al., 2011). A greater positive affective response may also occur when the physical activity facilitates opportunities for social interaction (i.e., exercising with others). Plante, Gustafson, Brecht, Imberi, and Sanchez (2011) found that exercising with a friend is more enjoyable and offers more stress reduction benefits than exercising alone. However, these lines of research typically use retrospective measures of affective state, which may be prone to errors and biases (Sato & Kawahara, 2011), and examine structured activity bouts under experimental conditions instead of self-selected activities in free-living settings.

These methodological limitations may be addressed through real-time data capture strategies such as ecological momentary assessment (EMA) or experience sampling methods (Shiffman, Stone, & Hufford, 2008). EMA may reduce recall errors and biases that threaten retrospective self-report, and EMA methods enhance ecological validity by measuring affect and behaviors in the settings where they naturally occur (Schwarz, 2007). This strategy makes it possible to examine concurrent exposures and events (Dunton & Atienza, 2009). To date, a small but growing number of studies have applied EMA methodologies to examine affective responses to physical activity in adults (Bossmann, Kanning, Koudela-Hamila, Hey, & Ebner-Priemer, 2013; Ebner-Priemer, Koudela, Mutz, & Kanning, 2012; Kanning, Ebner-Priemer, & Brand, 2012; Kanning, Ebner-Priemer, & Schlicht, 2013; Schlicht, Ebner-Priemer, & Kanning, 2013; Wichers et al., 2012). EMA has also been used to test the effects of social and physical contexts on adults' concurrent activity levels (Liao, Intille, & Dunton, 2015). To date, there is only one known published study capitalizing on EMA methodology to investigate how affective responses to physical activity differ by context (Kanning, 2012). However, that research examined the effect of activity level and context on subsequent (instead of concurrent) affective states. It also operationalized context as the purpose of the behavior (i.e., for work, transport, chores, leisure) and did not specifically assess where (e.g., indoors, outdoors) or with whom (e.g., alone, with others) activities were taking place.

The current study moves beyond prior work in this area by using EMA to examine whether affective responses during physical activity differ across specific social and physical contexts. The primary objective was to determine whether momentary physical activity level (i.e., being physically active at the time of assessment) moderated differences in affective response across contexts. Building on preliminary evidence that exercising with people may be more enjoyable than exercising alone (Plante et al., 2011), we hypothesized that individuals would experience higher positive affect (and lower negative affect) when engaging in physical activity with someone as compared with being alone. We also expected that individuals would report higher positive affect (and lower negative affect) when physical activity was performed outdoors as compared with indoors, expanding from initial studies on potential psychologically restorative benefits of outdoor physical activity (Thompson Coon et al., 2011).

Method

Participants and Recruitment

Participants included healthy adults living in and around Chino, California (a suburban community located about 35 miles east of downtown Los Angeles). The current study analyzed data from a longitudinal study called Project MOBILE (Measuring Our Behaviors in Living Environments), which investigated the effects of environmental and intrapersonal factors on health behavior decision-making processes. Recruitment occurred through a number of channels, including posters placed at community locations, letters sent to places of residence, and references from other research studies. Inclusion criteria consisted of the following: (a) age 25 years or older, (b) residence in Chino or a surrounding community, and (c) ability to answer electronic EMA surveys while at work. Participants were excluded who (a) did not speak and read fluently in English, (b) had an annual household income greater than $210,000, (c) regularly performed more than 150 min per week of exercise or physical activity, and (d) had physical limitations making them unable to exercise. High-active and high-income individuals were excluded because the goal of the larger study was to examine how neighborhood environmental features promote physical activity initiation in individuals at elevated risk for obesity (i.e., low-active and low-to-moderate income). Individuals who met the eligibility criteria were scheduled for a data collection appointment at a local community site or their home. This research was reviewed and approved by the Institutional Review Board at the University of Southern California.

Study Design

Each participant completed three data collection waves of EMA (each separated by 6 months). No data collection took place from late July to August and during January because of the extreme temperatures and weather in the study sites, which can alter physical activity patterns.

Procedure

EMA data were collected through a mobile phone (HTC Shadow, T-Mobile U.S.A., Bellevue, WA) with a custom version of the MyExperience software installed (Froehlich, Chen, Consolvo, Harrison, & Landay, 2007). The software was programmed to display electronic question sequences and response choices on the mobile phone screen. Each wave of data collection lasted 4 days (Saturday–Tuesday). Eight EMA surveys were prompted per day between the hours of 6:30 a.m. and 10 p.m. Each EMA survey was prompted at a random time within eight preprogrammed windows to ensure adequate spacing across the day. Upon receiving a phone signal, participants were instructed to stop their current activity and complete a short electronic EMA question sequence. This process required 2–3 min. If a signal occurred during an incompatible activity (e.g., sleeping or bathing), participants were instructed to ignore it. If no entry was made, the phone emitted up to three reminder signals at 5-min intervals. After this point, the electronic EMA survey became inaccessible until the next recording opportunity. Participants were asked to wear a waist-worn accelerometer during waking hours across the 4 monitoring days of each wave. Paper questionnaires and anthropometric assessments were conducted at an in-person session at the beginning of each wave. All items were administered in English. Participants were compensated up to $50 for each wave of the study based on their compliance with the EMA procedures.

Measures

Activity level.—During each EMA question sequence, participants were asked to indicate their current activity level, "What were you DOING right before the beep went off [Choose your main activity]?" with response options "reading/computer," "watching TV/ movies," "eating/drinking," "physical activity/exercising," and "other." They were instructed to indicate "physical activity/exercising" for any activity that raised their heart rate and made them breath harder. If "physical activity/exercising" was selected, the participant received the follow-up question, "What type of PHYSICAL ACTIVITY/EXERCISE?" If a participant responded "other" to the initial question, he or she received the follow-up question, "What was this OTHER activity?" with response options "talking on the phone," "cooking/chores," "riding in a car," "childcare/helping children," and "something else." If he or she indicated "something else," the question "Were you (sitting, standing, walking, jogging/running)?" was shown. Responses indicating "physical activity/exercising" and "jogging/running" were coded as *physical activity*. All other responses were coded as *not physical activity*. These EMA-reported physical activity items have been validated again accelerometer measures (Dunton, Liao, Kawabata, & Intille, 2012).

Social and physical context.—The EMA question sequence also asked participants to indicate their current physical and social context. Participants were asked to answer either "yes" or "no" to indicate whether they were alone. If not alone, they received a series of follow-up questions requiring "yes" or "no" responses to indicate whether they were with their "spouse," "child(ren)," "other family members," "friend(s)," "coworkers," "other types of acquaintances," or people they did not know. Responses to these items were used to create a summary variable for social context (alone vs. not alone). Participants were also asked, "WHERE were you just before the beep went off?" with response options, "home (indoors)," "home (outdoors), "work (indoors)," "outdoors (not at home)," "car/van/truck, and "other." If "outdoors (not at home)" was selected, the participant received the follow-up question, "WHERE were you OUTDOORS just before the beep went off?" Responses to these items were used to create a summary item for physical context (outdoors vs. indoors). To limit the length of each EMA survey, a randomly programmed 60% of the EMA prompts asked the questions about social and physical context.

Positive and negative affect.—The EMA affect items covered the two fundamental dimensions of affect posited by the circumplex model: valence (ranging from pleasure to displeasure) and arousal (ranging from activation to deactivation; Posner, Russell, & Peterson, 2005). To assess positive affect, items were selected to represent activated (happy, cheerful) and deactivated (calm or relaxed) pleasure (three items total, Cronbach's alpha = .85). Negative affect items represented combinations of activated (nervous or anxious, stressed) and deactivated (sad or depressed, frustrated or angry) displeasure (four items total, Cronbach's alpha = .84). Participants were asked to indicate the extent to which each affective state was felt just before the auditory EMA prompt. Response options included "not at all," "a little," "moderately," "quite a bit," and "extremely." To limit potential participant burden, a randomly programmed 60% of the total EMA prompts included the affect items. Thus, the likelihood of receiving a context and affect question together in the same EMA survey was .60 × .60 = .36.

Activity intensity.—The Actigraph GT2M model activity monitor (firmware v06.02.00; Pensacola, FL) provided an objective measure of physical activity intensity to be included as a covariate. The device was worn on the right hip attached to an adjustable belt. Actigraphs were not worn when sleeping, bathing, or swimming. A 30-s epoch was used. The moderate-to-vigorous physical activity (MVPA) threshold was 2,020 counts per minute (equivalent to 3 metabolic equivalents [METs]), consistent with studies using national surveillance data (Troiano et al., 2008). Activity intensity was operationalized by the minutes of MVPA occurring in the 30 min surrounding each EMA prompt (i.e., 15 min before and 15 min after). EMA entries with a total of zero activity counts in the 30 min surrounding each EMA prompt were considered accelerometer nonwear and excluded from analyses.

Body mass index (BMI) and waist circumference.—At Wave 1, research staff measured height and weight using an electronically calibrated digital scale (Tanita WB-110A) and professional stadiometer (PE-AIM-101) to the nearest 0.1 kg and 0.1 cm, respectively. BMI was calculated (kg/m^2). Waist circumference (in cm) was measured.

Demographic and time variables.—Participants' age, sex, ethnicity, race, and annual household income were assessed through a self-report paper-and pencil questionnaire at Wave 1. Each EMA survey was also coded for whether it occurred on a weekend day or weekday and the time of day that it occurred (i.e., morning [6:30–11:59 a.m.], afternoon [12–5:59 p.m.], or evening [6–10 p.m.]).

Data Analyses

Descriptive statistics for demographic characteristics were calculated with individual participant as the unit of analysis (Level 2); all other descriptive statistics use occasions (i.e., EMA prompts) as the unit of analysis (Level 1). Data were analyzed with multilevel modeling in HLM (Version 7) using the HLM2 procedure. Multilevel models adjust the standard errors for clustering of EMA prompts (Level 1) within people (Level 2; Bryk & Raudenbush, 1992). A series of multilevel logistic regression models were run to examine whether any demographic or temporal variables were associated with EMA compliance, operationalized as a binary outcome (0 = unanswered prompt and 1 = answered prompt). Multilevel models also tested whether positive and negative affect were associated with participant age, sex, ethnicity, BMI, waist circumference, number of EMA-reported bouts of physical activity, day of the week, time of day, and data collection wave to determine whether any of these variables should be included as model covariates.

Multilevel models tested whether momentary activity level moderated the association of being alone (vs. with other people) and being outdoors (vs. indoors) with concurrent affective state. Random intercepts models were estimated. Between-subjects and within-subject versions (i.e., partitioning the variance) of the main effects were generated (Hedeker, Mermelstein, & Demirtas, 2012). The between-subjects version represents the individual mean deviation from the grand mean, and the within-subject version represents deviation from one's own mean at any given prompt (Curran & Bauer, 2011). Similarly, the between-subjects and within-subject variation terms for binary predictors were created using grand mean-centering (i.e., subtracting by the group mean proportion) and person mean-centering (i.e., subtracting by the individual mean proportion) methods, respectively. Interaction terms were created by multiplying the within-subject person-mean centered values for the predictor variables (i.e., Positive Affect × Alone and Positive Affect × Outdoors). Multilevel models entered the activity level by context interaction terms together with its constituent main effects in Level 1.

All models controlled for within-subject and between-subjects variation in activity intensity (i.e., MVPA minutes measured by accelerometer in the ±15 min surrounding the EMA prompt). Data were collapsed across all three data collection waves. Models testing the effects on positive and negative affect were run separately. Robust standard errors were generated because the distribution of responses for negative affect was positively skewed (skewness statistic = 2.089, *SE* = 0.040). HLM 7 calculates robust standard errors using the Huber/White or sandwich estimator (White, 1982) to obtain corrected tests and confidence intervals when there are nonnormally distributed outcome data. Equations 1 and 2 show the general form of the multilevel models tested, where i indicates individual and t indicates occasion or time (i.e., EMA prompt).

Level 1 model (Equation 1).

$$
\begin{aligned}
AFFECT_{ti} = \pi_{0i} + \pi_{1i} * (ACTIVITY_{ti}) + \pi_{2i} * (CONTEXT_{ti}) \\
+ \pi_{3i} * (ACTIVITY \times CONTEXT) \\
+ \pi_{4i} * (INTENSITY) + \ldots \\
+ \pi_{ki} * (Level\ 1\ COVARIATES) + e_{ti}\,.
\end{aligned}
$$

Level 2 model (Equation 2).

$$
\begin{aligned}
\pi_{0i} = \beta_{00} + \beta_{01} * (ACTIVITY_i) + \beta_{02} * (CONTEXT_i) \\
+ \beta_{03} * (INTENSITY_i) + r_{0i}\,. \\
\pi_{1i} = \beta_{10}\,. \\
\pi_{2i} = \beta_{20}\,. \\
\pi_{3i} = \beta_{30}\,. \\
\pi_{5i} = \beta_{k0}\,.
\end{aligned}
$$

Results

Participant Characteristics

A total of 116 adults participated in the study. Of these individuals, 90 (78%) had three waves of data, 11 (9%) had two waves of data, and 15 (13%) had one wave of data.

Demographic characteristics for the sample are shown in Table 1. Participants were mainly female (72%) and overweight or obese (61%). Individuals ranged in age from 27 to 73 years, with an average age of 40.5 years (*SD* = 9.5). The sample was 30% Hispanic/Latino. Twenty-four percent had an annual household income less than $40,000. Approximately 5% participants engaged in >150 min per week of MVPA during all three data collection waves according to the accelerometer data. The number of waves of data available was unrelated to participants' age, sex, ethnicity, income, BMI, and waist circumference.

EMA Compliance

On average, participants answered 83% (range = 46–100) of EMA prompts, yielding 7,910 Level 1 observations (*M* = 68.19, *SD* = 22.20, range = 10–96 per participant). EMA compliance rates were higher during the third wave of data collection (87%) than the first wave (82%; β= 0.323, *SE* = 0.113, *p* = .006). EMA compliance also differed by day of the week and time of day, with participants exhibiting higher EMA compliance on weekdays (85%) than weekend days (82%; β = 0.201, *SE* = 0.079, *p* = .013) and in the afternoon (85%) than the morning (82%; β = 0.251, *SE* = 0.080, *p* = .003). Individuals with greater BMI score (β = −0.027, *SE* = 0.012, *p* = .020) or waist circumference (β= −0.010, *SE* = 0.005, *p* = .036) had significantly lower EMA compliance. However, EMA compliance rates did not differ by age, sex, ethnicity, or annual household income. Accelerometers were not worn during 1,572 of the answered EMA prompts, leaving a Level 1 sample size of 6,338 observations. After taking into account planned EMA item skip patterns, between 2,068 and 2,281 Level 1 observations remained for each analysis.

Descriptive Statistics

Overall, participants reported a nonphysical activity in 91.3% and a physical activity in 8.7% of EMA surveys. The breakdown of nonphysical activity was as follows: 18.1% reading/computer, 17.4% watching TV/movies, 12.0% eating/drinking, 9.9% riding in a car, 9.1% cooking/chores, 6.0% talking/on the phone, 4.6% childcare/helping children, 22.9% other. In total, 108 participants had at least one EMA-reported instance of physical activity during the three waves of data collection. Across these individuals, there were a total of 549 instances of physical activity (*M* = 5.2, *SD* = 4.2, range = 1–18 per participant), which consisted of walking (55%); running, jogging, or using cardiovascular equipment (7%); weight lifting or strength training (6%); bicycling (3%); and other (29%). For EMA prompts when physical activity was reported, 37% occurred alone, 40% occurred with one's children present (with or without other adults), 8% occurred with one's spouse present (without children but with or without other adults), and 15% occurred with other adults (without one's children or spouse). When physical activity was reported, 62% of EMA prompts indicated being outdoors. Specific locations for outdoor physical activity were as follows: 22% at home outdoors, 14% at a park or trail, and 26% in other outdoor locations. Given the small numbers that remained in each response category after breaking down EMA-reported physical activity by type of social company, type of outdoor location, and type of physical activity/exercise, it was not possible to run further statistical tests to examine differences in affective response across these categories. On average, participants engaged in 0.75 min (*SD* = 2.13, range = 0–30) of MVPA in the ±15-min window surrounding each EMA prompt and a total of 22.24 min (*SD* = 14.43, range = 4.39–96.20) of MVPA per day. This daily level of physical activity is similar to the average recorded for adults using accelerometers national surveillance studies (Troiano et al., 2008).

Across all EMA reports (i.e., both physical activity and nonphysical activity), the average ratings for positive and negative affect were 3.06 (*SD* = 0.98) and 1.44 (*SD* = 0.64) on a 5-point response scale, respectively. Neither positive affect nor negative affect was associated with participant age, sex, ethnicity, BMI, waist circumference, number of EMA-reported bouts of physical activity, or data collection wave. Positive affect was significantly higher on weekend days as compared with weekdays (β= 0.290, *SE* = 0.036, $p < .001$), and in the afternoon (β = 0.083, *SE* = 0.035, $p = .021$) and evening (β= 0.123, *SE* = 0.039, $p = .001$) as compared with in the morning. Negative affect was lower in the evening as compared with in the morning (β = −0.069, *SE* = 0.025, $p = .007$). Therefore, day of the week and time of day were entered as Level 1 covariates in all subsequent models.

Social Contextual Influences on Affective Response During Physical Activity

Table 2 shows that results of the multilevel models testing whether momentary activity level moderated the association of being alone (vs. with other people) and being outdoors (vs. indoors) with concurrent affective state. Results indicated a statistically significant interaction for Activity Level × Alone for predicting positive affect (β = −0.302, *SE* = 0.133, $p = .024$). Examination of the simple effects showed that greater positive affect during physical activity was reported when with other people (vs. alone; see Figure 1). The Activity Level × Alone interaction was not significant for negative affect.

Physical Contextual Influences on Affective Response During Physical Activity

The results of multilevel models examining whether momentary activity level moderated the differences in affective states while outdoors (vs. indoors) are displayed in Table 3. Individuals reported greater positive affect when outdoors than when indoors (β= 0.265, *SE* = 0.044, $p < .001$; main effects data not shown). However, being physically active did not moderate differences in positive affect while outdoors versus indoors, as indicated by the nonsignificant coefficient for the Activity Level × Outdoors interaction. However, the Activity Level × Outdoors interaction was significant for predicting negative affect (β = −0.206, *SE* = 0.097, $p = .034$). Examination of the simple effects showed that lower negative affect during physical activity was reported outdoors (vs. indoors; see Figure 2).

Discussion

The current study is the first known attempt to use a real-time data capture strategy to examine how being alone and outdoors are associated with one's affective response during physical activity in naturalistic settings encountered in everyday life. Results indicated that higher positive affect was reported when engaging in physical activity with other people as compared with being alone. Also, higher negative affect was reported when engaging in physical activity indoors as compared with outdoors. Thus, variability in affective response during physical activity appeared to be related to where and with whom the activity was performed.

These findings shed light on the relevance of social context to mood-enhancing effects of engaging in physical activity. Results showed that positive affective benefits of physical activity were greater when the behavior was performed in the presence of other people as compared with being alone. These findings fall in line with a large body of evidence linking social connectedness and support to affective well-being (Okun & Keith, 1998). The nonsignificant coefficient for the between-subjects effect of being alone on positive affect suggests that the observed results are not explained by a tendency for individuals with lower positive affect than average to spend more time alone. Understanding the mechanisms linking social company to augmented positive affective response during physical activity is an important area for future work. Approximately half of the physical activity reported through EMA in the current study consisted of walking, of which equal proportions were performed with others and alone. One explanation is that the positive social interactions such as social support, empathy, companionship, or entertaining conversations occurring while walking can boost positive affect, as has been shown in related literature (Vranceanu, Gallo, & Bogart, 2009). Alternatively, group-oriented physical activities such as classes and team sports may heighten positive affective response by providing greater challenge, or more opportunities for skill-building, cooperation, or feeling of success and accomplishment (Chow & Feltz, 2008).

Results from the current study also provide evidence that individuals experienced indoor physical activity as more unpleasant than physical activity performed outdoors. These findings are consistent with work on the restorative effects of nature and natural surroundings from the environmental psychology literature.(Berman, Jonides, & Kaplan, 2008). Natural environments, including being outside in one's own yard or garden, may provide a sense of escape that can promote less effortful brain functioning and reduced stress (Hartig, Böök, Garvill, Olsson, & Gärling, 1996). Results from the current study are in line with a recent systematic review, which found that across several studies, physical activity performed in indoor settings was associated with greater tension, anger, and depression than physical activity performed in outdoor settings (Thompson Coon et al., 2011). However, many of the studies included in this review had methodological concerns such as a lack of ecological validity and recall biases. The current study lends increased credibility to these findings through improvements in design and assessment including the capture of free-living activity bouts and objective activity monitoring. Despite the consistent evidence supporting the notion that outdoors settings can have beneficial effects on affective response during physical activity, a potential alternative explanation that warrants further investigation is whether certain types of physical activities that are inherently less unpleasant to some people (e.g., bicycling, team sports) need to be performed outdoors by necessity.

Despite the use of EMA and objective physical activity monitoring, the current study had limitations. The use of affect measures consisting of three to four items is not preferable, yet it is often necessary in EMA research to keep electronic surveys reasonably short to limit potential participant burden. Also, the negative affect items used (i.e., stressed, frustrated or angry, nervous or anxious, sad or depressed) may not fully capture unpleasant feelings experienced during physical activity such as discomfort, pain, boredom, or fatigue. In addition, the EMA-reported physical activity item captured activities that increased breathing and heart rate. Thus, it is not entirely known how affective responses during light-intensity physical activity (e.g., slow walking) differ across contexts. Furthermore, results reported elsewhere (Dunton et al., 2012) have indicated that, for this sample, unanswered EMA prompts had greater MVPA (±15 min) than answered EMA prompts ($p = .029$) for underweight/normal-weight participants, indicating that activity level might influence the likelihood of responding for some individuals. If this pattern of missing data had not existed, more instances of physical activity may have been reported for underweight/normal-weight participants. However, because affect scores were unrelated to BMI, we would not expect the results to be meaningfully different. Also, contextual exposure, behavior, and affect were measured concurrently. Therefore, reverse causational effects, such as being in a more positive mood leading an individual to seek out companions for physical activity, cannot be fully ruled out. However, the within-subject design reduces concerns about between-subjects confounding effects such as individuals with greater trait-level positive affect having more social companions than individuals with lower trait-level positive affect. Lastly, participants were mainly low-active women recruited from suburban communities with primarily detached single-family housing. Results may not generalize to men, highly physically active individuals, or more dense urban outdoor environments with fewer natural features and less greenspace (e.g., yards, parks).

Overall, the current findings suggest that being with other people is associated with enhanced positive affective response during physical activity, and being outdoors is associated with a dampened negative affective response during physical activity. Identifying the conditions that optimize pleasant and diminish unpleasant responses to physical activity may have important policy and programmatic implications, given the reinforcing properties of these affective experiences. If physical activity is more affectively rewarding when performed with other people and less affectively aversive when performed outdoors, then motivation to engage in future physical activity may be reinforced by encouraging and providing opportunities for adults to be physically active in these settings. Examples of these types of interventions and initiatives may include parks-based exercise programming, classes, and equipment for adults; offering personal fitness training in outdoor locations; and using social media sites to create meet-up physical activity events to connect individuals. Future work is needed to understand whether individuals who perform more physical activity in the company of other people or in outdoor locations are more likely to sustain regular patterns of physical activity over the long term.

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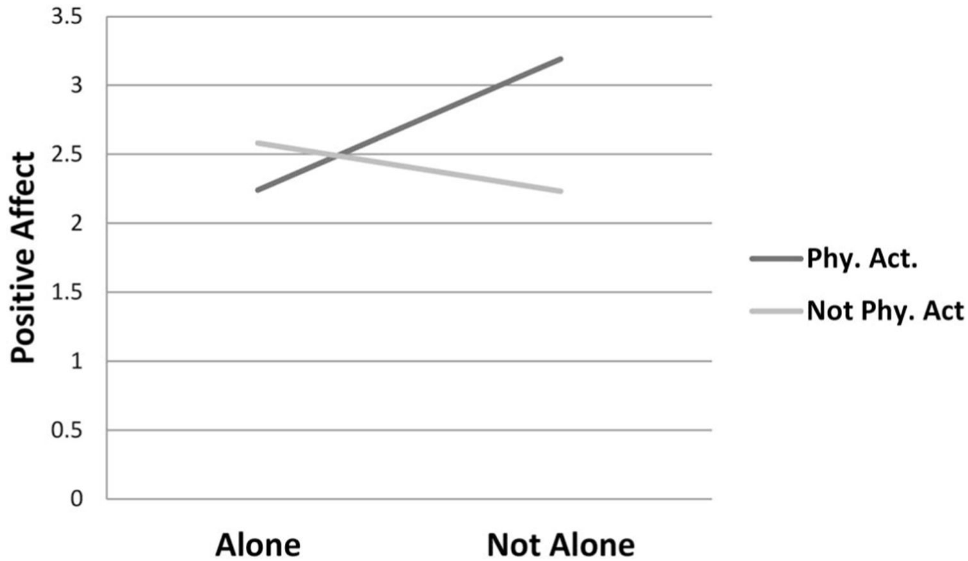

Figure 1.

Plot of the Activity Level × Alone interaction for predicting positive affect based on the unstandardized regression coefficients for the within-subjects main effects and interaction terms generated from the multilevel model. There were 2,210 Level 1 observations (*n* = 72 physical activity/alone, *n* = 123 physical activity/not alone, *n* = 782 not physical activity/alone, *n* = 1,233 not physical activity/not alone).

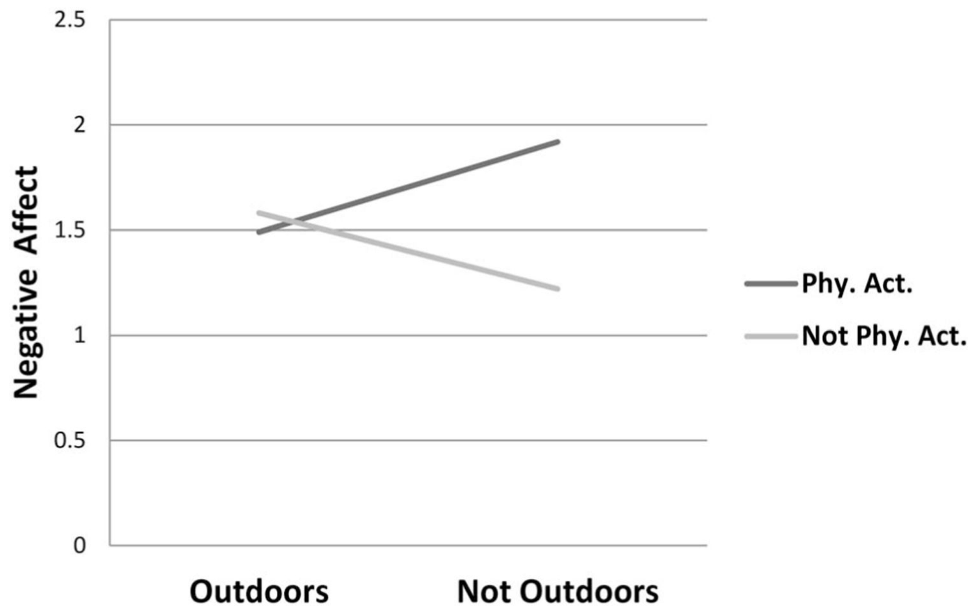

Figure 2.

Plot of the Activity Level × Outdoors interaction for predicting negative affect based on the unstandardized regression coefficients for the within-subjects main effects and interaction terms generated from the multilevel model. There were 2,092 Level 1 observations (n = 111 physical activity/outdoors, n = 62 physical activity/not outdoors, n = 252 not physical activity/outdoors, n = 1,667 not physical activity/not outdoors).

Table 1

Participant Characteristics

Variable	
Sex, *n* (%)[a]	
Male	32 (27.8)
Female	83 (72.2)
Annual household income ($), *n* (%)[b]	
<40,000	26 (23.9)
40,001–70,000	29 (26.6)
70,001–100,000	27 (24.8)
≥100,001	27 (24.8)
Ethnicity, *n* (%)[c]	
Hispanic	35 (30.4)
Non-Hispanic	80 (69.6)
Race, *n* (%)[d]	
African American	8 (7.2)
Asian	31 (27.9)
Native Hawaiian/Pacific Islander	1 (0.9)
White/Caucasian	51 (45.9)
Native American/Alaskan Native	5 (4.5)
Multiracial	11 (9.9)
Mean (*SD*) age (years)[e]	40.5 (9.5)
Mean (*SD*) body mass index	28.4 (7.2)
Mean (*SD*) waist circumference (cm)	95.9 (17.6)

Note. $N = 116$.

[a]Sex was missing for one participant.

[b]Income was missing for seven participants.

[c]Ethnicity was missing for one participant.

[d]Race was missing for five participants.

[e]Age was missing for one participant.

Table 2

Results of Multilevel Models Examining Current Physical Activity Level as a Moderator of the Effects of Social Context on Positive and Negative Affective Response

	Positive affect		Negative affect	
Level 1	***n* = 2,208**		***n* = 2,281**	
Level 2	***n* = 113**		***n* = 116**	
	β (*SE*)	***p***	**β (*SE*)**	***p***
Intercept activity intensity[a]	2.569 (0.084)	<.001	1.573 (0.063)	<.001
BS	−0.127 (0.073)	.086	0.003 (0.055)	.956
WS	0.011 (0.006)	.068	−0.005 (0.005)	.347
Alone[b]				
BS	−0.123 (0.264)	.642	0.285 (0.180)	.117
WS	−0.175 (0.046)	<.001	0.007 (0.029)	.783
Activity level[c]				
BS	1.461 (0.665)	.030	−0.255 (0.367)	.489
WS	0.128 (0.053)	.016	0.034 (0.048)	.478
Activity Level[c] × Alone[b]				
WS	−0.302 (0.133)	.024	0.080 (0.091)	.377

Note. BS = between-subjects (centered on the group mean); WS = within-subjects (centered on the person mean). Each column represents a separate model.

[a]Minutes of moderate-to-vigorous physical activity measured by accelerometer in the ±15 min surrounding the ecological momentary assessment (EMA) prompt.

[b]Currently alone = 1 versus not currently alone = 0 as self-reported through EMA.

[c]Currently engaging in physical activity = 1 versus not currently engaging in physical activity = 0 as self-reported through EMA. All models control for time of day (afternoon and evening vs. morning) and weekend day versus weekday. Random intercept multilevel models with robust standard errors are used.

Table 3

Results of Multilevel Models Examining Current Physical Activity Level as a Moderator of the Effects of Physical Context on Positive and Negative Affective Response

	Positive affect		Negative affect	
Level 1	***n* = 2,068**		***n* = 2,092**	
Level 2	***n* = 114**		***n* = 116**	
	β (*SE*)	***p***	**β (*SE*)**	***p***
Intercept activity intensity[a]	2.581 (0.092)	<.0001	1.543 (0.061)	<.001
BS	−0.135 (0.084)	.111	−0.007 (0.057)	.900
WS	−0.001 (0.006)	.900	−0.007 (0.004)	.120
Outdoors[b]				
BS	−0.122 (0.514)	.813	0.048 (0.315)	.880
WS	0.270 (0.048)	<.001	−0.027 (0.043)	.536
Activity Level[c]				
BS	1.786 (0.676)	.010	−0.551 (0.487)	.261
WS	0.049 (0.089)	.585	0.153 (0.066)	.022
Activity Level[c] × Outdoors[b]				
WS	−0.099 (0.146)	.497	−0.206 (0.097)	.034

Note. BS = between-subjects (centered on the group mean); WS = within-subjects (uncentered for dichotomous variables and centered on the person mean for continuous variables). Each column represents a separate model.

[a]Minutes of moderate-to-vigorous physical activity measured by accelerometer in the ±15 min surrounding the ecological momentary assessment (EMA) prompt.

[b]Currently outdoors = 1 versus not currently outdoors = 0 (centered on the person mean) as self-reported through EMA.

[c]Currently engaging in physical activity = 1 versus not currently engaging in physical activity = 0 (centered on the person mean) as self-reported through EMA. All models control for time of day (afternoon and evening vs. morning) and weekend day versus weekday. Random intercept multilevel models with robust standard errors are used.