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Exercise habit formation in new gym members: a longitudinal study

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Abstract Reasoned action approaches have primarily been applied to understand exercise behaviour for the past three decades, yet emerging findings in unconscious and Dual Process research show that behavior may also be predicted by automatic processes such as habit. The purpose of this study was to: (1) investigate the behavioral requirements for exercise habit formation, (2) how Dual Process approach predicts behaviour, and (3) what predicts habit by testing a model (Lally and Gardner in Health Psychol Rev 7:S137–S158, 2013). Participants (n = 111) were new gym members who completed surveys across 12 weeks. It was found that exercising for at least four bouts per week for 6 weeks was the minimum requirement to establish an exercise habit. Dual Process analysis using Linear Mixed Models (LMM) revealed habit and intention to be parallel predictors of exercise behavior in the trajectory analysis. Finally, the habit antecedent model in LLM showed that consistency ($\beta = .21$), low behavioral complexity ($\beta = .19$), environment ($\beta = .17$) and affective judgments ($\beta = .13$) all significantly ($p < .05$) predicted changes in habit formation over time. Trainers should keep exercises fun and simple for new clients and focus on consistency which could lead to habit formation in nearly 6 weeks.

Keywords Habit · Dual Process · Exercise · MVPA · Longitudinal

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Introduction

Incorporating 150 min of moderate-to-vigorous intensity physical activity (MVPA) a week has been associated with the prevention of at least 25 chronic health diseases and conditions (Garber et al., 2011; Warburton et al., 2007); however, most people do not meet these recommendations (Colley et al., 2011; Troiano et al., 2008). Thus, understanding factors that contribute to regular MVPA is paramount. Research in the past two decades has investigated this issue primarily through reasoned action approaches (Hagger, 2010; Head & Noar, 2014; Linke et al., 2014; Rhodes & Nasuti, 2011), that assume behavior is a volitional and reflective process (Sheeran et al., 2013). However, a combination of several recent reviews outlining the shortcomings of reasoned action approaches, combined with emerging proponents of alternative frameworks, have suggested that a movement beyond reasoned action approaches could be insightful (Ekkekakis et al., 2013; Rhodes, 2014a, 2014b; Rhodes & Nigg, 2011; Sheeran et al., 2013; Sniehotta et al., 2014). In line with this reasoning, one direction to consider are models that also incorporate unconscious processes (Sheeran et al., 2013). It has been proposed that conscious intention and unconscious processes operate parallel on behavior which is known as a Dual Process approach (see Evans, 2008 for review). Based on previous conscious rational models, social cognitive theorists propose intention to be the strongest predictor of behavior, thus suggesting intention as the primary conscious motive for behavior (Ajzen, 1991; Rogers, 1974; Rosenstock, 1974). By contrast, research in unconscious processes have ranked habit as possibly the strongest unconscious determinant of behavior (Sheeran et al., 2013).

Habit can be defined as “a learned sequence of acts that have become automatic responses to specific cues, and are functional in obtaining certain goals or end-states" (Verplanken & Aarts, 1999, p. 104). Habit is thought to have a reciprocal relationship with behavior (Gardner, 2014), where habit affects behavioral repetition but that repetition also strengthens habit formation. Overall, habit has demonstrated predictive validity in the physical activity domain; for example, a recent meta-analysis found it to correlate r = .43 with behavior which is similar to the magnitude of the intention-behavior relationship (Gardner et al., 2011).

Despite the importance of habit outlined in these reviews, there are still several limitations in the contemporary habit literature. For example, the majority of the studies on exercise habit are cross-sectional (Gardner et al., 2011). Given that habit is a dynamic construct, longitudinal studies would provide stronger support for understanding habit formation (Gardner, 2014; Lally et al., 2010). To the authors' current knowledge only one study has used a longitudinal design to understand habit development (Lally et al., 2010); the researchers found that it took on average 66 days to develop a health related habit (healthy eating, drinking and exercise) among a small student sample. While this is a compelling finding, it warrants replication and extension with other samples with a focus on exercise habit. Exercise is a type of physical activity that is planned, structured, and repetitive (WHO, 2015). However, it is important to note that 95 % of adults fail to achieve the recommended physical activity guidelines (Colley et al., 2011) with the majority of unsuccessful adopters ranking time as the largest barrier to their exercise (Salmon et al., 2003). With these findings in perspective, simply prescribing the general population to exercise every day for over 2 months is not a realistic goal. It would be helpful to understand the minimum exercise frequency and time required to successfully establish an exercise habit. Behavioral frequency or repetition is a necessary component for habit formation (Ouellette & Wood, 1998), thus it would stand to reason that habit formation is partly dependent on time and frequency. Currently, no study has examined a time × frequency effect on habit formation.

A second shortcoming in the habit and exercise literature is the limited understanding of the antecedents required for habit formation. Several models have been proposed to predict habit formation (Aarts et al., 1997; Bargh, 1994; Grove & Zillich, 2003; Lally & Gardner, 2013; Triandis, 1977; Verplanken et al., 1997). Despite some differences in antecedents or the process of habit formation, these models share the importance of behavior repetition based on consistent situational cues or context. One of the most recent models has been proposed by Lally & Gardner (2013), which suggests that there are four antecedents that are conducive for habit formation: reward, consistency, environmental cues, and low behavioral complexity. The researchers theorize the reward component to be intrinsic, which in exercise research could be interpreted as positive affective responses to a behavior (Ekkekakis et al., 2013) or affective judgments (Rhodes et al., 2009) about the behavioral experience. Affect has been proposed as having both effects on behavior that are conscious and unconscious (Custers & Aarts, 2005; Williams & Evans, 2014; Zajonc, 1980).

Behaviors that are perceived as complex or have not been sufficiently practiced likely require conscious processes (Verplanken & Melkevik, 2008; Wood et al., 2002) which would consequently prevent automaticity. Building from this research and the habit model proposed by Lally and Gardner (2013) we theorize that behavioral complexity represents the level of challenge of performing a task, independent from motivation or planning. The use of conscious process can also be reduced depending on cues present in the environment. The environment plays a critical role that can prompt or disrupt automatic behavior (Orbell & Verplanken, 2010; Rothman et al., 2009; Wood & Neal, 2009). Environmental cues, such as mirrors (Sentyrz & Bushman, 1998), lights (Kasof, 2002), or cue cards (Almeida et al., 2005) have predicted behavior in past research. Additionally, close proximity to recreation facilities have also been shown to predict behavior which could act partly via ease of access but also via environmental cues (Kaushal & Rhodes, 2014; Moudon et al., 2007; Rhodes, 2006; Rhodes et al., 2007). In addition to facilitating habit, we theorize that if an individual does not feel comfortable in a particular environment due to the presence of any negative cues (i.e. safety concerns, social physique anxiety, etc.), then the automaticity process would be interrupted. Hence we theorize that an environment which provides discomfort functions as a distraction that would consequently increase the level of conscious awareness and prevent habit formation.

Consistency is arguably the most unique of the four antecedents as it is a practice rather than feedback (i.e. perceived affect, complexity, or environment). Although the measurement of temporal consistency in exercise behavior is scarce, it has been hypothesized that temporal consistency helps create a protected time for exercise habits (Rhodes & De Bruijn, 2010). Hence, we define temporal consistency as performing the behavior at a particular time or after a particular activity such as exercising regularly at 6 a.m. or after supper. The closest proposed construct involving consistency is patterned action, i.e. Grove and Zillich (2003).

The purpose of this study was to understand habit formation in new gym members. This was a relevant population for this study as the enrolment spike during the New Year followed by a large drop-out of gym members is a well-known trend but is not clearly understood. The objectives of the present study were trifold with a focus on understanding: (1) exercise behaviour, (2) habit formation and (3) habit predictors.

1. The first objective was to test the Dual Process approach by investigating how habit predicts exercise behavior over 12 weeks while controlling for intention. It was hypothesized that habit and intention would both be required to work in synergy to predict exercise behavior.
2. The secondary objective was to further understand habit formation by: (1) determining how long it takes to develop an exercise habit, (2) discerning the cut-off score for habit, and (3) testing for a time × behavior interaction. The time required for habit formation would be found by conducting survival analysis. This analysis would determine when the changes of habit scores would no longer be significant across time (Bland & Altman, 1998; Greenhouse et al., 1989; Luke & Homan, 1998). Habit cut-off score would be revealed by receiver operating characteristic (ROC) analysis with habit being the test variable and exercise requirement as state variable; the cut-off score would be identified from having the highest sensitivity and lowest specificity values (Greiner et al., 2000; Kraemer et al., 1999). We hypothesized that habit formation depends on frequency (Gardner, 2014) and time; hence, this can be represented with the following equation: time × frequency = habit strength. Previous analyses which would identify the time required for habit formation and cut-off score would be substituted as *time* and *habit strength* respectively in the equation to determine the frequency requirement.
3. The final objective was to test the multivariate model by Lally and Gardner (2013) to predict habit development. We hypothesized that habit formation would first depend on affective judgements about exercise, as a repeated behavior without reward would require conscious evaluation. We also expected that complexity would be a strong antecedent as it could determine if the behavior is consciously directed or automatically brought to attention. Finally, we expected that practice consistency would be a strong predictor of habit formation to reinforce stimulus–response (S–R) (environment-affect) as well as operant response (O-R) (exercise-affect) systems (Skinner, 1954).

Methods

Participants and procedure

One hundred and forty-four adults showed interest in participating in our study by requesting a consent form and of these individuals, 77 % (n = 111) signed the consent and completed baseline measures. Participants who were excluded were those who indicated that they did not meet one of the following inclusion criteria: (1) being in the age of 18–65, and (2) being a recent gym member, which was defined as someone who has joined a gym/recreation centre within the past 2 weeks. Thirteen gyms and recreation centres were randomly contacted in the Greater Victoria region in British Columbia, Canada. Eleven of the thirteen facilities granted permission to advertise this study. Methods of advertising included: posting wall posters in high traffic areas (i.e., main lobby, water fountain, change rooms), placing information sheets at the main desk, and on-site recruitment which was performed by the primary investigator. Potential participants who were interested contacted the primary investigator to receive the consent form via e-mail along with a web link to the baseline survey. Consent was implied if participants clicked on the link and completed the baseline survey. Follow-up questionnaires were sent at week six, nine, and twelve. We used a 12 week longitudinal design based on the average time required to develop habit in a prior research study (66 days) (Lally et al., 2010). All questionnaires measured the same constructs described under the Instruments section. The questionnaires and study protocol were approved by Human Research Ethics at the University of Victoria.

Instruments

The participants were instructed to consider the definition of "exercising regularly" as performing 30 min of moderate-to-vigorous in duration five times per week (CSEP, 2012). They were advised to only count exercise that was done during free time (i.e. not occupation or housework).

Exercise behavior

Exercise behavior was measured by administering the Godin Leisure Time Exercise Questionnaire (GLTEQ) (Godin et al., 1986). The questionnaire consists of three open-ended questions of time and frequency spent on type of physical activity (mild, moderate and strenuous). The 2-week test–retest reliability of the measures of total physical activity and the frequency of activity have been estimated to be 0.74 and 0.80, respectively (Godin et al., 1986). For the purpose of this study, only moderate and strenuous values were used to calculate the exercise behavior. These categories reflect the definition of moderate-to-vigorous physical activity provided by recommended guidelines (CSEP, 2012; Garber et al., 2011).

Exercise habit

Exercise habit was assessed by administering the Self-Report Behavioral Automaticity Index (SRBAI) (Gardner, 2012; Gardner et al., 2012). This scale has been modified from the Self-Report Habit Index (SRHI) which was developed by Verplanken and Orbell (2003). The SRBAI consists of 4 items on a 5-point Likert scale with 1 being strongly disagree to 5 being strongly agree. The question stem stated "When I exercise…" which was then followed by four items on the scale: "I do it without having to consciously remember", "I do it automatically", "I do it without thinking", and "I start before I realize I am doing it". The internal consistencies of this measure were high across baseline (α = .84), week 6 (α = .92), week 9 (α = .91), and week 12 (α = .95).

Intention

Intention was used as the proximal measure of reflective, conscious motivation to enact exercise. This construct was assessed by using a continuous open measure worded, "I intend to engage in regular exercise ______ times per week for the next twelve weeks" (Courneya, 1994). Continuous open measurement of intention preserves scale correspondence with our measure of behavior and has been shown to be a superior predictor of behavior over dichotomous closed measures of intention (Courneya, 1994; Courneya & McAuley, 1994; Rhodes et al., 2006).

Reward

A modified version of the Subjective Exercise Experience Scale (SEES) (McAuley & Courneya, 1994) was used to measure exercise reward in the form of affective judgments about exercise. This instrument has been shown to be a valid and reliable measure of affect in a variety of exercise settings (Lox & Rudolph, 1994; McAuley & Courneya, 1994). Items that did not convey a sense of reward were removed from the scale a priori which were: drain, exhaust, fatigue, tired, and strong. These terms reflect energy levels which could be independent from affective reward. For instance, an individual can experience a very enjoyable run (intrinsically rewarding) but feel tired after. The remaining items included: great, positive, terrific, and reverse-scored items of awful, crummy, discourage and miserable. The Cronbach alphas across each measurement period were: baseline (α = .84), week 6 (α = .84), week 9 (α = .86), and week 12 (α = .90).

Consistency

Temporal consistency had not been assessed in previous research at the time of the study. Hence, a measure was created to assess this construct. The item read, "How consistently did you exercise at the same time each day (e.g., every morning at 7 am, or exercising daily after supper)?" The options ranged on a 5-point Likert scale with 1 = not consistent, always at a random time to 5 = very consistent.

Environment

Asking participants to recall an object or context which functions as a cue has been shown to be problematic (Gardner & Tang, 2013). The researchers proposed that individuals may not be able to accurately recall particular cues as they influence behavioral responses on an unconscious level. With this rationale, it is likely that a distinct stimuli/change in the environment would be consciously processed and disrupt automaticity such as encountering a construction site while driving or the presence of an uncomfortable object on the driver's seat. We theorize that an individual would not be in an automatic state if he/she felt threatened in the environment as this would trigger conscious sensory awareness. Herein, an item worded "How comfortable do you feel in your exercise environment" which was scored on a five point Likert scale (1 = not very comfortable to 5 = very comfortable) was used to assess if the environment supported the process of behavior.

Behavioral complexity

Similar to consistency, a measure to assess behavioral complexity of performing exercise has not been used in previous research. A behavior which an individual finds difficult would require conscious deliberation to perform and consequently hinder automaticity. The original Self-Report Habit Index (SRHI) (Verplanken & Orbell, 2003) recognized this importance and incorporated related items. The present study applied these items to function as antecedents to automaticity based on the proposed model (Lally & Gardner, 2013). Hence two items were adapted from the SRHI which included: "Exercise is something that (1) requires effort to do, and (2) I find hard to do" (Verplanken & Orbell, 2003). In addition, an individuals' physical ability could also reflect behavioral complexity. For instance, a novice exerciser would not be as fluent exercising compared to an experienced individual. An item adapted from Rhodes et al., (2006) was also incorporated into this scale which was worded "I have good athletic ability". All three items were measured on a 5-point Likert scale with 1 = strongly disagree to 5 = strongly agree. The internal consistencies in the present study were: baseline (α = .80), week 6 (α = .76), week 9 (α = .73), and week 12 (α = .77).

Analysis plan

Dual process approach

Linear Mixed Model (LMM) in SPSS 20.0 (IBM, 2011) was used to understand how intention and habit predicted exercise behavior across time (Field, 2009; Shek & Ma, 2011; West, 2009). LMM provides strong methodological advantages over traditional repeated measures analysis of variance which includes: (1) maintaining precision with multiple time waves, (2) examining intra- and inter-individual differences in the growth parameters (e.g., slopes and intercepts), (3) selecting an appropriate covariance structure for the growth curve model (this helps reduce error variance as researchers can choose the correct model that reflects the patterns of change over time), and (4) handling missing data (for further explanation see Field, 2009; Shek & Ma, 2011). In the present study, LMM allowed for simultaneous assessment of the effects of within-person variation in predictor variables (level 1) across each time measurement (level 2). Before any analysis was conducted, the time parameters were grand mean centered to reduce multicollinearity. The next procedure involved a series of steps to determine appropriate model fit (Field, 2009). This consisted of first determining if a random intercept would provide a significant difference based on Chi squared values. A random intercept in a longitudinal model tests the assumption that each participant can have his or her own starting point. The next step consisted of calculating the Intraclass Correlation Coefficient (ICC) on the baseline model. The ICC describes the amount of variance in the outcome from differences between individuals. A high ICC value indicates the stability of the dependent variable over time. The last step involved conducting a slope analysis to identify which time polynomial would provide a suitable fit for the model (Field, 2009; Shek & Ma, 2011; West, 2009).

Once the model demonstrates appropriate fit parameters (Field, 2009) then LMM/multilevel analysis can be performed by selecting the Restricted Maximum Likelihood for estimation method (Field, 2009). Two sets of multilevel analysis were performed which consisted of testing intention and habit as predictors of exercise behavior at baseline and at trajectory/across time.

Habit stabilization, cut-off score, and required frequency

LMM was also used to determine if length of time for habit formation would be moderated by frequency of behavior. The interaction can be represented by the following equation: time $\times$ frequency = habit strength. Identifying the values for this equation is a multi-step process which involved finding how long it takes for habit to develop and identifying the interaction value. Survival analysis was used to understand the stability of habit formation; in particular, this analysis determined when the changes of habit scores were no longer significant across time (Bland & Altman, 1998; Greenhouse et al., 1989; Luke & Homan, 1998). The next step involved calculating a cut-off score for habit formation. Determining the cut-off score was performed by ROC analysis (Greiner et al., 2000; Kraemer et al., 1999). ROC curves were constructed by plotting true-positive rates (sensitivity) against false-positive rates (1-specificity). "Habit" was the test variable and "exercise requirement" was the state variable. The cut-off values for each time period were then averaged to find the overall cut-off score for the measure. Cut-off values were determined by identifying points on the curve which demonstrated maximum sensitivity and minimal specificity. The area under the curve was also calculated with 95 % confidence interval (Greiner et al., 2000; Kraemer et al., 1999). Finally, the time requirement for habit formation and cut-off values were then substituted as "time" and "habit strength" respectively in the interaction equation to determine the required minimum "frequency" to achieve habit formation. This would then be tested by first grouping participants into meeting, or not meeting the required frequency values then using those groups to predict habit formation in LMM.

Habit antecedents as predictors of habit formation

LMM was used to test if the antecedents (affect, consistency, complexity, and environment) predicted habit formation. This was a similar procedure to the Dual Process Approach which first involved testing the antecedents as predictors of habit at baseline followed by a time-varying model. Four time measurements of each variable were used to test if the change of each of antecedent predicted change of habit in the trajectory LMM.

Results

Descriptives

The mean age of participants was 47.7 (SD = 13.5 years), 70 % were female, and the BMI for the sample was 25.8 (SD = 4.63) suggesting an overweight sample (NIH, 2011). The majority of the participants completed post-secondary education with 59 % of the sample having a university degree. Approximately 40 % of the sample had a household income >$75 000. The participants reported an average of 186 (SD = 158 min) of total physical activity (light, moderate and vigorous) but 72 % were not meeting the recommended exercise guidelines at baseline (CSEP, 2012). All participants were within their first 2 weeks of enrolling in their gym or recreation centre and reported being a new member in a gym or recreation facility with the intention to develop a regular exercise routine. Descriptive data for the participants are displayed in Table 1. Bivariate correlations of the antecedents with habit and exercise are presented in Table 2.

Dual Process approach

Model setup and baseline analysis

Habit and intention were placed in LMM to compare the model with and without a random intercept. The Chi squared difference was not significant [χ^2 (1, N = 111) = 1.96, $p = .37$]. Thus, participants' random starting points did not significantly change the model (Field, 2009). The baseline model did not find habit F (1, 101) = .22, $p = .64$; or intention F (1, 101) = .90, $p = .34$ to be a significant predictors of exercise. The ICC intercept/(intercept + residual) = .76, suggesting that about 76 % of total variation from the predictors was due to individual differences. ICC values were in acceptable range for model fit (>.25) and allowed us to proceed with testing independent growth curves (Shek & Ma, 2011).

Table 1 Descriptive data

Characteristic	Percentage
Household income	
<$50 000	27
$50 001–$75 000	32
$75 001–$100 000	19
$100 001–$150 000	12
>$150 000	10
Job status	
Homemaker	7
Temporary unemployed	3
Part-time employed	23
Full-time employed	51
Retired	16
Education	
Less than highschool	1
Highschool diploma	23
College diploma	17
University degree	29
Graduate or professional degree	30
Marital status	
Never married	13
Married/common law	76
Separated/divorced/widowed	11

Trajectory analysis

Analysis of independent growth curves (IGC) was used to understand which polynomial value of time would demonstrate the best fit for changes in exercise behavior. The 2-log likelihood was used to calculate the Chi squared difference which was significant between all three models. Since all three time slopes showed significance, the Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC) were compared. From these results, the cubic polynomial was selected as smaller statistical values reflect stronger model fit to the data (Shek & Ma, 2011). The trajectory model found habit habit, $\beta = .23$ ($p = .001$) and intention, $\beta = .23$, ($p = .007$) to be equivalent in strength for predicting exercise behavior across time.

Habit stabilization, cut-off score, and required frequency

LMM was used to test how frequency and time interacted to predict habit. Testing of random intercepts revealed that the Chi squared difference was not significant [χ^2 (1, N = 111) = .06, $p = .68$]. Thus, a random intercept model did not improve fit (Field, 2009). The baseline habit model found habit to significantly predict exercise F (1, 99) = 8.78, $p = .004$. The ICC value was .38, which means that 38 % of total variation from exercise was due to individual differences. This was also in the acceptable range to continue testing IGC.

Test for IGC found a significant Chi squared difference between linear and quadratic models, χ^2 (1, N = 111) = 14.1, $p = .03$. It was optimal to proceed with the quadratic time value for further analysis as: (1) the study consists of four measurement points and a valid polynomial can be a maximum of one less than the number of time points (Field, 2009), and (2) it has been theorized that habit develops non-linearly (Lally et al., 2010). A quadratic polynomial for time was then used to test habit change across 12 weeks, which was found to be significant F (1, 233) = 14.96, $p = .001$.

The next step was to perform Kaplan Meir survivor analysis to investigate interaction values at each of the time slopes. The Kaplan Meir survival curve showed a significant difference ($p < .001$) between each time curve over the three tests: Log Rank, Brewslow and Trone-Ware. Each of these tests compares the differences between curves (Breslow = first third of the curve, Trone = middle section, and Log rank = last third of curve). Pairwise comparisons were used to further determine the significant

Table 2 Bivariate correlations of habit antecedents with MVPA and Habit

Antecedent	Baseline: M, H	Week 6: M, H	Week 9: M, H	Week 12: M, H
Consistency	.20*, .48**	.20*, .30**	.10, .48*	.27*, .31**
Reward	.33*, .59**	.29**, .46**	.14, .21*	.12, .26**
Behavioural complexity	.38*, .38**	.25*, .63**	.27**, .48**	.22*, .64**
Environment cue	.19*, .44**	.26**, .23*	.17, .18	.28**, .23*

M = MVPA, H = Habit

* $p < .05$

differences among the three sections of the curve. This showed that the second curve (week 6) was significantly different ($p < .001$) than baseline but not with the other curves (week 9) and (week 12). This stability suggests that the majority of habit formation in the sample was by week 6 with an interaction value of 12.16 (lower bound of 95 % Confidence Interval).

Habit cut-off score

Four separate ROC analyses were performed for habit scores at each time point. The baseline cut-off was 2.91 with a sensitivity of 0.70 and 1-specificity of .18. The AUC value was 0.76 (95 % CI 0.667–0.858, $p < .001$). Cut-scores for week 6, 9 and 12 were 2.52, 2.76, and 3.01 respectively which averaged a cut-off score of 2.80. The AUC values ranged from .63 to .76 and were considered in acceptable range (Akobeng, 2007; Fischer et al., 2003).

Frequency required for habit formation

Previous analysis found habit stabilized at week 6, with the interaction value of 12.16 (lower bound of 95 % Confidence Interval). We substituted this value with the habit cut-off score of 2.8 in the equation to solve for minimal frequency of exercise bouts required to achieve habit formation and found that a frequency of approximately 4 days per week was required to achieve an interaction score of 12. This finding was tested by first determining if behavioral frequency predicted habit across time. The LMM analyses found behavioral frequency to predict habit over 12 weeks ($\beta = .24$, $p < .001$). The next step involved separating values based on high frequency (≥4 days/week) and low frequency (<4 days/week) groups. When these groups were then tested as predictors of habit, the low frequency group did not predict habit ($\beta = .09$, $p = .42$) but the high frequency group was significant ($\beta = .24$, $p < .001$). A descriptive plot was produced to depict how the frequency groups affected habit scores across time (Fig. 1). The figure shows that those in the high frequency group demonstrated stability of habit scores and maintenance of habit (≥3/5) scores across the 12 weeks. In particular, week 6 shows that 61.5 % of participants achieved habit in the high frequency group compared with 44.8 % in the low frequency. By week 12, the values for high and low frequency groups were 63.8 and 22.6 % respectively.

Habit antecedents as predictors of habit formation

Baseline

The four baseline antecedents (affect, consistency, complexity, cues) were placed in LMM to compare two variations of the model: with and without a random intercept. The Chi squared difference was not significant [χ^2 (1, N = 111) = 3.82, $p = .12$]. Thus, a random intercept model did not improve fit (Field, 2009). The ICC intercept/(intercept + residual) = .64, suggesting that about 64 % of total variation from the antecedents was due to individual differences. LMM analysis of the baseline habit model found that affective judgments (reward) predicted habit with a medium-large effect size $\beta = .47$, $F(1, 106) = 31.56$, $p < .001$ followed by consistency $\beta = .45$, $F(1, 106) = 13.36$, $p = .001$; behavioral complexity and cues were not significant (Table 3).

Trajectory analysis

The following trajectory analysis would reveal if the antecedents contributed a significant change to habit scores across 12 weeks. A quadratic polynomial was used for the trajectory analysis as the results from the previous IGC found this time slope to be a suitable fit for a model with habit as the DV. When time was added in the trajectory analysis, consistency demonstrated the largest effect size for predicting habit formation, ($\beta = .21$, $p < .001$), followed by low behavioral complexity ($\beta = .19$, $p < .001$), environment ($\beta = .17$, $p = .008$) and affective judgements ($\beta = .13$, $p = .003$) (Table 3).

Discussion

The primary purpose of this study was to understand the process of habit formation in new gym members over 12 weeks. The secondary purpose was to investigate how

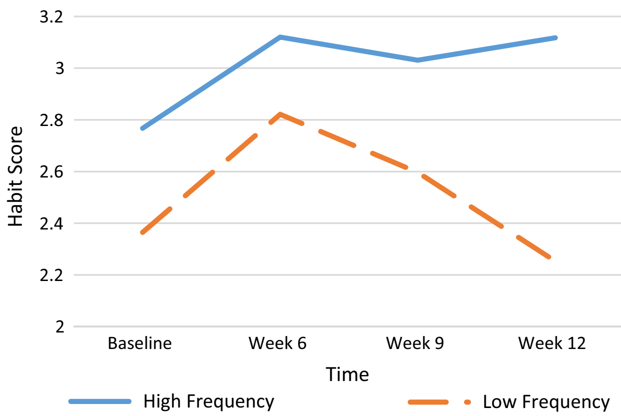

Fig. 1 Habit scores between high and low frequency groups. *Note* high frequency (≥4 times/week), low frequency (<4 times/week)

the Dual Process approach predicts exercise behavior and how the antecedents in the habit model predict habit formation. The present study found the SRBAI (Gardner et al., 2012) to have a cut-off score of 2.80/5. With regards to behavioural requirement for habit formation, it was found that participants who exercised for at least four bouts per week for 6 weeks successfully established an exercise habit. Dual Process tests showed that intention and habit were not significant at baseline but they became equal predictors of exercise behavior in the trajectory analysis. Finally, the habit model found that affect and consistency were the largest predictors for people starting a habit; however, trajectory analyses revealed that consistency was the most important predictor followed by low behavioral complexity, environment, and affect.

It was hypothesized that habit and intention would both be significant predictors of exercise behavior, commensurate with the Dual Process approach. The present study did not find habit or intention to significantly predict exercise behavior during baseline; however, both constructs became significant predictors over time with equal effect sizes (β = .23, respectively) in support of our hypothesis. The non-significant finding of intention at baseline could be attributed to the sample being new gym members with already high intentions. Intention-based approaches have been criticised in this particular situation and it represents a practical application of the intention-behavior gap (Rhodes & De Bruijn, 2013). However, as time progressed, the change of intention and habit scores predicted change of exercise over the 12 weeks. Overall, the results add support to a small literature on Dual Process approach applied to exercise behavior (Calitri et al., 2009; Conroy et al., 2010; Hyde et al., 2010).

In terms of the time required to establish an exercise habit, the present research found that exercise habit plateaued on the 6th week (42–49 days) of the study with 48 % of the sample achieving habit formation. Previous work has found that it took an average of 66 days to establish a health related habit (Lally et al., 2010). However the differences in methodologies do not warrant much comparison. For instance, Lally et al., (2010) used a combination of data and projected analysis to determine exercise habit formation. The present study also found the cut-off score of the SRBAI to be 2.8/5 using ROC analyses. This indicates that 2.8/5 is the minimal score to detect that the behavior is not entirely controlled by conscious processes. Scores ≥2.8/5 would suggest that automaticity is significantly involved in the behavior. The score is fairly low on the measure, suggesting that automaticity may be a continuum where low scores still represent predictive values. Scores that are very low on this continuum would reflect high cognitive process with minimal automaticity (i.e. controlling air traffic) and the other end of the continuum would indicate the opposite (i.e. sleeping). These findings and theorizing satisfy both perspectives of habit research; the results support theorizing that exercise is not

Table 3 Baseline and trajectory analysis: antecedents as predictors of habit formation

Source	B	β	SE	95 % Confidence lower bound	Interval upper bound
Baseline					
Consistency	.22**	.45**	.13	.14	.64
Reward	.36***	.47***	.08	.30	.64
Complexity	.03	.02	.08	−.18	.13
Environment cue	.16*	.09	.08	−.06	.25
Trajectory analysis					
Consistency	.26***	.21***	.07	.11	.38
Reward	.05**	.13**	.04	.07	.25
Complexity	.09 *	.19**	.05	.01	.32
Environment cue	.14**	.17**	.07	.08	.36

β = standardized beta, nv = non-significant variability in sample to predict trajectory change

*** $p < .001$, ** $p < 0.01$, * $p < .005$

completely automatic (Maddux, 1997) yet it demonstrates that habit may be critical for exercise continuance (Rhodes & De Bruijn, 2013).

Although, the present study estimated a similar time required for habit formation to Lally et al. (2010), we also hypothesized that time would be moderated by performance frequency. The results clearly supported this conjecture, with a time × frequency interaction. A large drop (44.8–22.6 %) in habit was noticed from week 6 and to 12 in the low frequency group (<4X/week); however, those in the high frequency group maintained habit across time (61.5–63.8 %). Theoretically, this pattern aligns with several models that propose establishing a habit requires repeated behavioral practice across time (Hall & Fong, 2007; Ouellette & Wood, 1998; Rhodes & De Bruijn, 2013; Triandis, 1977; West, 2006). Fortunately, these findings are also aligned with public health guidelines suggesting that an exercise habit can be achieved in 4–5 bouts with 30/40 min per session.

We also hypothesized that habit formation would depend on the presence of the antecedents theorized by Lally and Gardner (2013), with affective judgments and complexity predicting habit in the initial phases but consistency predicting habit formation over time. We had some support for this hypothesis. Affective judgments about the exercise experience were found to be the primary predictor of habit formation at baseline but consistency became the strongest predictor in the trajectory analysis. This supports prior theorizing on the foundation of habits. Affect has been investigated in understanding general unconscious goals (Custers & Aarts, 2005) and habit of fruit consumption (Wiedemann et al., 2014) but not for exercise behavior. It is likely that negative feelings which stem from unfavourable experiences could prompt conscious deliberation for the individual before performing the behavior. On the other hand, a positive reward would not require evaluative process; the presence of positive affect may drive behavior at an unconscious level (Custers & Aarts, 2005; Zajonc, 1980).

In terms of consistency, our results support our conjecture that it may be a pillar in establishing both the stimulus–response (S–R) (environment-affect) as well as operant response (O-R) (exercise-affect) conditions as the behavior becomes more familiar. The significant effect of consistency also helps establish a potentially different antecedent for habit formation than motivation. This construct suggests that how, rather than why one practices may be more important to forming habits. Hence, these results suggest that initiating an exercise routine that is enjoyable and consistent can help in habit formation.

Behavioral complexity was found to predict change of habit across time which aligns with previously theorized research on the importance of low cognitive load for habit formation (Verplanken & Melkevik, 2008; Wood et al., 2002). Although exercise is a complex behavior, it was likely that practicing consistently eventually eased the challenges of the behavior across time thus allowing for the facilitation of habit. A comfortable environment that does not stimulate more conscious thinking was also shown to predict habit over time. Environment cue assessment from traditional methods may not be clear due to variability in the type of cues and the method of measurement (Gardner & Tang, 2013). Hence the present finding could provide a novel approach to assess if the environment supports the development of habit.

Despite the longitudinal design, analyses, methods, and novel approach to understanding habit and its antecedents, the present study still has limitations that are important to address. For instance, although the sample consisted of new gym members, there was some variability in their exercise history. Since the present results found habit formation to occur by week six, this suggests that the majority of variation of habit occurred within this period. Assessing habit scores more frequently within the first 6 weeks could provide a more detailed scope of the habit formation phase. Second, the habit model proposed by Lally and Gardner (2013) presents a strong case of four antecedents of habit which have individually been found to correlate with habit in various studies (Gardner et al., 2011). However, the authors did not provide suggestions on measuring these predictors. The present study used a mixture of previous validated scales and customized items to this model. Although these scales demonstrated to predict change of habit across time, other measurements of these constructs may yield different findings and this warrants sustained research. Finally, future research should also provide objective measurement to yield a stronger interpretation of exercise behavior and habit formation.

In summary, the study found support for the Dual Process approach as intention and habit both predicted exercise behaviour over time. Exercising for at least four times per week for approximately 6 weeks was required to establish an exercise habit. Although affect was found to be the strongest predictor at baseline, consistency was the most important factor for predicting changes in habit. The environment and low behavioral complexity demonstrated to play a significant role in changing habit across time. Exercise promoters should focus on setting a consistent exercise schedule and keeping the workouts fun and skill appropriate to increase the likelihood of habit formation. In addition, the environment should be comfortable and welcoming for new clients. The first 6 weeks appear critical for habit formation and new exercisers should strive to workout at least four times per week.

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Conflict of Interest Navin Kaushal and Ryan E. Rhodes declare that they have no conflicts of interest in the research.

Human and Animal Rights and Informed Consent The present study was approved by the Human Research Ethics Board at the University of Victoria. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 (5). Informed consent was obtained from all participants for being included in the study.

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