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Affective Response During Physical Activity: Within-Subject Differences Across Phases of Behavior Change

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Abstract

Objective: Affective response during physical activity may be a key factor reinforcing future behavior. However, little is known about how affective responses during physical activity may differ across phases of behavior change. This study used real-time Ecological Momentary Assessment (EMA) to examine within-subject differences in affective response during physical activity in daily life as individuals transitioned across phases of behavior change.

Methods: A sample of 115 adults (M=41.0 years, 74% female) participated in an intensive longitudinal study with measurement bursts at 0-months, 6-months, and 12-months. Each burst consisted of eight randomly-prompted EMA occasions per day across four days. EMA self-report items assessed current activity level (i.e., physical activity or non-physical activity), and positive and negative affect. Questionnaires measured phase of behavior change (e.g., pre-action [no regular physical activity], action [regular physical activity <6 months], maintenance [regular physical activity ≥6 months]) at each burst. Three-level (Level-1 = occasion, Level-2 = burst, Level-3 = person) linear regression models tested phase of change (Level-2, within-person) × physical activity level (Level-1, within-person) interactions controlling for day of week, time of day, and sex.

Results: Positive affective response during physical activity (vs. non-physical activity) was higher when individuals were in pre-action phases (vs. action). Negative affective response during physical activity (vs. non-physical activity) was lower when individuals were in the maintenance phase (vs. action).

Conclusions: Long-term maintenance of physical activity may be particularly challenging, given the lack of positive reinforcement that is thought to be needed to sustain behavior.

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Keywords

positive affect; negative affect; physical activity; adoption; maintenance; stage of behavior change; ecological momentary assessment; within-subjects

Physical activity reduces risks of numerous chronic diseases, including cardiovascular disease, type 2 diabetes, and breast and colon cancers (Pate et al., 1995). These health benefits are more likely to be achieved when physical activity is performed regularly (i.e., daily) over sustained periods of time (Warburton, Nicol, & Bredin, 2006; Wen et al., 2011). However, given the amount of time and effort required to maintain regular levels of physical activity, it is not surprising that at any given time only about one in five U.S. adults meet the 2008 Physical Activity Guidelines (i.e., ≥150 min/week of moderate or ≥75 min/week of vigorous activity) (Matthews et al., 2008). Understanding the factors influencing participation in regular physical activity is an important step in the development of intervention strategies to promote activity.

A promising factor that may influence physical activity is an individual's affective (or emotional) response to engaging in the behavior. Affective states experienced while performing a behavior may have motivational and reinforcement properties according to theories of hedonic motivation (O'Connor-Fleming, Parker, Higgins, & Gould, 2006) and operant conditioning (Skinner, 1953). This line of research suggests that behaviors which generate desirable affective states (i.e., high positive affect, low negative affect) have a greater likelihood of being performed in the future (Loewenstein, 2000) because the desirable affective state reinforces the behavior. In contrast, experiencing negative affect while engaging in a behavior may decrease the likelihood of future performance because a motivational state of behavioral avoidance is triggered (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 (Liao, Chou, Huh, Leventhal, & Dunton, 2016; Magnan, Kwan, & Bryan, 2013; Rhodes & Kates, 2015; Williams, Dunsiger, Jennings, & Marcus, 2012).

Despite emerging evidence for the role of affective response in predicting future patterns of behavior, little is known about how affective responses during physical activity may differ across phases of behavior change. Stage theories of behavior change such as the Transtheoretical Model (Prochaska & Velicer, 1997) suggest that individuals progress through a series of distinct phases as they adopt and maintain a regular pattern of health behavior (Hall & Fong, 2007; Rothman, 2004; Weinstein, Rothman, & Sutton, 1998; Weinstein & Sandman, 2002). These theories make important conceptual distinctions between the pre-action phase (when the individual is considering and making plans to initiate behavior change), the action phase (when a new pattern of behavior has been recently adopted), and the maintenance phase (when a pattern of behavior has been sustained for a prolonged period of time). Levels of motivational, cognitive, and social factors influencing behavior are thought to differ across these distinct phases of behavior change (Herrick, Stone, & Mettler, 1997; Mullan & Markland, 1997). Underlying this notion is the idea that different psychological processes are activated at different phases of the behavior change continuum as a consequence of previous shifts in behavior and/or an antecedent to subsequent shifts in behavior (Rothman, 2004). Thus, not only do levels of the behavior itself vary across the phases of change, but determinants of the behavior may also differ across phases of change in a functional and adaptive manner to facilitate behavior change. Although evidence suggests that intrinsic motivation for physical activity (e.g., enjoyment, interest) increases (Mullan & Markland, 1997) and perceived affective barriers to physical activity (e.g., not liking it) decrease (Sørensen & Gill, 2008) across the phases of change from pre-action to maintenance, no known research has examined whether positive and negative affective responses measured during physical activity differ within people as they transition across these phases of behavior change.

Support for the hypothesis that affective responses during physical activity may differ in meaningful ways across phases of behavior change comes from laboratory-based studies examining emotional reactions to structured exercise bouts using cross-sectional research designs and between-person comparisons. Research in this area shows that there is considerable variability in positive and negative affective response to physical activities that bring an individual close to the ventilatory or lactate threshold (i.e., increase breathing and heart rate) (Ekkekakis, Parfitt, & Petruzzello, 2011). Individual difference factors related to past experiences with performing the behavior may explain variability in these responses. Unpleasant experiences during physical activity may diminish as training and fitness levels increase (Hallgren, Moss, & Gastin, 2010; Steptoe, Kearsley, & Walters, 1993).

Building on this previous work, the current study used a real-time data capture strategy, Ecological Momentary Assessment (EMA) (Shiffman, Stone, & Hufford, 2008), to examine within-subject differences in affective response during physical activity in daily life as individuals transition across phases of behavior change. EMA methods collect data “in the moment” across real-world settings, thus increasing ecological validity and reducing recall errors. To date, a small but growing number of studies have applied EMA methodologies to examine affective responses to physical activity in adults (Kanning, Ebner-Priemer, & Schlicht, 2013; Liao, Chou, Huh, Leventhal, & Dunton, 2017; Liao, Shonkoff, & Dunton, 2015; Schlicht, Ebner-Priemer, & Kanning, 2013; Wichers et al., 2012). Given the low rates of regular physical activity among U.S. adults (Troiano et al., 2008) coupled with the potential motivational and reinforcement properties of affective response to behavior, intervention strategies targeting affective response to physical activity by phases of behavior change could have an important public health impact.

The current study examined within-person (phase of behavior change) × within-person (activity level) interactions by collecting intensive longitudinal data (ILD) nested within a prospective cohort study. This novel approach allowed for more precise comparisons and control for person-level confounders than would be possible using a between-person (phase of change) × within-person (activity level) interaction design. Based on preliminary evidence of differences in affective response during physical activity due to training and fitness levels (Hallgren et al., 2010; Steptoe et al., 1993), it was hypothesized that individuals would experience higher positive affect (and lower negative affect) during physical activity when in the maintenance phase as compared to the action phase, and in the action phase as compared to the pre-action phases.

Methods

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 of 25 years or older, b) living in Chino, CA or a surrounding community, and c) able to answer electronic EMA surveys while at work. At baseline, 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 minutes per week of leisure-time physical activity (e.g., exercise, sports, physically active hobbies, strengthening activities), and d) had physical limitations making them unable to exercise. Highly active and high-income individuals were excluded because the goal of the larger study was to examine how neighborhood environmental features promoted 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

ILD were collected within a prospective cohort design. Each participant completed EMA measurement bursts at 0-months, 6-months, and 12-months. Each EMA measurement burst had a duration of four continuous days (Saturday – Tuesday). On each day, eight EMA surveys were prompted between the hours of 6:30am and 10:00pm. Each EMA survey was prompted at a random time within eight pre-programmed windows in order to ensure adequate spacing across the day. No data collection took place from late July-August and during January due to the extreme temperatures and weather in study sites, which can alter physical activity patterns.

Procedures

EMA data were collected using a mobile phone (HTC Shadow, T-Mobile USA, Inc.) 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 multiple-choice responses on the mobile phone screen. Upon receiving a phone signal, participants were instructed to stop their current activity and complete a short EMA question sequence by tapping on the phone’s screen. This process required two to three minutes. If a signal occurred during an incompatible activity (e.g., sleeping or bathing), participants were instructed to ignore it. EMA surveys assessed a range of behavioral and psychosocial constructs including activity type, positive and negative affect, and other constructs reported elsewhere (e.g., context, self-efficacy, outcome expectancies) (Dunton, Liao, Intille, Huh, & Leventhal, 2015; Pickering et al., 2016). If no entry was made, the phone emitted up to three reminder signals at five-minute intervals. After this point, the electronic EMA survey became inaccessible until the next recording opportunity. Paper questionnaires and anthropometric assessments were conducted at an in-person session at the beginning of each measurement burst. All items were administered in English. Participants were compensated a base rate of $20 per wave for taking part in this study. An additional $1 was paid for each EMA survey completed (up to $50 total per wave).

Measures

Activity level.—During each EMA survey, 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 breathe harder. If "Physical Activity/Exercising" was selected, participants received the follow-up question, "What type of PHYSICAL ACTIVITY/EXERCISE?" Response options included "Running/jogging," "Walking," "Weightlifting/Strength training," "Using cardiovascular equipment," "Bicycling," and "Other." If participants responded "Other" to the initial question, they 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 they 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 *non-physical activity*. These EMA-reported physical activity items have been validated against waist-worn accelerometer measures in the current study (Dunton, Liao, Kawabata, & Intille, 2012). As compared with non-physical activity, EMA-reported physical activity was associated with significantly greater moderate-to-vigorous physical activity (MVPA) in the ±15 minutes of the EMA prompt (p's< .0001).

Positive and negative affect.—EMA assessed affective response during physical activity and non-physical activity behaviors. As such, this construct represented the participants' hedonic reaction to the behavior (Williams & Evans, 2014). 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 (3 items total, Cronbach's α = .85). Negative affect items represented combinations of activated (NERVOUS OR ANXIOUS, STRESSED) and deactivated (SAD OR DEPRESSED, FRUSTRATED OR ANGRY) displeasure (4 items total, Cronbach's α = .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," "Extremely." To limit potential participant burden given the large number of constructs assessed the EMA surveys, a randomly programmed 60% of the total EMA prompts included positive affect items and 60% included negative affect items. Thus, both positive and negative valences were not assessed at every EMA prompt.

Phase of behavior change.—Phase of behavior change was assessed according to stages defined by the Transtheoretical Model (Prochaska & DiClemente, 1986). Participants were first asked to indicate whether they currently engage in regular physical activity (yes or no) as defined by being physically active for at least 75 minutes per week at a vigorous intensity (such as running, fast biking, or heavy lifting) or at least 150 minutes per week at a moderate intensity (such as brisk walking, yoga, or lawn mowing). A second question asked whether they have been regularly physically active consistently over the past six months (yes or no). This staging of behavior change scale assessed overall physical activity including leisure, transportation, household, and occupation forms. Based on responses to these two questions, individuals were categorized into (1) pre-action (not currently engage in regular physical activity), (2) action (currently engaging in regular physical activity but not consistently over the past six months), or (3) maintenance, (currently engaging in regular physical activity and doing so consistently over the past six months) at each time point.

Body Mass Index and waist circumference.—At the first measurement burst, research staff measured height and weight using an electronically calibrated digital scale and professional stadiometer to the nearest 0.1 kg and 0.1 cm, respectively. Measures were made in triplicate, and shoes were removed. Body Mass Index (BMI) was calculated (kg/m^2).

Demographic and time variables.—Participants' age, sex, ethnicity, race, and annual household income were assessed through a self-report paper-and pencil questionnaire the first measurement burst. 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 am - 11:59 am], afternoon [12:00 pm - 5:59 pm], or evening [6:00 pm - 10:00 pm]).

Data Analyses

Data were analyzed with multilevel modeling in HLM (version 7, SSI Inc.) using the HLM3 procedure. Multilevel models adjust the standard errors for clustering of EMA prompting occasions (Level-1), within measurement bursts (Level-2), within people (Level-3) (Bryk, 1992). Modeling tested whether phase of behavior change (at any given measurement burst) moderated momentary associations between activity level and concurrent affective response. Random intercept models were estimated. Between-subject (BS) and within-subject (WS) versions (i.e., partitioning the variance) of the main effects were generated (Hedeker, Mermelstein, & Demirtas, 2012). The BS version represents the individual mean deviation from the grand mean, and the WS version represents deviation from one's own mean at any given prompt (Curran & Bauer, 2011). Cross-level interactions between phase of behavior change (within-subject, Level-2) and activity level (physical activity vs. non-physical activity) (within-subject, Level-1) were tested predicting affective response. Models testing the effects on positive and negative affect were run separately. Separate models were run comparing action versus pre-action and for maintenance versus action. For models testing negative affect, robust standard errors were generated because the distribution of responses was positively skewed (skewness statistic = 2.09, SE = 0.04). HLM 7 calculates robust standard errors using the Huber/White or sandwich estimator (Huber, 1967; White, 1982) to obtain corrected tests and confidence intervals when there are non-normally distributed outcome data.

Results

Participant Characteristics

A total of 117 adults participated in the study. Of these participants, one individual did not provide any EMA data, and one individual did not respond to any phase of behavior change questions, leaving an analytic sample of n = 115 participants. Of which, n = 90 (78.3%) had three bursts of data, n = 11 (9.6%) had two bursts of data, and n = 14 (12.2%) had one burst of data. Participants were mainly female (72%) and overweight or obese (61%). Individuals ranged in age from 27–73 years with an average age of 40.4 years (SD = 9.6). The sample was 30% Hispanic/Latino. About a quarter of the participants had an annual household income of less than $40,000. The number of measurement bursts 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 7,870 Level-1 observations (M = 67.88, SD = 22.62, range = 10–96 per participant). EMA compliance rates were higher during the third burst of data collection (87%) than the first burst (82%) (β = 0.17, SE = 0.04, p < .001). 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 = 0.24, SE = 0.06, p < .001), in the afternoon (85%) than the morning (82%) (β = 0.26, SE = 0.07, p < .001), and in the evening (84%) than the morning 82%) (β = 0.18, SE = 0.08, p < .014). Individuals with greater BMI score (β = −0.03 SE = 0.01, p = .012) or waist circumference (β = −0.01 SE = 0.01, p = .037) had significantly lower EMA compliance. However, EMA compliance rates did not differ by age, sex, ethnicity, or annual household income. After taking into account planned EMA affect item random skip patterns, there were 6,583 answered EMA prompts with either positive or negative affect data.

Descriptive Statistics

Overall, participants reported engaging in a non-physical activity in 92.3% and a physical activity in 7.7% of EMA surveys. Across all participants and measurement bursts, there were a total of 498 instances of physical activity (M = 4.3, SD = 3.9, range = 0–18 per participant), which consisted of walking (51%); running or jogging (4%); cardiovascular equipment (4%); weight lifting or strength training (4%), bicycling (3%), and other (34%). Participants in the action phase (vs. pre-action phase) were almost twice as likely to report physical activity vs. non-physical activity on any given occasion (OR = 1.90, 95% CI = 1.14–3.18). However, participants in the action and maintenance phase did not differ in the likelihood of reporting physical activity vs. no physical activity on any given occasion (OR = 0.79, 95% CI = 0.44–1.42). At each burst, the number of participants in each phase of behavior change were as follows: burst 1 (n = 59 [52.2%] in pre-action, n = 16 [14.2%] in action, n = 35 [31.0%] in maintenance, n = 5 [5.2%] missing); burst 2 (n = 37 [38.5%] in pre-action, n = 17 [17.7%] in action, n = 37 [38.5%] in maintenance, n = 3 [2.7%] missing); and burst 3 (n = 50 [53.2%] in pre-action, n = 4 [4.3%] in action, n = 35 [37.2%] in maintenance; n = 5 [5.3%] missing). Of the participants with two or more bursts (n = 101), 49 (48.5%) did not change phases, 33 (32.7%) changed phases once, and 19 (18.8%) changed phases twice. Between any two adjacent measurement bursts, 8 participants transitioned from pre-action to action, 8 transitioned from action to pre-action, 15 transitioned from action to maintenance, and 7 transitioned from maintenance to action.

After taking into account planned EMA affect item skip patterns, 4,655 Level-1 occasions were available for positive affect, and 4,700 Level-1 occasions were available for negative affect. Across available EMA occasions (i.e., both physical activity and non-physical activity), the average ratings for positive and negative affect were 3.02 (SD = 0.64) and 1.41 (SD = 0.32) on a 5-point response scale, respectively. Neither positive affect nor negative affect was associated with participant age, ethnicity, BMI, waist circumference, number of EMA-reported bouts of physical activity, or measurement burst. Positive affect was significantly higher on weekend days as compared with weekdays ($\beta = 0.26$, SE = 0.03, $p < .001$), and in the afternoon ($\beta = 0.27$, SE = 0.03, $p < .001$) and evening ($\beta = 0.27$, SE = 0.03, $p < .001$) as compared with the morning. Negative affect was lower on weekend days as compared with weekdays ($\beta = 0.05$, SE = 0.02, $p < .001$) and higher in the afternoon as compared with the morning ($\beta = 0.07$, SE = 0.02, $p < .001$). Therefore, day of the week and time of day were entered as level-1 covariates in all subsequent models. Sex was also retained as a covariate in subsequent models given prior evidence that mood and emotional states differ between men and women (Nolen-Hoeksema, 2001; Wood, Rhodes, & Whelan, 1989).

Within-Subject Differences in Positive Affective Response During Physical Activity by Phase of Behavior Change

Table 1 shows results of the multilevel models testing whether phase of behavior change (at any given measurement burst) moderated momentary associations between activity level and concurrent positive affective response controlling for day of the week, time of day, and sex. Separate models were run comparing action versus pre-action and comparing maintenance versus action. The phase of change × physical activity interaction was significant for predicting positive affect ($\beta = -0.64$, SE=0.29, $p = .028$) when comparing action versus pre-action phases. Positive affective response during physical activity (vs. non-physical activity) was lower when individuals were in action (vs. pre-action) (See Figure 1). The phase of change × physical activity interaction predicting positive affect was not significant when comparing action versus maintenance phases ($p > .05$).

Within-Subject Differences in Negative Affective Response During Physical Activity by Phase of Behavior Change

Results of the multilevel models testing whether phase of behavior change (at any given measurement burst) moderated momentary associations between activity level and concurrent negative affective response are shown in Table 2. Separate models were run comparing action versus pre-action and for maintenance versus action. Controlling for day of the week, time of day, and sex; the phase of change × physical activity interaction predicting negative affect (β=−0.27, SE=0.13, p=.045) was significant when comparing maintenance versus action phases. Negative affective response during physical activity (vs. non-physical activity) was lower when individuals were in the maintenance phase (vs. action) (See Figure 2). The phase of change × physical activity interaction predicting negative affect was not significant when comparing pre-action versus action phases ($p > .05$).

Discussion

This research is the first known study to use real-time data capture within a longitudinal cohort study design to examine whether differences in affective response during physical activity in daily life differed as individuals transitioned across phases of behavior change. A particular strength of the study was the within × within design, which examined *within-subject differences* in affective response (during physical activity vs. non-physical activity) by *within-subject changes* in phase of change (over time). Through this design, this study was able to compare each individual to him/herself across different occasions (Level-1) and different measurement bursts (Level-2), which reduces the likelihood that findings are merely due to differences in average background levels of affective response across phases of change.

As expected, individuals experienced lower negative affect during physical activity when in the maintenance phase as compared to the action phase. Individuals who have successfully maintained regular physical activity levels for periods greater than six months may have increased cardiorespiratory reserve, thus lessening fear of and frustration with uncomfortable physical sensations that come from physical activity (Ekkekakis & Petruzzello, 1999). Also, adopting a regular physical activity routine may involve learning to avoid activities that are unpleasant or upsetting. Post-hoc multilevel modeling analyses found that activity counts per minute (measured by a waist-worn Actigraph accelerometer) in the ±15 minutes surrounding EMA prompts reporting physical activity did not differ between the action and maintenance phases within-subjects (WS coef. = 51.60, SE = 373.67, t = 0.138, df = 37, p = .891). Therefore, the observed results do not appear to be due to reductions in exercise intensity in order to sustain a set level of tolerable negative affect. Contrary to hypotheses, negative affective response during physical activity did not differ between the pre-action and action phases. Further research is needed to understand why increases in physical activity level do not translate to decreases in negative affective response until the latter phases of change.

Also, contrary to hypotheses, positive affective response during physical activity (vs. non-physical activity) did not differ between the action and maintenance phase, and was lower when individuals were in the action phase as compared to pre-action. These results do not appear to be due to increases in exercise intensity as post-hoc analyses found that activity counts per minute (measured by accelerometer) in the ±15 minutes surrounding EMA prompts reporting physical activity did not differ between the pre-action and action phases within-subjects (WS coef. = −124.28, SE = 143.00, t = −0.869, df = 44, p = .390). Therefore, the argument that people change exercise intensity as they transition across phases of behavior change in order to maintain a desired level or positive affect is not supported. Why might individuals report experiencing a lower positive affective response during physical activity in the action as compared to pre-action phases? First, the novelty of experimenting with new physical activities in the pre-action phase may generate positive affect (e.g., enjoyment, interest, challenge learning something new) (Chen, Darst, & Pangrazi, 2001), which attenuate during the action phase when behavior is no longer new. Second, individuals may have encountered new challenges with performing regular physical activity during the action phase, including lost time and costs (Heesch, Brown, & Blanton, 2000), which may diminish pleasant experiences during the behavior. Furthermore, the lack of improvement in positive affective response during the maintenance as compared with the action phase is also noteworthy— suggesting that potential gains in cardiorespiratory fitness may not translate into greater reward experiences during the behavior.

Despite the doubly within-subjects design and use of real-time EMA, the current study had limitations. 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. A similar criticism could be made for the positive affect items, which may not capture all types of pleasant feelings experienced during physical activity such as euphoria, interest, relief, or pride. Additionally, the EMA item captured self-reported engagement in physical activity or exercising based on the perception of increased heart rate and breathing, which could vary as cardiovascular fitness changes. However, this EMA item has been shown to be valid as compared to an objective measure of exercise intensity captured through a waist-worn accelerometer (Dunton et al., 2012). Also, the study measured behavior and affect concurrently, and thus captured affective response *during* physical activity. It is possible that individuals have different patterns of affective responses following physical activity that were not assessed here. Furthermore, although a 6-month threshold for differentiating the action and maintenance phases is widely used (Prochaska & DiClemente, 1986), it has been argued that phases of behavior change may be more fluid than static with individuals fluctuating back and forth between phases during shorter periods of time (e.g., days or weeks) (Adams & White, 2004). Additionally, the current study did not examine whether differences in affective response during physical activity across phases of changes differed according to interindividual (i.e., between-subject) characteristics such as sex, age, or BMI given that 3-way cross-level interaction tests would be required. Further, the impact of other variables such as major life stressors, depression, and anxiety on affective response to physical activity is not known. Given the goal of this study was to examine self-selected physical activities in the normal daily life of free-living individuals, we were unable to control the type, purpose, or context of the behavior. Therefore, results may reflect volitional changes in these mutable characteristics of physical activity behavior. Future research should investigate whether affective response to the same behavior type differs by phase or whether differences in affective response are due to differences in behavior characteristics. Additionally, the effect sizes for the simple effects of differences in positive and affect response during physical activity vs. non-physical activity were generally small (Cohen's f^2 = 0.05–0.02). However, observed phase of behavior change differences in mean positive and negative affect ratings during physical activity represented a 19% decrease from pre-action to action and a 20% decrease action to maintenance, respectively. Lastly, participants were mainly women who engaged in lower levels of leisure-time physical activity at baseline. Results may not generalize to men or individuals who perform high levels of leisure-time physical activity (such as marathon runner, athletes, or adults involved in organized sports).

From a broader theoretical perspective, affective responses during physical activity may serve as a motivational impetus that connects prior behavioral experiences with the likelihood of continuing those behaviors in the future. Rothman and colleagues (Baldwin et al., 2006; Rothman, 2004) contend that a key feature differentiating the phases of initial behavior change response from continued behavior change response is a shift of attention from one's expectations of the behavior to one's experiences of the behavior. The extent to which an individual has a positive or negative affective response during a behavior may be a *consequence* of their past encounters with the behavior as well as an *antecedent* to engaging in subsequent behavior. Indeed, anticipated affect (i.e., emotional response that one expects to experience in the future) has been shown to influence physical activity behavior in a number of studies (Dunton & Vaughan, 2008; Williams & Evans, 2014). How phase changes in affective response during physical activity contribute to the likelihood of success at long-term behavior maintenance is an important question for future research. A declining negative affective response may not be as motivating as a growing positive affective response, making the long-term maintenance of physical activity particularly challenging. The extent to which people fail to have pleasant experiences with behaviors may reduce their motivation to continue performing those behaviors through the later phases of maintenance (Prochaska & DiClemente, 1986). To address this problem, interventions strategies could be developed to target individuals who have recently adopted or re-adopted a regular physical activity routine in order to identify types of activities that can boost positive affective responses (e.g., fun and enjoyment) in order to support the transition to maintenance. Given the lack of intervention success at sustaining behavior maintenance (Fjeldsoe, Neuhaus, Winkler, & Eakin, 2011), efforts targeting affective response to physical activity may be a promising direction of focus.

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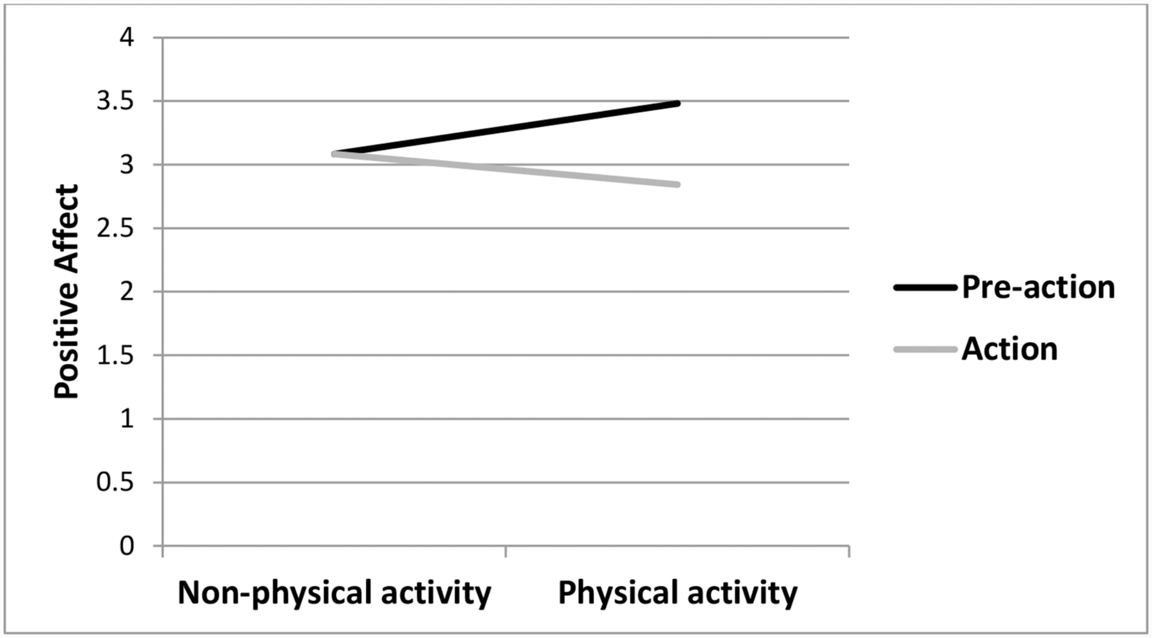

Figure 1.

Plot of the phase of behavior change (within-subject) × activity level (within-subject) interaction for predicting positive affect based on the unstandardized regression coefficients for the within-subject main effects and interaction terms generated from the multilevel model. n = 2,760 Level-1 observations (n = 54 Physical activity/Action, n = 149 Physical activity/Pre-action, n = 502 Non-physical activity/Action, n = 2,055 Non-physical activity/Pre-action)

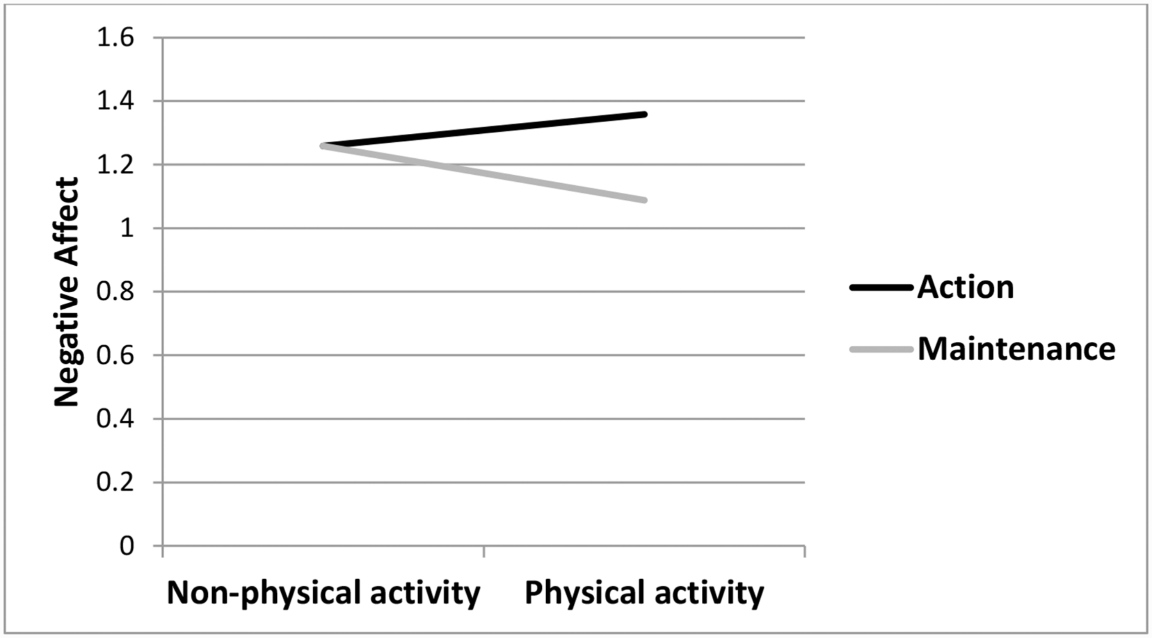

Figure 2.
Plot of the phase of behavior change (within-subject) × activity level (within-subject) interaction for predicting negative affect based on the unstandardized regression coefficients for the within-subject main effects and interaction terms generated from the multilevel model. n = 2,257 Level-1 observations (n = 131 Physical activity/Maintenance, n = 52 Physical activity/Action, n = 1,582 Non-physical activity/Maintenance, n = 492 Non-physical activity/Action)

Table 1

Results of Multilevel Models Examining Phase of Behavior Change as a Moderator of the Within-Subject Effects of Physical Activity Level on Positive Affective Response

Pre-action (Pre-A) vs. Action (A) Phases					Action (A) vs. Maintenance (M) Phases				
	n					***n***			
Level-1 (occasion)	2,760				Level-1 (occasion)	2,247			
Level-2 (burst)	183				Level-2 (burst)	144			
Level-3 (person)	93				Level-3 (person)	75			
	β (SE)	*p*	*t*	*df*		*β (SE)*	*p*	*t*	*df*
Intercept	2.86 (0.20)	<.001	14.02	89	Intercept	3.03 (0.23)	<.001	13.28	71
Sex[a]	−0.19 (0.15)	.214	−1.25	89	Sex[a]	−0.11 (0.16)	.496	−0.68	71
Afternoon[b]	0.30 (0.04)	<.001	7.89	2479	Afternoon[b]	0.15 (0.039)	<.001	3.77	2023
Evening[b]	0.29 (0.04)	<.001	6.68	2479	Evening[b]	0.21 (0.04)	<.001	4.71	2023
Day of Week[c]	0.29 (0.03)	<.001	8.85	2479	Day of the Week[c]	0.19 (0.03)	<.001	5.66	2023
Activity Level[d]					Activity Level[d]				
BS	2.29 (1.13)	.046	2.02	89	BS	0.89 (1.10)	.419	0.81	71
WS	0.40 (0.07)	<.001	6.08	2479	WS	0.19 (0.06)	.003	2.95	2023
Phase of Change (A vs. Pre-A)[e]					Phase of Change (M vs. A)[f]				
BS	−0.18 (0.18)	.310	−1.01	89	BS	0.47 (0.20)	.021	2.36	71
WS Activity Level[d] × WS Phase of Change (A vs. Pre-A)[e]	−0.64 (0.29)	.028	−2.19	2479	WS Activity Level[d] × WS Phase of Change (M vs. A)[f]	−0.11 (0.20)	.579	−0.55	2023

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

[a]Male = 1 versus Female =0.

[b]Reference group is morning.

[c]Weekend day = 1 versus weekday = 0.

[d]Currently engaging in physical activity = 1 versus not currently engaging in physical activity = 0.

[e]Action (A) = 1 versus pre-action (Pre-A) = 0.

[f]Maintenance (M) = 1 versus action (A) = 0.

Multilevel models include a random intercept.

Table 2

Results of Multilevel Models Examining Phase of Behavior Change as a Moderator of the Within-Subject Effects of Physical Activity Level on Negative Affective Response

Pre-action (Pre-A) vs. Action (A) Phases					Action (A) vs. Maintenance (M) Phases				
	n					***n***			
Level-1 (occasion)	2,805				Level-1 (occasion)	2,257			
Level-2 (burst)	183				Level-2 (burst)	144			
Level-3 (person)	93				Level-3 (person)	75			
	β (SE)	*p*	*t*	*df*		*β (SE)*	*p*	*t*	*df*
Intercept	1.37 (0.12)	<.001	11.54	89	Intercept	1.19 (0.12)	<.001	9.96	71
Sex[a]	0.07 (0.09)	.466	0.73	89	Sex[a]	0.12 (0.09)	.165	1.40	71
Afternoon[b]	0.08 (0.03)	.003	3.33	2524	Afternoon[b]	0.08 (0.03)	.005	2.81	2033
Evening[b]	0.01 (0.09)	.704	0.38	2524	Evening[b]	−0.01 (0.03)	.827	−0.22	
Day of Week[c]	−0.09 (0.03)	.010	−2.97	2524	Day of the Week[c]	0.001 (0.03)	.980	0.03	2033
Activity Level[d]					Activity Level[d]				
BS	−0.48 (0.62)	.449	−0.76	89	BS	0.18 (0.64)	.780	0.28	71
WS	0.10 (0.05)	.049	1.97	2524	WS	−0.10 (0.05)	.061	1.88	2033
Phase of Change (A vs. Pre-A)[e]					Phase of Change (M vs. A)[f]				
BS	0.09 (0.11)	.391	0.83	89	BS	−0.21 (0.09)	.026	−2.28	71
WS Activity Level[d] × WS Phase of Change (A vs. Pre-A)[e]	−0.08 (0.19)	.688	−0.40	2524	WS Activity Level[d] × WS Phase of Change (M vs. A)[f]	−0.27 (0.13)	.045	−2.01	2033

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

[a] Male = 1 versus Female =0.

[b] Reference group is morning.

[c] Weekend day = 1 versus weekday = 0.

[d] Currently engaging in physical activity = 1 versus not currently engaging in physical activity = 0.

[e] Action (A) = 1 versus pre-action (Pre-A) = 0.

[f] Maintenance (M) = 1 versus action (A) = 0.

Random intercept multilevel models with robust standard errors are used.