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Reinforcement Sensitivity Theory Factors as Predictors of Exercise Habits, Self-Efficacy, Social Support, and Affect

Alex C. Garn
Louisiana State University and Agricultural and Mechanical College, agarn@lsu.edu

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Objective: The study investigated contemporary reinforcement sensitivity theory (RST) personality factors as predictors of short-term changes in young adults' exercise-related outcomes. Specifically, we explore RST factors as predictors of short-term changes in young adults' reports of their exercise habits, exercise self-efficacy, exercise affect, and elicitation of exercise social support.

Design: Participants (*N*=406) completed surveys related to RST including four aspects of behavioral approach system, behavioral inhibition system, and fight-flight-freeze system as well as exercise habits, self-efficacy, affect, and social support at the beginning of one semester and took the same exercise survey six-weeks later.

Main Outcomes: Changes in exercise habits, exercise self-efficacy, exercise affect, and elicitation of exercise social support.

Results: Path analysis results demonstrated a good model fit. The fight-flight-freeze system (β = -.12) and behavioral inhibition systems (β = -.15) predicted changes in exercise habits, but not exercise beliefs or affect. The behavioral approach system goal-drive-persistence component predicted increases in exercise self-efficacy (β = .12) while the impulsivity (β = -.15) predicted increases in eliciting exercise social support.

Conclusion: While our study highlighted meaningful links between RST factors and changes in exercise outcomes, inconsistent patterns and weak magnitudes also underscore the need for future exploration. Weak reward and punishment associations with exercise may help explain the inconsistent relations with RST factors.

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Key words: personality, approach motivation, avoidance motivation, exercise habits

Introduction

Regular exercise behaviors improve one's brain health, psychological well-being, and quality of life as well as reduce risk for non-communicable diseases such as obesity, cardiovascular disease, and type 2 diabetes (United States Department of Health and Human Services, 2018). Despite the numerous benefits associated with exercise, a large proportion of adults in the United States as well as other countries throughout the world do not exercise regularly (Healthy People 2020; World Health Organization, 2020). Young adults, especially those who attend colleges or universities, are disproportionally at risk for physical inactivity compared to other segments of the population (Bray & Born, 2004; Kwan et al., 2012). In fact, it is estimated that a majority of students attending colleges and universities fail to meet recommended levels of physical activity (American College Health Association, 2020; Haase et al., 2004).

Acquiring greater knowledge about young adults' exercise habits, thoughts, and feelings can provide insightful information on how to develop effective exercise interventions. There are many possible mechanisms to explain variations in young adults' exercise habits thoughts, and feelings. The role of motivation has been one avenue of study used to investigate individual differences in exercise outcomes across numerous demographic groups (Chatzisarantis & Hagger, 2008; Duncan et al., 2010; Sylvester et al., 2018). Reinforcement sensitivity theory (RST) posits three brain-behavioral systems that underpin approach and avoidance motivation and behavior (Corr & Krupic, 2017; Gray & McNaughton, 2000). In the following paragraphs, we outline the major tenets of RST and describe how it can potentially advance understanding about young adults' exercise-related thoughts, feelings, and actions.

The three brain-behavioral systems postulated in RST include an approach-oriented system, the behavioral approach system (BAS), an avoidance-oriented system, the fight-flight-freeze system (FFFS), and the behavioral inhibition system (BIS) that resolves goal conflict between or within BAS and FFFS (Corr, 2008; Corr & Cooper, 2016). Corr and Cooper (2016) suggests that BAS is the mechanistic pathway consisting of four processes that regulates appetitive stimuli leading to approach motivation. Reward interest and reward reactivity reflect BAS components that modulate attraction and response to appetitive stimuli, respectively. Goal-drive-persistence is the third BAS component designed to activate goal directed pursuits of appetitive stimuli. The final BAS component is impulsivity, which underpins short-term spontaneous reactions to appetitive stimuli. FFFS, on the other hand, regulates evaluations of aversive stimuli leading to avoidance motivation. Together, BAS and FFFS generate basic reward or punishment assessments about stimuli that activates behavior through approach or avoidance motivation. The BIS works to resolve stimuli that creates goal conflict when a single behavioral response is insufficient to settle competing goals (Corr & Krupic, 2017). Goal conflict can occur between (e.g., is the excitement of exercise worth the possible fatigue) or within (e.g., would running or swimming be more enjoyable) systems. When faced with goal opposition, the BIS produces thoughts and actions grounded in inhibition, risk assessment, and caution.

Pickering and Corr (2008) provide in-depth detail about the underlying cognitive structures of BAS, FFFS, and BIS. In simple terms, BAS and its processes drive individuals to seek out rewarding environments by generating feelings of pleasure through the activation of dopaminergic pathways. FFFS and BIS have a complex neural underpinning that drive individuals to avoid threating environments through feelings of fear or rage (FFFS) or cautiously assess whether to approach or avoid environments through feelings of anxiety. Exercise environments can be interpreted as rewarding (e.g., exhilaration; challenge; improved appearance), punishing (e.g., pain, fatigue, embarrassment) or a combination of the two providing alignment to the three brain-behavioral systems highlighted in RST.

There is a paucity of research examining links between exercise outcomes and RST factors despite its mechanistic explanation of approach and avoidance motivation. Almost all of the current studies on exercise use a simplified BAS-BIS paradigm (Hall et al., 2005; Schneider & Graham, 2009; Wilson et al., 2014) while one study included BAS processes (Voigt et al., 2009). Interestingly, two of these studies (Hall et al., 2005; Schneider & Graham, 2009) explored acute bouts of exercise, one explored chronic exercise (Wilson et al., 2014) and one physical inactivity (Voight et al., 2009). All of these studies except Schneider and Graham (2009), who studied adolescents, used samples of undergraduate university students. BAS demonstrated a pattern of positive relationships with rate of perceived exertion at high intensity (Hall et al., 2005), self-reported exercise (Wilson et al., 2014), and lower rates of physical inactivity (Voigt et al., 2009). BIS was related to lower reports of exercise affect (Schneider & Graham, 2009). There is a clear need to examine the full scope of BAS, FFFS, and BIS factors outlined in revised RST.

The acute exercise studies examined BAS and BIS in relation to exercise intensity, rate of perceived exertion, and exercise-related affect in adults (Hall et al., 2005) and adolescents (Schneider & Graham, 2009). Findings revealed that BIS was negatively related to exercise-related affect, especially at high intensity levels and positively related to rate of perceived exertion (Hall et al., 2005; Schneider & Graham, 2009). BAS was positively related to exercise enjoyment (Schneider & Graham, 2009) and negatively related to rate of perceived exertion during exercise at low intensity (Hall et al., 2005). Hall et al. (2005) also reported a negative relationship between

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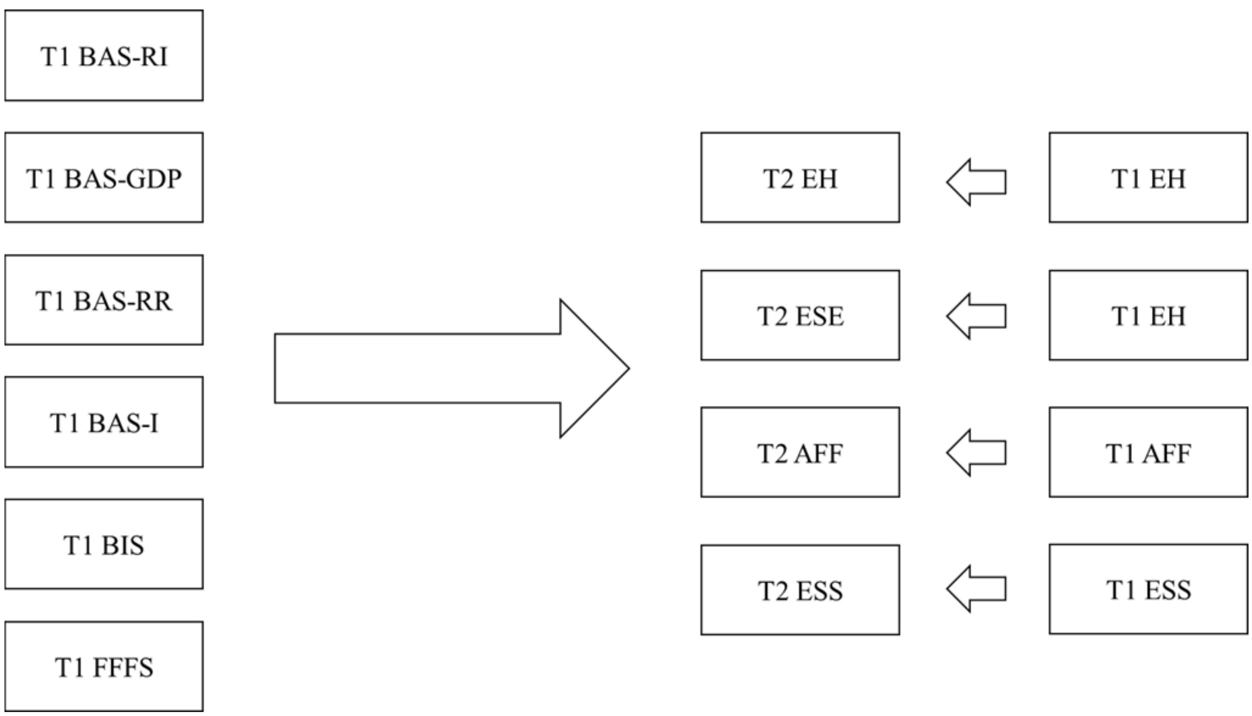
BIS and exercise-related beliefs (i.e., self-efficacy) whereas no correlation was present between BAS and self-efficacy.

Wilson et al. (2014) investigated how BAS and BIS related to both self-report and objective measures of physical activity in a sample of young adult females attending university. Findings revealed inconsistent relations based on the type of exercise measurement. Specifically, correlational evidence suggested that BAS (positive) and BIS (negative) were related to self-report but not objective physical activity. Interactions with other personality factors were also present, adding complexity to results. Voigt et al. (2009) explored how BAS processes and BIS related to various risk behaviors in young adults including physical inactivity. Major findings showed that BIS was related to higher reports and BAS goal-driven-persistence lower reports of sedentary behaviors, both with a low-to-moderate magnitude. The general pattern across all four studies highlighted BIS as a potential inhibitor and BAS as an inconsistent promotor to exercise-related outcomes.

Figure 1

Simplified path model of study hypotheses



Note. Time 1 (T1) Reinforcement Sensitivity Theory factors including Behavioral Activation System – Reward Interest (BAS-RI), Behavioral Activation System –Goal, Drive, Persistence (BAS-GDP), Behavioral Activation System – Reward Reactivity (BAS-RR), Behavioral Activation System – Impulsiveness (BAS-I), Behavior Inhibition System (BIS), and Flight, Flight, Fear System (FFFS) predict T2 exercise habit (EH), exercise self-efficacy (ESE), exercise affect (AFF), and exercise social support (ESS) after controlling for T1 EH, ESE, AFF, and ESS.

We underscore the need for further investigation of RST factors and exercise-related outcomes. To date, none of these exercise studies have examined the fully revised version of RST that includes BIS, all four processes of BAS, and FFFS. It seems especially important to explore the role of FFFS in exercise outcomes considering it represents a pure avoidance motivation system (Corr, 2008). Furthermore, contemporary theorizing on the four processes of BAS (Corr & Cooper, 2016) may provide greater clarity about its relations with exercise factors. There is also a clear need to move beyond correlational study designs in order to consider how effectively RST factors predict changes in exercise thoughts, feelings, and actions.

Therefore, the purpose of this study was to investigate contemporary RST factors as predictors of short-term changes in young adults' exercise-related outcomes. Specifically, we explore RST factors as predictors of change in young adults' reports of their exercise habits, exercise self-efficacy, exercise affect, and elicitation of exercise social support over a six-week period (see Figure 1). Because there is minimal evidence on relations between contemporary RST factors and exercise outcomes, we did not generate formal hypotheses. However, based on RST theory we assume that BAS processes will positively predict exercise outcomes while FFFS and BIS will negatively predict exercise outcomes.

Methods

Participants

Four hundred and six undergraduate students majoring in Kinesiology from one large university in the Southeastern United States participated in the study. Students reported their grade level as freshman (10%), sophomore (38%), junior (35%), and senior (17%) with an average age of 20.27 years (SD = 1.70). Approximately 75% of the sample were females. The sample reported their race/ethnicity as White (72%) Black (13%), Asian or Asian American (6%), Hispanic (4%), and Multi-Racial (5%). Finally, approximately 18% of the sample reported being first generation in their family to attend college.

Procedure

Permission to conduct the study was approved by the University Institutional Review Board of the primary researcher. Students were recruited from two large lecture-based Kinesiology courses (class 1, n = 266; class 2, n = 140) after receiving approval from course instructors. Just over 80% of the students agreed to take part in the study. We sent an electronic survey link containing all measures to participants within three days of the face-to-face recruiting visit. Before students could start the survey, they provided informed consent. Participants had a 72-hour window to complete the survey at the first time-point (T1). Participants received a second electronic survey link containing only exercise-related outcome measures approximately 6-weeks after they completed the first survey (T2). Again, participants had a 72-hour window to complete the survey. Two hundred and ninety of the original four hundred and six (71%) completed the survey at T2. Previous research has shown that university students' report substantial variation in exercise in this timeframe (Garn & Simonton, 2020; Miller & Hartman, 2020). We did not measure RST variables at T2 based on assumptions they represent primary causal processes of behavioral regulation and stable sources of its variation (Corr, 2008; McNaughton & Corr, 2008).

Measures

Reinforcement sensitivity theory personality questionnaire (RST-PQ).

The RST-PQ consists of 65 declarative statements measuring FFFS, BIS, and four aspects of BAS including reward interest, goal-drive-persistence, reward reactivity, and impulsivity (Corr & Cooper, 2016). Examples items include "I would run fast if I knew someone was following me late at night" (FFF); "When nervous, I find it hard to find the right words" (BIS); "I am always finding new and interesting things to do" (BAS reward interest); "I feel driven to succeed in my chosen career" (BAS goal-drive-persistence); "I am especially sensitive to reward" (BAS reward sensitivity); and "I think I should 'stop and think' more instead of jumping into things too quickly"

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(BAS impulsivity). Participants were asked to rate how accurately each statement described them on a scale ranging from 1 (not at all) to 4 (highly).

Exercise habit.

The automaticity subscale of the Self-Report Habit Index measured participants' habitual exercise behaviors (Gardner et al., 2012). Using the stem "Regular exercise is something …" participants answered four items such as "I do automatically" and "I do without thinking". Each item was answered on a scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Exercise self-efficacy.

Participants' exercise self-efficacy was measured using a scale developed by Marcus et al. (1992) that has been widely used in exercise studies (Dishman et al., 2014). This scale consists of five items related to one's efficacy to exercise when common barriers arise. Example items include "I am confident that I can participate in regular exercise when I am tired" and "I am confident that I can participate in regular exercise when I feel I don't have time". Each item was answered on a scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Exercise affect.

Our measure of exercise affect was patterned after the Feeling Scale (Hardy & Rejeski, 1989), which is a popular measure of affect in exercise research (Ekkekakis, 2003). The Feeling Scale is a single item scale of valance ranging from pleasant to unpleasant. Participants answered the following item: "When I exercise, I normally feel…" on a scale ranging from 1 (extremely unpleasant) to 6 (extremely pleasant).

Eliciting exercise social support.

Eliciting exercise social support was measured with the Physical Activity Self-Regulation Scale (PASR-12; Umstattd et al., 2009). Specifically, the eliciting exercise social support subscale of the PASR-12 consists of three items focused on participants' ability to acquire social support from important others. Example items including "I establish a commitment with others to exercise regularly" and "I seek out people to help me exercise regularly". Each item was answered on a scale ranging from 1 (strongly disagree) to 5 (strongly agree). The PASR-12 is a widely used measure in exercise-related studies (Olson & McAuley, 2015).

Data Analysis

Missing data were treated as missing at random and handled with full information likelihood procedures (FIML). FIML is a recommended approach for handling missing data in longitudinal analysis because of its ability to reduce bias compared to other approaches including list-wise deletion (Enders, 2010; Jeličić et al., 2009). We calculated descriptive statistics, bivariate correlations, and coefficient alpha estimates for study variables. Main research questions were tested using path analysis with robust maximum likelihood procedures (Kline, 2016). Composite scores for FFFS, BIS, BAS reward interest, BAS goal-drive-persistence, BAS reward sensitivity, and BAS impulsivity were treated as main predictors of T2 exercise habit, T2 exercise affect, T2 exercise self-efficacy, and T2 eliciting exercise social support. We modeled change in exercise outcomes by including autoregressive paths between each corresponding T1 measure (e.g., T1 exercise habit → T2 exercise habit; T1 exercise affect → T2 exercise affect; etc.). Factors measured at each time point were allowed to covary with one another.

Evaluation of path analysis results considered both measurement and structural models. Specifically, we examined the measurement model with fit indices including robust chi-square ($R\chi^2$) estimate based on degrees of freedom (df) with *p*-value, comparative fit index (CFI), root mean square error of approximation (RMSEA) with 90% confidence intervals, and standardized root mean square residual (SRMR). Joint criteria outlined by Hu and Bentler (1999) were used to judge model fit. Parameters including covariance/correlation and beta coefficients were used to explore the pattern of relations within the structural model.

Results

Table 1 displays all descriptive statistics and bivariate correlation estimates for study variables. All RST variables produced mean scores above the mid-point of their 4-point scale with a range from 2.33 (BAS impulsivity) to 3.49 (BAS reward reactivity). All exercise variables at T1 and T2 also had mean scores above the mid-point of their respective scales. Coefficient alpha estimates revealed adequate internal consistency for study variables although FFFS (.69) and T1 eliciting exercise social support (.67) were slightly below .70.

Table 1

Descriptive statistics and bivariate correlations of all study variables.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 FFFS	1.00	0.29**	-0.06	0.13*	0.25**	0.02	-0.04	-0.12	-0.23**	0.12	0.06	0.02	-0.14*	0.08
2 BIS		1.00	-0.16**	-0.16**	0.08	0.15**	-0.21**	-0.20**	-0.26**	-0.11	-0.16**	-0.25**	-0.20**	-0.04
3 BAS RI			1.00	0.40**	0.32**	0.23**	0.35**	0.46**	0.38**	0.30**	0.28**	0.35**	0.31**	0.21**
4 BAS GDP				1.00	0.43**	0.04	0.30**	0.24**	0.19**	0.22**	0.29**	0.26**	0.24**	0.11
5 BAS RR					1.00	0.37**	0.29**	0.18**	0.05	0.22**	0.28**	0.21**	0.06	0.21**
6 BAS Impulsivity						1.00	0.12*	0.09	-0.05	0.18**	0.11	0.05	0.01	0.25**
7 Exercise Affect							1.00	0.50**	0.43**	0.24**	0.66**	0.43**	0.35**	0.15*
8 Exercise Habit								1.00	0.58**	0.32**	0.38**	0.73**	0.50**	0.30**
9 Exercise SE									1.00	0.13	0.25**	0.51**	0.67**	0.20**
10 Exercise Social										1.00	0.18*	0.29**	0.18*	0.60**
11 T2_Exercise Affect											1.00	0.39**	0.33**	0.17**
12 T2_Exercise Habit												1.00	0.53**	0.25**
13 T2_Exercise SE													1.00	0.21**
14 T2_Exercise Social														1.00
Mean	2.51	2.45	2.76	3.49	3.04	2.33	5.00	3.15	3.45	3.12	4.91	3.13	3.28	3.26
SD	0.50	0.57	0.58	0.54	0.49	0.59	0.94	1.10	0.97	1.03	0.95	1.06	0.89	1.01
Scale	1 to 4	1 to 4	1 to 4	1 to 4	1 to 4	1 to 4	1 to 6	1 to 5	1 to 5	1 to 5	1 to 6	1 to 5	1 to 5	1 to 5
Coefficient Alpha	0.69	0.92	0.80	0.86	0.83	0.77	na	0.91	0.85	0.67	na	0.91	0.81	0.73

Note. FFFS = fight, flight, freeze system; BIS = behavioral inhibition system; BAS = behavioral approach system; RI = reward interest; GDP = goal-drive-persistence; RR = reward reactivity; SE = self-efficacy; Social = elicitation of exercise social support; T2 = time two; SD = standard deviation. * $p < .05$; ** $p < .01$.

Results from the path analysis measurement model produced a good fit of the data, Rχ^2 (12) = 24.41, $p = .02$, CFI = .98, RMSEA = .05 90% CI (.02 - .08), SRMR = .03. Table 2 presents findings from the path analysis structural model including unstandardized beta coefficients with standard errors and standardized beta coefficients. We initially ran our path model with covariates including age, gender, and ethnicity, but these factors were not predictors of any exercise outcomes and removed for parsimony purposes. Autoregressive coefficients for each exercise outcome demonstrated moderately stable longitudinal patterns of change (Table 3). After accounting for autoregressive relationships, BIS (β = -.15) and FFFS (β = .12) were the only two predictors of participants' T2 exercise habits. No RST variable predicted participants' T2 exercise affect. BAS goal-drive-persistence (β = .12) was the only predictor of T2 exercise self-efficacy while BAS impulsivity (β = 15) was the only predictor of T2 social support. Explained variance estimates were: (a) T2 exercise habit $R^2 = .54$, (b) T2 exercise affect $R^2 = .43$, (c) T2 exercise self-efficacy $r^2 = .44$. and (d) T2 eliciting exercise social support $r^2 = .38$.

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Table 2
Cross-sectional path model results of reinforcement sensitivity theory factors predicting exercise outcomes.

	T1 Affect		T1 Habit		T1 SE		T1 Social	
	b (SE)	β	b (SE)	β	b (SE)	β	b (SE)	β
FFFS	-.08 (.11)	-.04	-.18 (.14)	-.08	-.35 (.13)**	-.18	.34 (.14)*	.17
BIS	-.26 (.11)*	-.16	-.26 (.11)*	-.13	-.28 (.11)**	-.16	-.21 (.14)	-.12
BAS RI	.36 (.09)**	.22	.77 (.11)**	.41	.61 (.10)**	.36	.38 (.11)**	.22
BAS GDP	.17 (.12)	.10	.05 (.13)	.02	.02 (.13)	.01	.15 (.15)	.08
BAS RR	.39 (.14)**	.20	.17 (.17)	.08	.06 (.14)	.03	.08 (.15)	.04
BAS Impulsivity	.05 (.09)	.01	-.05 (.12)	-.03	-.22 (.10)*	-.13	.21 (.11)	.12

Note. FFFS = fight, flight, freeze system; BIS = behavioral inhibition system; BAS = behavioral approach system; RI = reward interest; GDP = goal-drive persistence; RR = reward reactivity; SE = exercise self-efficacy; Social = elicitation of exercise social support; T2 = time two; b = unstandardized beta coefficient; (SE) standard error); β = standardized beta coefficient. * $p < .05$; ** $p < .01$.

Table 3
Longitudinal path model results of reinforcement sensitivity theory factors predicting changes in exercise outcomes.

	T2 Affect		T2 Habit		T2 SE		T2 Social	
	b (SE)	β	b (SE)	β	b (SE)	β	b (SE)	β
FFFS	.13 (.09)	.08	-.25 (.10)*	-.12	-.02 (.10)	-.01	.08 (.12)	.04
BIS	-.10 (.09)	-.06	-.29 (.09)**	-.15	-.02 (.09)	-.02	-.08 (.10)	-.05
BAS RI	.08 (.08)	.05	.11 (.10)	.06	.08 (.11)	.06	.04 (.10)	.02
BAS GDP	.06 (.11)	.04	.06 (.09)	.03	.20 (.10)*	.12	-.07 (.11)	-.04
BAS RR	.14 (.11)	.07	.15 (.12)	.07	-.08 (.11)	-.05	.09 (.13)	.04
BAS Impulsivity	.02 (.09)	.01	-.06 (.10)	-.03	-.06 (.09)	.04	.26 (.11)*	.15
Exercise Affect	.58 (.06)**	.58						
Exercise Habit			.62 (.05)**	.64				
Exercise SE					.54 (.05)**	.60		
Exercise Social							.54(.06)**	.55

Note. FFFS = fight, flight, freeze system; BIS = behavioral inhibition system; BAS = behavioral approach system; RI = reward interest; GDP = goal-drive persistence; RR = reward reactivity; SE = exercise self-efficacy; Social = elicitation of exercise social support; T2 = time two; b = unstandardized beta coefficient; (SE) standard error); β = standardized beta coefficient. * $p < .05$; ** $p < .01$.

Discussion

The purpose of this study was to investigate contemporary RST factors as predictors of changes in young adults' exercise habits, exercise self-efficacy, exercise affect, and elicitation of exercise social support over a six-week period. In general, our findings did not uncover systematic longitudinal relations between RST factors and short-term changes in exercise outcomes although individual differences were present in some cases. Approach and avoidance motivation systems may work indirectly through other factors, such as goals, reinforcements, punishments, and enculturation (Corr & Krupic, 2017). In the following paragraphs, we describe our findings in more detail and provide possible explanations based on RST and previous research.

FFFS and BIS

FFFS and BIS modulate avoidance motivation and goal conflict, which produces defensive behaviors under normal circumstances (Corr, 2013). Our findings suggested that while BIS eroded these young adults' exercise habits over the six-week period, FFFS actually strengthened it. This is the first RST exercise study we are aware of that included FFFS. Although the magnitude of these relations were small, both FFFS and BIS related to changes in participants' exercise habits in a relatively short timeframe. It was surprising that FFFS positively related to a strengthening of exercise habits. One possible explanation is that FFFS reinforces exercise habits because exercise facilitates core functions of the FFFS. Specifically, exercise habits may enhance one's ability to fight or flee from stimuli determined to be harmful and dangerous. In fact, language used in FFFS items that focus on flight in the RST-PQ include descriptions such as "run fast" (Corr & Cooper, 2016). While replication in future longitudinal research is needed to confirm this relationship. We did conduct follow up analyses to evaluate possible suppression situations because of statistically significant beta coefficient and the non-significant zero-order correlation between FFFS and T2 exercise habit. However, even after removing all other predictors from the model, the relation between FFFS and T2 exercise habit remained stable.

Because exercise habits are closely linked to numerous health benefits and prevention of non-communicable diseases (United States Department of Health and Human Services, 2018) and young adults are at risk for sedentary behaviors (Bray & Born, 2004; Voight et al., 2009), the need for exercise interventions to consider individual differences in personality factors appears warranted (Wilson & Dishman, 2015). Specifically, young adults with high BIS activation may benefit from strategies such as attribution and active coping counseling and training (Hurley et al., 2007; Stewart et al., 2009). It may also be important to gather information on what aspects of chronic exercise individuals' view as conflicting with other goals to identify ways to reframe these negative attitudes.

FFFS and BIS did not predict changes in exercise self-efficacy, exercise affect, or elicitation of exercise social support. This was especially surprising for exercise affect because of the role the approach and avoidance motivation systems play in emotional regulation (Corr, 2013) and previous studies underscoring negative relations between BIS and exercise affect (Hall et al., 2005; Schneider & Graham, 2009; Voight et al., 2009). To some degree, this may reflect the differences in measurement and research design between studies. Specifically, we examined RST factors in relation to changes in exercise affect over a six-week period and did not measure affect during exercise. Previous studies explored differences in exercise affect during acute exercise bouts ranging from 3-minute (Hall et al., 2005) to 10-minute (Schneider & Graham, 2009) intervals. Furthermore, in our design we controlled for previous levels of exercise-related affect, moving past cross-sectional findings (Voight et al., 2009). Collectively, these differences may explain divergent results. Because participants were not engaged in exercise when assessing affect, it is possible that their reflection of exercise-related affect worked through higher-order aspects of motivation such as offline cognitive processing of emotion rather than their lower-order FFFS and BIS mechanisms (Corr, 2008; Krupic & Corr, 2020).

BAS

The BAS is a complex set of processes that coordinate approach behaviors. According to Corr and Cooper (2016), the initial stages of approach behavior focus on identifying rewards (i.e., BAS reward interest) and directing resources that aim to achieve them (i.e., BAS goal-drive-

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persistence). Impulsivity and reward reactivity reflect latter stages of approach behavior that emphasize one's interactions with rewards. Thus, it was interesting that the four elements of BAS were limited in relation to changes in exercise outcomes. Goal-drive-persistence predicted increases in participants' exercise self-efficacy while impulsivity predicted increases in elicitation of exercise social support. Reward interest and reward reactivity failed to predict changes in any of the study's exercise outcomes.

It is possible that BAS goal-drive-persistence stimulates exercise behavior through exercise beliefs such as self-efficacy once the formation of exercise habit occurs. However, this study was not suited to uncover such a sequence (Cole & Maxwell, 2003). Other RST researchers have theorized this type of mediation sequence in adolescent and adult drinking behaviors (Hasking, Boyes, & Mullan, 2015; Lopez-Vergara et al., 2012). Specifically, these researchers suggest that over time the BAS shapes behavior beliefs such as self-efficacy and expectation outcomes, which in turn directs approach behaviors. However, we are unaware of any RST studies that fully disentangled mediation assumptions (Cole & Maxwell, 2003) or theorized why the offline link (i.e., beliefs) would override the online link (i.e., BAS) to approach behavior (Corr, 2008; Krupic & Corr, 2020).

The complex nature of exercise may also provide a reasonable explanation for why BAS processes were not robust predictors of exercise outcomes. Many exercise benefits such as muscle hypertrophy, weight loss, and anxiolytic effects occur over time (Asmundson et al., 2013; Miller et al., 2014). In other words, exercisers must often focus on long-term incentives rather than instant rewards. Furthermore, benefits occur more quickly through vigorous exercise engagement, yet people are less likely to adhere to vigorous exercise because of associations with aversive stimuli such as a high rate of perceived exertion, pain, and negative affect (Hall et al., 2005; Miller et al., 2014; Schneider & Graham, 2009). These complexities may accentuate BIS activation over BAS processes.

BAS impulsivity predicted increased changes in participants' reporting of eliciting exercise social support. Many researchers theorize that impulsivity plays an important role in social functioning (Strack & Deutsch, 2004). It seems possible based on our previous arguments that BAS impulsivity may help create associations with short-term rewards (i.e. exercise socialization) instead of relying on long-term exercise incentives. In terms of RST, researchers consider extraversion closely associated with BAS function (Pickering, Corr, & Gray, 1999; Smillie et al., 2006). Thus, our results showing that participants with higher levels of impulsivity appeared to be outgoing and sociable in the context of exercise are likely a reflection of this personality trait that would likely translate to other contexts as well.

Limitations

This study is not without limitations. First, the convenient sample of young adults included mostly of White female participants, which should be considered when making generalizations about the results. Future studies with more diverse populations are needed to draw stronger conclusions about relations between RST factors and exercise outcomes. With only two waves of data, we were not able to properly test the possibility of a mediation sequence of RST → exercise beliefs → exercise behavior. Future studies should explore this developmental sequence in order to obtain a better understanding of the nature of RST and exercise. Our exercise measures were all self-report, therefore, future studies should incorporate objective measures of exercise such as observations methods or devices such as accelerometers.

Conclusions

The somewhat inconclusive findings between FFFS, BIS, BAS processes and exercise outcomes may reflect the mixed incentive nature of exercise environments. In many cases, exercisers may have to give up short term rewards in order to obtain long term incentives and experience the juxtaposition of aversive and appetitive stimuli before, during, and after their workouts. Smillie et al. (2006) noted that most environments produce combinations of rewards and punishments that produce a combined influence of the three RST systems on behavioral outcomes. Therefore, relations between RST systems and behavioral outcomes can be difficult for researchers to disentangle. Finding innovative ways to address this problem will certainly advance RST personality research in the future.

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