In-task and post-task affective response to exercise: Translating exercise intentions into behaviour

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Objectives. To test whether affective response to an acute bout of exercise can predict regular voluntary exercise, and specifically whether a positive affective response helps translate intentions into behaviour.

Design. A prospective correlational design.

Methods. Participants (N = 127) recruited from the community reported intentions to engage in voluntary exercise and frequency of participation in voluntary exercise both at baseline and at a 3-month follow-up. Self-reported positive affect, negative affect, tranquillity, and fatigue were assessed during a bout of moderate intensity exercise.

Results. Within subject slopes for increases in positive affect and decreases in fatigue during exercise, and increased tranquillity and decreased fatigue post-exercise were associated with more frequent participation in exercise at follow-up. Changes in negative affect did not predict exercise at follow-up; however, this was likely due to floor effects leading to lack of baseline variability in negative affect. Importantly, a positive affective response to exercise moderated the intention–behaviour relationship, such that those who responded to exercise more favourably exhibited stronger relationships between intentions and future exercise behaviour.

Conclusions. We conclude that exercise-related increases in positive affect and tranquillity and decreases in feelings of fatigue can aid in the successful translation of exercise intentions into behaviour.

Although there is abundant evidence regarding the benefits of regular physical activity (Pate \etal, 1995; Penedo & Dahn, 2005), reports show that only about a third of UK adults over age 16 and less than half of USA adults engage in physical activity consistent with recommendations (Department of Health, 2004; Macera \etal, 2005). A substantial number of interventions have focused on social cognitive predictors of exercise behaviour including perceived benefits of and barriers to exercise, self-efficacy, and intentions, with somewhat improved success compared to educational approaches.
(Kahn et al., 2002). Nonetheless, the success of interventions based on this primarily rational cognitive perspective has been limited, especially in terms of predicting behaviour maintenance (e.g. Wadden, Vogt, Foster, & Anderson, 1998; Oman & King, 1998). It would seem reasonable to go beyond social cognitive variables and move towards the identification of other important predictors of physical activity. Predicting exercise behaviour longitudinally likely requires a transdisciplinary approach (Rosenfield, 1992), including consideration of psychological, behavioural, genetic, and physiological determinants (Dishman et al., 2006; Marcus et al., 2006).

Recently, a transdisciplinary framework was proposed for understanding the adoption and maintenance of voluntary exercise (Bryan, Hutchison, Seals, & Allen, 2007). The purpose of this framework was to broadly outline the relationships, and potential areas of overlap, between the various disciplines that contribute to the literature on exercise. Specifically, it draws upon the theories, methodologies, and extant literature on behavioural genetics, exercise physiology, and exercise psychology.

The basic premise of this framework is that the ways in which our bodies and minds respond to the physical act of exercise contribute to the motivational and self-regulatory processes involved in long-term maintenance of voluntary exercise behaviour. Among the relationships proposed by this model is the indirect effect of the subjective experience of exercise on voluntary exercise behaviour, a process of behavioural reinforcement mediated by motivation.

The subjective experience of exercise is complex and multidimensional, and likely includes a wide variety of factors, including emotional, cognitive, and self-relevant processes (e.g. self-esteem). One factor that is surely critical is the affective response to exercise. On average, acute bouts of exercise are associated with an immediate improvement in both basic affect (good/bad, pleasure/displeasure) and more distinct affective states (specific emotions and moods that contain basic affect), both in terms of increases in positive affect (e.g. happiness) and decreases in negative affect (e.g. anxiety; Reed, 2005). The quality of the affective response is far from universal, however, and some people experience no change or even deterioration of affect during exercise (Ekkekakis, Hall, & Petruzzello, 2005; Parfitt, Rose, & Burgess, 2006; Van Landuyt, Ekkekakis, Hall, & Petruzzello, 2000).

Individual differences in affective response to exercise have been shown to be a significant predictor of exercise behaviour (e.g. Annesi, 2005; Berger & Owen, 1992; Bryan et al., 2007; Carels, Berger, & Darby, 2006; Williams et al., 2008). Williams et al. (2008) recently found that responses on the Feeling Scale (Hardy & Rejeski, 1989) to an acute, moderate intensity exercise stimulus positively predicted self-reported minutes of at least moderate intensity activity at both a 6- and 12-month follow-up. In general, however, prior work is limited by small sample sizes (< 60), lack of consideration of in-task affective response (vs. pre-post changes), and/or consideration of only one assessment during exercise. More importantly, while there has been speculation as to the mechanisms by which affective response leads to greater physical activity, there are, to our knowledge, no tests of these mechanisms.

The first aim of this analysis is thus to further establish the role of affective response to an acute bout of exercise in predicting the frequency of voluntary exercise over time. That is, we predicted that there would be a simple linear relationship between affective response to exercise and subsequent exercise behaviour. We also consider possible differences in the relationship between in-task versus post-task affective response on future exercise behaviour in terms of typical frequency of voluntary aerobic exercise. While most people tend to report improvement in affect after completing a bout of
aerobic exercise, there is considerably more variability in task (Ekkekakis, 2003). Thus, it might be useful to distinguish between the influence of in-task versus post-task affective response to exercise on exercise behaviour; this is an exploratory focus in this analysis.

The second aim of this analysis is to consider a potential mechanism by which affective response influences exercise behaviour. Bandura (1977) notes that affective responses to a behaviour are likely not directly reinforcing, and suggests a mediational role of social cognitive constructs such as self-efficacy. Baumeister, Vohs, Dewall, and Zhang (2007) also argue against a direct causation account of the relationship between emotions and behaviour, and support a theory in which the experience of emotion provides feedback as to the effectiveness of a behavioural script and influences the likelihood that the behaviour would be repeated. Thus, emotion could play a role in self-regulation, specifically contributing to the volitional phase of behaviour change, i.e. the translation of intentions into action. It is often the case that people who are inactive nevertheless have positive intentions to exercise (Godin & Conner, 2008). Meta-analyses of the intention–behaviour relationship show that intentions to exercise on average explain only around 20% of the variance in behaviour (Hagger, Chatzisarantis, & Biddle, 2002; Hausenblas, Carron, & Mack, 1997). A review of experimental evidence revealed that a variety of health behaviour interventions based on the Theory of Planned Behaviour (Ajzen, 1991) led to moderate to large changes in intentions (Cohen’s $d \sim 0.66$) but only small to moderate changes in behaviour (Cohen’s $d \sim 0.36$; Webb & Sheeran, 2006). Interventions based on our existing social cognitive models appear to do well in changing intentions (a motivational phase of behaviour change), but do not fare as well in changing behaviour after intentions are taken into account (a volitional phase), especially long term.

In an effort to expand upon the existing models by considering the volitional phase of behaviour change, researchers (e.g. Kiviniemi, Voss-Hunke, & Seifert, 2007; McAuley, Jerome, Elavsky, Marquez, & Ramsey, 2003) have explored a variety of mediators and moderators of the intention–behaviour relationship, including emotion (e.g. anticipated regret; Abraham & Sheeran, 2003; self-reported affect during exercise in general; Crites, Fabrigar, & Petty, 1994). To our knowledge, no research has considered the effects of actual affective responses on the volitional processes by which intentions are translated into behaviour. In this paper, we will focus on the hypothesis that a more positive affective response to exercise will moderate the intention–behaviour relationship, thereby increasing the likelihood that those with positive intentions to exercise would follow through on those intentions. That is, we predict that intentions will be better predictors of exercise behaviour for those who experience greater increases in positive affective compared to those with less positive affective responses to exercise.

The current study assessed self-reported positive affect, negative affect, tranquillity and fatigue during a 30 min bout of moderate intensity aerobic exercise for a sample of healthy adults who varied in baseline activity level. Participants reported exercise intentions and frequency of physical activity both at baseline and 3 months later.

Method

Participants

The sample consisted of 129 adults (67 females, 62 males) from the local community in a mid-size USA metropolitan area. Our goal was to recruit healthy participants who would not be vulnerable to negative cardiopulmonary events as a result of exercise, whose
affective response would not be compromised by psychological disorder or treatment, and who were neither completely sedentary nor elite athletes. Eligible participants were between the ages of 18 and 35, non-smokers, not currently pregnant and having regular menstrual cycles, not currently on a restricted diet, not on psychotropic medications and not currently under treatment for any psychiatric disorder, not diabetic, no history of cardiovascular or respiratory disease, no flu or illness in the previous 3 months, a body mass index in the range of 18–29, and physically capable of engaging in moderate exercise activity. Sample characteristics are shown in Table 1.

Table 1. Sample characteristics

<table>
<thead>
<tr>
<th></th>
<th>Full sample (N = 129)</th>
<th>Men (N = 62)</th>
<th>Women (N = 67)</th>
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</thead>
<tbody>
<tr>
<td><strong>Age:</strong> Mean (SD)</td>
<td>22.40 (4.15)</td>
<td>22.60 (4.22)</td>
<td>22.22 (4.12)</td>
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<tr>
<td><strong>Race:</strong> N (%) White</td>
<td>102 (79.69)</td>
<td>51 (82.26)</td>
<td>51 (77.27)</td>
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<tr>
<td><strong>Current students</strong></td>
<td>112 (86.82)</td>
<td>52 (83.87)</td>
<td>60 (89.55)</td>
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<td></td>
<td>(undergraduate/graduate): N (%)</td>
<td></td>
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<tr>
<td><strong>Family income:</strong> N (%) at least US$50k</td>
<td>84 (67.74)</td>
<td>40 (64.52)</td>
<td>44 (70.97)</td>
</tr>
<tr>
<td><strong>VO₂max:</strong> Mean (SD)</td>
<td>47.51 (7.42)</td>
<td>52.04 (6.60)</td>
<td>43.45 (5.55)*</td>
</tr>
<tr>
<td><strong>Exercise at baseline:</strong> Mean days/week last 3 months (SD)</td>
<td>3.83 (1.69)</td>
<td>3.65 (1.86)</td>
<td>4.00 (1.52)</td>
</tr>
<tr>
<td><strong>Exercise at follow-up:</strong> Mean days/week last 3 months (SD)</td>
<td>3.60 (1.79)</td>
<td>3.61 (1.95)</td>
<td>3.60 (1.63)</td>
</tr>
</tbody>
</table>

*Note.* aSignificant gender difference, p < .0001.

**Measures**

**Exercise behaviour**

As we were primarily interested in voluntary exercise, our main outcome measure was typical frequency of exercise, assessed with three questions specifically targeting voluntary aerobic exercise (Bryan et al., 2007). Participants read a definition of aerobic exercise (‘Any activity that uses large muscle groups, is done for at least 20 min each time, and is done at a-level that causes your breathing to be heavy and your heart to beat faster (examples are running, swimming, bicycling, step aerobics, and basketball’). They then reported, (1) How often they engaged in aerobic exercise in the past 3 months (from 1 ‘Never’ to 7 ‘Often’); (2) The average number of days per week they engaged in aerobic exercise in the past 3 months (0–7 days per week); and, (3) How many days they engaged in aerobic exercise in the past week (0–7 days; α = .86). An index of voluntary exercise frequency (VEF) was created by standardizing each of these items and calculating the mean.

Participants also completed a self-report 7-day Physical Activity Recall (PAR); (Blair et al., 1985; Sallis et al., 1985; see a review by Pereira et al., 1997). The self-report PAR assesses total minutes of moderate, hard and very hard intensity activity in the previous seven days, and includes leisure-time aerobic exercise, and occupation-related and commuting physical activity. While interviewer-administered PARs tend to be more accurate, the self-report PAR reduces respondent burden and takes significantly less time to complete. Participants first read descriptions of physical activity that would be considered moderate, hard and very hard intensity. They then were asked to list all of the moderate, hard and very hard activities that they did during the last five weekdays and weekend, and the amount of time they spent on each activity.
At follow-up, VEF (past 3 months) was significantly correlated with total minutes of activity ($r = .35, p < .001$), minutes of very hard intensity activity ($r = .40, p < .001$), and minutes of hard intensity activity ($r = .36, p < .001$), but not with minutes of moderate intensity activity ($r = -.03, p = .77$) in the past week. VEF was most strongly correlated with total minutes of vigorous intensity (hard and very hard combined), $r = .50, p < .001$. This is consistent with the description of aerobic exercise as that which causes increased respiration and heart rate.

**Exercise intentions**

Intentions to exercise were assessed with four items: (1) How likely is it that you will talk to your friends about aerobic exercise in the next 3 months?, (2) How likely is it that you will get or buy equipment that can be used for aerobic exercise (workout clothes, special shoes) in the next 3 months?, (3) How likely is it that you will go to a recreation centre or a health club to do aerobic exercise in the next 3 months?, and (4) How likely is it that you will actually do aerobic exercise for at least 3 times a week in the next 3 months? ($\alpha = .69$), on a scale from 1 = Not at all likely, to 7 = Very likely. The item-whole correlation for item #4, which best represents the standard measurement of intentions in the TPB in which there is correspondence between the measurement of intentions and behaviour, was .48. The mean of these items was calculated to represent intentions. This measure has exhibited high reliability and predictive validity in previous work (Bryan & Rocheleau, 2002; Bryan et al., 2007), and adequate reliability in this study.

**Affect**

The physical activity affect scale (PAAS; see Lox, Jackson, Tuholski, Wasley, & Treasure, 2000) was used to assess affective response to exercise. The 12-item PAAS has four subscales: positive affect ('enthusiastic', 'energetic', and 'upbeat'; $\alpha = .94$), negative affect ('miserable', 'discouraged', and 'crummy'; $\alpha = .86$), tranquility ('calm', 'relaxed', and 'peaceful'; $\alpha = .84$) and fatigue ('fatigued', 'tired', and 'worn-out'; $\alpha = .91$). Alphas are for the present study. Participants rated their current affective state for each item on a scale from 0 ('do not feel') to 4 ('feel very strongly'). A mean score was calculated for each subscale at each time point.1

**Procedure**

Participants were recruited via posters displayed around campus and in local businesses. Interested individuals called the study phone number, and research assistants explained the study details and completed eligibility assessments. Most of those who called were eligible, and the few who were not were elite athletes or were unable to commit the

1 An ongoing quarrel in this literature concerns the measurement of exercise-related affect (e.g. Ekkekakis & Petruzzello, 2000). For a number of reasons, we chose the PAAS (Lox et al., 2000) to measure affective response in this study. The PAAS conceptualizes affective response to exercise with four subscales – positive affect, negative affect, tranquility, and fatigue (or physical exhaustion). The PAAS is sensitive to affective changes during exercise (e.g. Bryan et al., 2007) and its multi-item scales allow reliability of each subscale to be established. Convergent and discriminant validity among the factors have been established in both active and sedentary populations (Carpenter, Tompkins, Schmiege, Nilsson, & Bryan, 2009). Further, a recent investigation (Kwan et al., 2008) showed that the PAAS is theoretically supported by the circumplex model of affect (Russell, 1980), while other multi-item measures have not performed as well from this perspective (cf. Huelsman, Furr, & Nemanick, 2003).
time requested. Eligible individuals were scheduled at the university's General Clinical Research Centre (GCRC). All procedures were reviewed and approved by our university's internal review board and scientific advisory committee of the GCRC. Participants received up to US$50 as an incentive for successful completion of all parts of the study. Participants gave informed consent, completed the baseline questionnaire, and then engaged in a treadmill test of their maximal aerobic capacity (VO2max). Participants were asked to wear exercise attire and athletic shoes, to eat and drink normally, and to refrain from consuming alcohol during the 24 h prior to testing.

Consistent with established procedures (Christou, Gentile, DeSouza, Seals, & Gates, 2005; Bryan et al., 2007), VO2max was assessed via on-line computer-assisted open-circuit spirometry during incremental treadmill exercise on a motorized treadmill (Trackmaster 425 treadmill, Newton, KS). Each participant engaged in a 6–10 min warm-up period to determine a starting speed that corresponded to 70–80% of age-predicted maximal heart rate, assessed using a 12-lead EKG (Pulmonary Exercise System, St Paul, MN). They then ran or walked at this speed, with the treadmill grade increasing by 2.5% (or 2.0% at < 6.0 mph) every 2 min until volitional exhaustion. For a valid measurement of VO2max, each participant had to meet at least three of the following four criteria: (1) plateau in VO2 with increasing exercise intensity, (2) a maximal respiratory exchange ratio of ≥ 1.10, (3) achievement of age-predicted maximal heart rate (±10 beat/min), and (4) a RPE of ≥ 18 on the Borg (1985) scale. Oxygen levels were assessed using the MedGraphics Cardi02/CP system (St Paul, MN).

Participants returned to the laboratory for a submaximal exercise session about 1 week later. Participants reported pre-exercise values for the PAAS measures to serve as a baseline comparison for determining affective response to exercise. Participants then proceeded to warm up on the treadmill until they achieved 65% of their previously assessed VO2max, which (at the time) was consistent with the American College of Sports Medicine's (ACSM) definition of moderate intensity exercise (ACSM, 2000). Furthermore, as people often choose to exercise in the range of moderate intensity (Lind, Joens-Matre, & Ekkekakis, 2005), it was appropriate to examine our hypotheses at this level of intensity. Once participants achieved 65% VO2max (a warm-up period of about 3–7 min), they maintained this level of exertion for 30 min. Maintenance of 65% of VO2max during the course of the exercise bout was confirmed by both continuous heart rate and intermittent VO2 assessment using a mouthpiece. Following each affect assessment, 65% VO2max was reconfirmed, and then participants removed the mouthpiece. Heart rate was measured using a Polar S610 heart rate monitor.

The PAAS was administered at four time points during exercise (at 5, 10, and 20 min, and immediately prior to completion of the 30 min bout), and at two time points post-exercise (at 15 and 30 min). Without slowing down the treadmill, participants were presented with an enlarged version of the PAAS, and a research assistant read the items aloud and recorded their verbal responses. These time points were chosen so that, we could assess changes early in exercise as well as at multiple other time points during exercise so that nonlinear trends could be analyzed. However, because different participants required different amounts of time to warm up, these time points should not be considered strict indicators of the time course of the exercise bout, but as markers of time after 65% of VO2max was initially achieved. Following exercise, participants were allowed a 5 min cool down and then sat quietly on a chair for 30 min, during which their vital signs were monitored. Three months later, participants completed a follow-up questionnaire, re-assessing intentions, and participation in exercise during the previous 3 months.
Overview of analyses
Our hypotheses were that a positive affective response to exercise would predict more frequent participation in exercise, and that affective response would moderate the relationship between intentions and behaviour. In-task affective response was conceptualized as the rate at which affect changed during exercise, compared to baseline affect. Post-task affective response was conceptualized as reported affect at 15 min post-exercise, compared to baseline affect. Using PROC MIXED in SAS version 9.1, we first used random coefficient regression to assess within-subject trends in affective changes during exercise. Within-subject regression coefficients for the during exercise time points were calculated using separate regressions for each participant in PROC REG. We then correlated these within-subject regression coefficients with measures of participation in exercise at follow-up, controlling for baseline affect and previous exercise behaviour. We use these slopes, rather than means, because our intention is to consider an affective response to exercise, and slopes represent a response in terms of change over time. To strengthen conclusions regarding the direction of the relationship between affective response to exercise and subsequent frequency of participation in exercise, we control for previous exercise behaviour. We control for previous behaviour using the PAR measure of minutes of vigorous exercise in models predicting frequency of voluntary exercise. This is done so as to reduce the problem of shared method variance in our behavioural outcome measures (Ajzen, 2002). For the post-task affect measures, we regressed exercise behaviour at follow-up on self-reported affect at 15 min post-exercise, controlling for baseline affect. As the results were similar for the 30 min post-exercise assessments, we present only the 15 min post-exercise findings here. Finally, we explore the hypotheses that these measures of affective response to exercise would moderate the intention–behaviour relationship.

Results
Univariate analyses
As two participants did not provide follow-up data, the sample size for this analysis is 127 (98.4% follow-up rate). Means, SD and zero-order correlations for affective response measures and exercise behaviour measures are shown in Table 2. The PAR measures were log-transformed to address skewness.

In-task affective response to exercise
Random coefficient regression was used to model within subject linear and quadratic changes in affect during exercise. On average, there was a significant linear effect of time, $\beta = 0.52$, $SE = 0.09$, $p < .0001$, qualified by a quadratic effect of time, $\beta = -0.09$, $SE = 0.027$, $p = .001$, on changes in positive affect across the 5 time points immediately prior to and during exercise. Similarly, there was a significant linear effect of time, $\beta = -0.12$, $SE = 0.04$, $p = .002$, qualified by a quadratic effect of time, $\beta = 0.03$, $SE = 0.01$, $p = .002$, on changes in negative affect during exercise. There was a significant linear effect of time, $\beta = -0.62$, $SE = 0.09$, $p < .0001$, qualified by a quadratic effect of time, $\beta = 0.26$, $SE = 0.03$, $p < .0001$, on tranquillity. There was a significant linear effect of time, $\beta = -0.39$, $SE = 0.09$, $p < .0001$, on exhaustion. Participants on
Table 2. Means, SD, and zero-order correlations for affective response to exercise and exercise behaviour

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<tr>
<th></th>
<th>M</th>
<th>SD</th>
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<tbody>
<tr>
<td>1. Positive affect T0</td>
<td>1.64</td>
<td>0.91</td>
<td>1.00</td>
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<tr>
<td>2. Positive affect slope</td>
<td>0.26</td>
<td>0.29</td>
<td>-0.48***</td>
<td>1.00</td>
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<tr>
<td>3. Positive affect P15</td>
<td>2.37</td>
<td>0.95</td>
<td>-0.29*</td>
<td>1.00</td>
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<tr>
<td>4. Negative affect T0</td>
<td>0.24</td>
<td>0.51</td>
<td>-0.22*</td>
<td>-0.17</td>
<td>1.00</td>
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<td>5. Negative affect slope</td>
<td>-0.02</td>
<td>0.11</td>
<td>0.09</td>
<td>-0.10</td>
<td>-0.01</td>
<td>-0.59***</td>
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<td>6. Negative affect P15</td>
<td>0.11</td>
<td>0.33</td>
<td>-0.21*</td>
<td>-0.04</td>
<td>-0.29***</td>
<td>0.46***</td>
<td>0.20*</td>
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<td>7. Tranquillity T0</td>
<td>2.28</td>
<td>0.92</td>
<td>0.30***</td>
<td>-0.12</td>
<td>0.30***</td>
<td>-0.14</td>
<td>-0.01</td>
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<td>8. Tranquillity slope</td>
<td>0.15</td>
<td>0.24</td>
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<td>9. Tranquillity P15</td>
<td>2.91</td>
<td>0.85</td>
<td>0.33***</td>
<td>-0.02</td>
<td>0.48***</td>
<td>-0.17</td>
<td>-0.01</td>
<td>-0.32***</td>
<td>0.46***</td>
<td>0.31***</td>
<td>1.00</td>
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<tr>
<td>10. Fatigue T0</td>
<td>1.09</td>
<td>0.91</td>
<td>-0.16</td>
<td>-0.06</td>
<td>-0.18*</td>
<td>0.38***</td>
<td>-0.19*</td>
<td>0.22*</td>
<td>0.10</td>
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<tr>
<td>11. Fatigue slope</td>
<td>-0.02</td>
<td>0.32</td>
<td>0.04</td>
<td>-0.31***</td>
<td>-0.10</td>
<td>-0.22*</td>
<td>0.37***</td>
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<td>12. Fatigue P15</td>
<td>0.88</td>
<td>0.79</td>
<td>-0.22*</td>
<td>-0.24**</td>
<td>-0.44***</td>
<td>0.25**</td>
<td>0.04</td>
<td>0.43***</td>
<td>-0.04</td>
<td>0.00</td>
<td>-0.16</td>
<td>0.45***</td>
<td>0.24**</td>
<td>1.00</td>
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<td>13. Exercise frequency*</td>
<td>0.00</td>
<td>0.90</td>
<td>0.24**</td>
<td>-0.11</td>
<td>-0.03</td>
<td>-0.14</td>
<td>0.14</td>
<td>0.05</td>
<td>0.26**</td>
<td>0.05</td>
<td>-0.22*</td>
<td>-0.18*</td>
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</table>

Note. ***p < .001; **p < .01; *p < .05. Affect measures are PAAS subscale values at baseline (T0) and 15 min post-exercise (P15), and within-subject slopes for during exercise time points. *Measure is a mean of z-scores, so mean = 0 and SD = 1 is expected.
average reported gradual increases in positive affect and decreases in negative affect, tranquility and exhaustion over time, and these effects tapered off as exercise progressed. Variance components for these analyses revealed that all of the linear and quadratic trends, except those for tranquility, covaried with the intercept (i.e. reported affect at baseline). Affective response was attenuated for those who started the exercise in a more favourable affective state (possible ceiling and floor effects).

**Post-task affective response to exercise**
On average, positive affect increased significantly between baseline and 15-min post-exercise, $\beta = 0.73$, $CI_{95} = 0.56, 0.89$, $t(126) = 8.63$, $p < .0001$. Negative affect decreased significantly between baseline and 15 min post-exercise, $\beta = -0.13$, $CI_{95} = -0.21, -0.05$, $t(126) = -3.20$, $p = .002$. Tranquility increased significantly between baseline and 15 min post-exercise, $\beta = 0.63$, $CI_{95} = 0.47, 0.79$, $t(126) = 7.27$, $p < .0001$. Fatigue decreased significantly between baseline and 15 min post-exercise, $\beta = -0.21$, $CI_{95} = -0.37, -0.05$, $t(126) = -2.62$, $p = .01$.

**In-task affective response to exercise and participation in voluntary exercise at follow-up**
Within-subject slopes for the linear time trends in affective response to exercise were calculated for each participant and used as the independent variables in the following analyses. Though linear time trends were qualified by quadratic time trends, we use only the linear slopes for simplicity and ease of interpretation. All analyses control for baseline level of the relevant affect subscale and baseline minutes of vigorous activity (BVIG). There was a significant positive relationship between the linear time trend for positive affect and frequency of participation in voluntary exercise at follow-up (VEF), $\beta = 0.62$, $CI_{95} = 0.03, 1.21$, Partial $\eta^2 = .03$, $F(1, 123) = 4.37$, $p = .04$. The greater the increase in positive affect during exercise, the greater the frequency of exercise reported at follow-up. There was a significant negative relationship between the linear time trend for fatigue and VEF, $\beta = -0.85$, $CI_{95} = -1.45, -0.25$, Partial $\eta^2 = .06$, $F(1, 123) = 7.95$, $p = .006$. The greater the decrease in fatigue during exercise, the greater the frequency of exercise reported at follow-up. No significant direct effects on VEF were found for in-task negative affect ($\beta = -1.05$, $CI_{95} = -2.77, 0.67$, Partial $\eta^2 = .01$, $F(1, 123) = 1.46$, $p = .23$) or tranquility ($\beta = 0.43$, $CI_{95} = -0.26, 1.13$, Partial $\eta^2 = .01$, $F(1, 123) = 1.51$, $p = .22$), although effects were in the expected directions.

**Post-task affective responses to exercise and frequency of participation in voluntary exercise at follow-up**
Controlling for baseline tranquility and BVIG, there was a significant positive relationship between tranquility at 15 min post-exercise and VEF, $\beta = 0.25$, $CI_{95} = 0.05, 0.45$, Partial $\eta^2 = .05$, $F(1, 123) = 6.11$, $p = .02$. Similarly, there was a significant negative relationship between fatigue at 15 min post-exercise and VEF, $\beta = -0.25$, $CI_{95} = -0.47, -0.04$, Partial $\eta^2 = .04$, $F(1, 123) = 5.34$, $p = .02$. Effects were in the expected direction but not significant for negative and positive affect.
We were then interested in whether a positive affective response to exercise would moderate, and specifically strengthen, the positive relationship between baseline intentions and exercise behaviour at follow-up. There was a significant positive relationship between intentions and behaviour, $\beta = 0.33, CI_{.95} = 0.21, 0.45, \text{Partial } \eta^2 = .20, F(1, 125) = 30.47, p < .0001$. On average at baseline, participants reported very strong intentions ($M = 5.90, SD = 1.20$ on a $1-7$ scale), and $91.5\%$ of participants reported positive intentions to exercise (an intentions score greater than the mid-point on the scale). Thus, the intention–behaviour gap in this study was primarily composed of 'inclined abstainers'. We did not control for previous behaviour in these analyses because it did not predict future behaviour over and above intentions in this sample. Consistent with the moderation hypothesis, controlling for baseline positive affect, there was a significant interaction between the linear slope for positive affect and intentions for VEF, $\beta = 0.48, CI_{.95} = 0.05, 0.91, \text{Partial } \eta^2 = .04, F(1, 122) = 4.88, p = .03$, such that those who experienced more steeply improving positive affect during exercise had a more strongly positive relationship between intentions and behaviour.

We then conducted an analysis of simple effects of intentions on behaviour at three levels of changes in positive affect: no change (slope $= 0$), decrease in positive affect ($1SD$ below slope $= 0$), and increase in positive affect ($1SD$ above slope $= 0$). When there was no change in positive affect, intentions explained $5.1\%$ of the variance in behaviour at follow-up, $\beta = 0.19, CI_{.95} = 0.04, 0.34, p = .01$. When there was an increase in positive affect, intentions explained $18.1\%$ of the variance in behaviour at follow-up, $\beta = 0.33, CI_{.95} = 0.21, 0.46, p < .001$. Yet when there was a decrease in positive affect during exercise, intentions did not predict behaviour at follow-up, $\beta = 0.05, CI_{.95} = -0.19, 0.30, p = .66$.

Controlling for baseline fatigue, there was a marginal interaction between the slope for fatigue and intentions to exercise, $\beta = -0.40, CI_{.95} = -0.83, 0.04, \text{Partial } \eta^2 = .03, F(1, 122) = 3.20, p = .08$. Intentions were weaker predictors of exercise for those who experienced less steep decreases in fatigue (i.e. did not feel increasingly energized) during exercise. We again conducted analyses of simple effects of intentions on behaviour at three levels of changes in fatigue: no change in fatigue (slope $= 0$), decrease in fatigue ($1SD$ below slope $= 0$), and increase in fatigue ($1SD$ above slope $= 0$). When there was no change in fatigue during exercise, intentions explained $17.7\%$ of the variance in behaviour at follow-up, $\beta = 0.34, CI_{.95} = 0.21, 0.48, p < .001$. When there was a decrease in fatigue during exercise, intentions explained $12.9\%$ of the variance in behaviour, $\beta = 0.47, CI_{.95} = 0.25, 0.69, p < .001$. Conversely, when there was an increase in fatigue during exercise, intentions explained only $5.5\%$ of the variance in behaviour, $\beta = 0.22, CI_{.95} = 0.06, 0.38, p = .009$.

There were no such interactions with intentions for negative affect or tranquillity, although effects were in the expected direction. To address the issue of correspondence for our composite measure of intentions, we repeated these analyses using only item #4 described above. The effects were all in the same direction but statistical tests did not reach standard criteria for significance, potentially due to the lower reliability of single item scales.

Post-task affective response as a moderator of the intention–behaviour relationship

Post-task affective response similarly moderated the intention–behaviour relationship. Controlling for baseline affect, the more positive affect ($\beta = 0.22, CI_{.95} = 0.10, 0.33,$
Partial $\eta^2 = 0.09$, $F(1, 122) = 12.67$, $p < .001$) and tranquillity ($\beta = 0.14$, $CI_{95} = 0.02, 0.26$, Partial $\eta^2 = 0.04$, $F(1, 122) = 5.11$, $p = .02$), and the less negative affect ($\beta = -0.10$, $CI_{95} = -0.20, 0.00$, Partial $\eta^2 = 0.03$, $F(1, 122) = 3.61$, $p = .06$), and fatigue ($\beta = -0.15$, $CI_{95} = -0.28, -0.02$, Partial $\eta^2 = 0.04$, $F(1, 122) = 5.48$, $p = .02$) reported at 15 min post-exercise, the stronger the relationship between intentions and VEF. As with in-task responses, simple effects analyses showed that intentions were far better predictors of behaviour at more favourable levels of post-task affect (see Figure 1a-d). For positive affect at and above the mean at 15 min post-task, intentions explained 23.0% ($\beta = 0.39$, $CI_{95} = 0.26, 0.52$, $p < .001$) and 21.8% ($\beta = 0.61$, $CI_{95} = 0.40, 0.81$, $p < .001$) of the variance in behaviour, respectively. For positive affect below the mean at 15 min post-task, intentions explained only 5.0% ($\beta = 0.18$, $CI_{95} = 0.04, 0.32$, $p = .01$) of the variance in behaviour. For negative affect at and below the mean at 15 min post-task, intentions explained 19.0% ($\beta = 0.33$, $CI_{95} = 0.21, 0.46$, $p < .001$) and 18.0% ($\beta = 0.43$, $CI_{95} = 0.27, 0.60$, $p < .001$) of the variance in behaviour, respectively. For negative affect above the mean at 15 min post-task, intentions explained only 6.8% ($\beta = 0.23$, $CI_{95} = 0.08, 0.39$, $p = .004$) of the variance in behaviour. For tranquillity at and above the mean at 15 minutes post-task, intentions explained 19.4% ($\beta = 0.34$, $CI_{95} = 0.22, 0.47$, $p < .001$) and 16.2% ($\beta = 0.48$, $CI_{95} = 0.28, 0.68$, $p < .001$) of the variance in behaviour, respectively. For tranquillity below the mean at 15 minutes post-task, intentions explained only 5.8% ($\beta = 0.20$, $CI_{95} = 0.06, 0.35$, $p = .007$) of the variance in behaviour. For fatigue at and below the mean at 15 min post-task, intentions explained

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Figure 1. Intention–behaviour relationship at different levels (at the mean and one standard deviation above and below the mean) of positive affect (1a: PosAff15), negative affect (1b: NegAff15), tranquillity (1c: TRNQ15), and fatigue (1d: Fatigue15) at 15 min post-exercise.
18.5% (β = 0.34, CI_95 = 0.22, 0.48, p < .001) and 16.6% (β = 0.50, CI_95 = 0.30, 0.70, p < .001) of the variance in behaviour, respectively. For fatigue above the mean at 15 min post-task, intentions explained only 4.6% (β = 0.20, CI_95 = 0.04, 0.36, p = .02) of the variance in behaviour. These effects were the same when using only item #4 as the measure of intentions.

Summary of findings
As anticipated, affective responses to exercise influenced frequency of voluntary participation in exercise. Compared to those who exhibited no change or deterioration in affect during exercise, participants who exhibited increases in positive affect and decreases in fatigue during exercise tended to exercise more frequently in the ensuing 3 months, and had stronger intention-behaviour relationships. Importantly, intentions were quite poor predictors of behaviour when there was a decrease in positive affect or an increase in fatigue during exercise. Greater feelings of tranquillity and fewer feelings of fatigue at 15 min post-exercise was associated with reported exercising more frequently at follow-up. Finally, greater positive affect and tranquillity and less negative affect and fatigue at 15 min post-exercise were associated with stronger intention-behaviour relationships.

Discussion
The literature has long referred to the idea that a positive affective response to exercise would support maintenance of exercise over time (e.g. Dishman & Buckworth, 1996; Rodgers & Gauvin, 1998). This study provides empirical support for this hypothesis, corroborating previous research (e.g. Williams et al., 2008). As expected, those who experienced greater improvements in positive affect, tranquillity, and fatigue in response to an acute submaximal bout of exercise tended to exercise more often in the ensuing 3 months, controlling for their previous exercise behaviour. While effect sizes were small (affective response explained between 1 and 6% of the variance in exercise behaviour), it is fairly remarkable that affective response to a single bout of exercise would predict behaviour over a 3-month time period. It was a strength of this study that we were sufficiently powered to detect such effects.

We also explored differences in the effects of in-task versus post-task affective response on subsequent exercise behaviour. Though exploratory, we anticipated that affective response related to high arousal would be more relevant in-task, whereas affective response related to low arousal would be more relevant post-task. In general, there was some support for this idea. In-task, but not post-task, positive affect (positive valence/high arousal) predicted exercise behaviour at follow-up. Post-task, but not in-task, tranquillity (positive valence/low arousal) predicted exercise behaviour at follow-up. The effect of in-task negative affect (negative valence/high arousal) was slightly stronger than the effect for post-task negative affect, but neither was significant. There was no marked difference in the effects of in-task and post-task fatigue (negative valence/low arousal) on exercise behaviour. As the effect sizes for the influence of in-task versus post-task affective response on exercise behaviour were not substantially or consistently different, we conclude only that there are different aspects of the affective response to exercise in-task versus post-task that appear to influence subsequent behaviour, and not stronger effects at one point or another.
An interesting, and perhaps counter-intuitive, finding was that tranquillity decreased during exercise (even while positive affect increased), but was significantly increased over baseline at the post-task assessments. This is consistent with a conceptualization of exercise as an arousal-inducing stimulus. As the tranquillity subscale of the PAAS is correlated with increased perceptions of arousal (Kwan et al., 2008), we would expect that tranquillity (i.e. feeling calm and relaxed) would decrease during exercise, but increase once the arousing stimulus has ceased. It is therefore not surprising that it was only the change in tranquillity from baseline to post-task that predicted future exercise behaviour. We might consider an increase in feelings of tranquillity following a bout of aerobic exercise (especially, if it persists throughout the day) to be a particularly important hedonic benefit of engaging in exercise, and may represent stress-reduction effects of regular exercise behaviour.

We also found that a positive affective response to exercise strengthened the relationship between intentions and behaviour. Participants who reported steeper increases in positive affect and decreases in fatigue during exercise tended to exercise more consistently with their intentions to exercise. An important aspect of this analysis was the way in which we conceptualized affective response to exercise. It was not simply how much (mean levels) positive or negative affect someone experienced during exercise that predicted subsequent behaviour – it was the rate at which affect changed during exercise. Together, with the finding that on average exercise led to greater changes (typically improvement) in affect when baseline affect was less positive, it seems as though exercise serves as mood management. This mood management effect (feeling better, not just feeling good) is an immediate benefit of exercise. The affective response to a single bout of exercise likely affects the degree to which we expect the next bout will be similarly associated with improvements in positive or negative affect. It can be very difficult to keep long-term goals in mind in the moment (e.g. temporal construal; Trope & Liberman, 2003), and anticipating such an immediate benefit might make it easier to follow through on intentions to exercise.

Although at this point we can only speculate as to how precisely affective response to exercise might aid in the volitional control of exercise behaviour, we would like to propose a possible mechanism to motivate further research in this area. Affective response to exercise may contribute to the ease of self-regulation as described above. Successfully translating intentions into behaviour may require overcoming a sort of volitional threshold, which is thought to be determined both by the strength of the motivation and the degree to which situational difficulties exist (Achtziger & Gollwitzer, 2008). Immediate benefits such as a positive affective response to exercise may lower this volitional threshold and reduce the effort (or willpower) needed to initiate action, whereas those who anticipate that exercise will not yield any affective benefits may find it particularly difficult to exert the effort needed to be regularly physically active.

Conceptualizing the affective response to exercise as contributing to the volitional phase of exercise behaviour change may be considered in contrast to the finding that affective attitudes towards exercise (i.e. exercise in general is pleasurable, satisfying, and rewarding) play more of a motivational role (French et al., 2005; Rhodes, Blanchard, & Matheson, 2006). Although our data cannot necessarily speak to the distinction between cognitive representations of how pleasurable or satisfying exercise is when considered in general (attitudes) versus actual affective change experienced during a bout of exercise, we showed that the actual experienced affect during exercise moderated the intention–behaviour relationship. To our knowledge, this has never been shown for attitudes. Others have also made a distinction between attitudes and anticipated
emotion (Bagozzi, Dholakia, & Basuroy, 2003), and as such we support the argument that experienced affect and affective attitudes, while likely related, are distinct.

**Practical implications**
The results of this investigation may provide insight into the design of more effective exercise interventions. Perhaps, most obvious is the idea that exercise interventions based on social cognitive models would be more effective if they also focused on improving participants' affective response to exercise or on encouraging participants to notice the contingency between exercise and mood management. Beyond this, experimental research is needed to determine if interventions at the level of affective response improve the effectiveness of exercise interventions. To do this, we require a better understanding of the determinants of the affective response. This will likely require a consideration of genetic, physiological, and cognitive factors (Bryan et al., 2007; Ekkekakis, 2003).

**Limitations**
The results of this study might not generalize beyond the specific population, we studied - younger, generally healthy and fit adults living in a region of the western USA with typically high rates of physical activity who were willing to participate in a study involving aerobic exercise in a clinical setting. We therefore can only guess as to whether the affective response to exercise would serve a similar role in exercise behaviour for those in other age groups (children, older adults) or other regions, or for those with physical or mental health conditions (e.g. diabetes, depression, etc.). Also, the interpretation of these results is limited by the self-report nature of the data, particularly the measure of exercise behaviour. Future studies including a more objective assessment of exercise intensity, duration, and frequency would add to the literature.

Affective response to exercise varies not only between, but also within individuals (Van Landuyt et al., 2000), and we have no guarantee that our exercise stimulus was similar to that typical for our participants. For instance, affective response to treadmill exercise may differ in both quality and magnitude when compared to affective response to cycling, swimming, tennis, etc. However, naturalistic studies involving a wide range of self-selected exercise have shown similar relationships between exercise and affect change (Rocheleau, Webster, Bryan, & Frazier, 2004) and the affective response to one's chosen exercise type, intensity, and duration is likely to only be stronger than a response observed in an artificial setting. This suggests that if anything our controlled laboratory approach underestimates the importance of affective response to exercise in the adoption and maintenance of regular exercise behaviour.

Finally, these results do not speak to adoption of regular exercise so much as maintenance of exercise, and do not address the role of affective response to exercise among those who are not inclined to be regular exercisers. These are also issues that might be considered in future research.

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