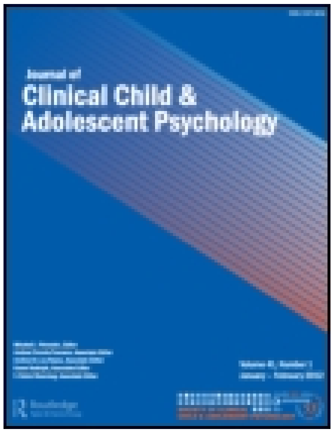

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The Interaction Between Self-Regulation and Motivation Prospectively Predicting Problem Behavior in Adolescence

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A large literature suggests associations between self-regulation and motivation and adolescent problem behavior; however, this research has mostly pitted these constructs against one another or tested them in isolation. Following recent neural-systems based theories (e.g., Ernst & Fudge, 2009), the present study investigated the interactions between self-regulation and approach and avoidance motivation prospectively predicting delinquency and depressive symptoms in early adolescence. The community sample included 387 adolescents aged 11 to 13 years old (55% female; 17% minority). Laboratory tasks were used to assess self-regulation and approach and avoidance motivation, and adolescent self-reports were used to measure depressive symptoms and delinquency. Analyses suggested that low levels of approach motivation were associated with high levels of depressive symptoms, but only at high levels of self-regulation ($p = .01$). High levels of approach were associated with high levels of rule breaking, but only at low levels of self-regulation ($p < .05$). These findings support contemporary neural-based systems theories that posit integration of motivational and self-regulatory individual differences via moderational models to understand adolescent problem behavior.

Adolescence represents the period between the onset of puberty and the attainment of adult roles and responsibilities (Steinberg et al., 2004). This period is marked by significant physical, psychological, and social changes, as well as increases in problem behavior. Delinquent behavior is a well-known problem in adolescence that can have dangerous consequences (for a review, see

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Spear, 2000). Depression is also of concern during adolescence (Lewinsohn et al., 1994; Zahn-Waxler, Klimes-Dougan, & Slattery, 2000). For example, epidemiological data suggest that suicide is the third leading cause of death (Centers for Disease Control and Prevention, 2011; Miniño, 2010). Adolescent depression and delinquency is best understood within an ontogenic context characterized by significant neural development that is believed to influence both motivation and self-regulatory capacity (Forbes, Silk, & Dahl, 2008; Spear, 2000; Steinberg et al., 2004). Prior research has linked self-regulation and motivation to both depression and delinquency (Beauchaine, 2001; Beauchaine, Gatzke-Kopp, & Mead, 2007; Brooks, Iverson, Sherman, & Roberge, 2010; Muris, Merckelbach, Wessel, & Van De Ven, 1999). These studies have largely tested simple main effects models, yet recent theories suggest that self-regulation and motivation operate interactively to influence behavior (e.g., Ernst & Fudge, 2009; Spear, 2010). The goal of this study was to use a longitudinal design to test whether the interaction between self-regulation and motivation prospectively predict delinquency and depression in early adolescence.

Both motivation and self-regulation represent broad domains of constitutionally based individual differences. Self-regulation refers to the capacity to purposefully restrain behavior, to detect errors, and to engage in planning (Rothbart & Rueda, 2005), and includes the ability to manage attention, and initiate (activational control) and inhibit (inhibitory control) behavior to adapt to contextual demands (Capaldi & Rothbart, 1992). Weak self-regulation is thought to underlie a variety of psychopathologies (Rothbart, 2007; Rueda, Posner, & Rothbart, 2004). Motivation involves individual differences in reactivity to incentives that activate approach and avoidance goals. Approach behavior is thought to be influenced by a behavioral activation system or a behavioral approach system that mediates responses to appetitive stimuli (Carver, 2006; Cloninger, 1987; Fowles, 1980; Gray & McNaughton, 2000). Avoidance or withdrawal is thought to be managed by a system typically referred to as a behavioral inhibition system (Carver, 2006; Cloninger, 1987; Gray & McNaughton, 2000) that mediates responses to goal conflicts or aversive stimuli. These two distinct systems have been linked to different neural pathways and give rise to diverse emotions (e.g., excited anticipation in the case of approach and anxiety/worry in the case of avoidance; Carver, 2006; Elliot & Thrash, 2002). There are points of overlap as well as differentiation between self-regulation and motivation. Self-regulation represents a "top-down" executive function that involves effortful modulation/regulation, whereas motivation involves "bottom-up" reactivity to stimuli and contexts relevant to approach and avoidance goals. For example, directing attention and inhibition/activation of behavior are central to both self-regulation and motivation. A key distinction is that these processes are effortful in the case of the former and reactive in the case of the latter.

Neuroscience-based models suggest that self-regulation and motivation are important in the etiology of delinquency and depression (e.g., Beauchaine, 2001; Carver, Johnson, & Joorman, 2008; Newman & Lorenz, 2003), and there is evidence to support these links. Poor self-regulation is associated with both delinquency and depression (Brooks et al., 2010; Kooijmans, Scheres, & Oosterlaan, 2000; Muris, van der Pennen, Sigmond, & Mayer, 2008). Strong approach motivation is associated with conduct disorder (Quay, 1993; Slobodskaya, 2007) and delinquency (Colder & O'Connor, 2004), whereas weak approach is associated with depression (Depue, Krauss, & Spoont, 1987; Kimbrel, Cobb, Mitchell, Hundt, & Nelson-Gray, 2007). Similarly, strong avoidance motivation is associated with depression (Hundt, Nelson-Gray, Kimbrel, Mitchell, & Kwapil, 2007; Kimbrel et al., 2007) and weak avoidance motivation with psychopathy, a behavior conceptually related to delinquency (Fowles, 1980).

Most of this prior work considering the role of self-regulation and motivation on problem behavior has examined one in isolation of the other, or considered them simultaneously but only as simple main effects. However, simple main effects models are not consistent with contemporary neural systems-based models of problem behavior. For example, Ernst and Fudge (2009) conceptualized adolescent problem behavior as motivated behavior governed by three primary systems of approach, avoidance, and regulation corresponding to different neural structures including the striatum, amygdala, and prefrontal cortex, respectively. These systems share considerable overlap with psychobiological models of motivation (e.g., Gray & McNaughton, 2000) and with models of self-regulation (e.g., Rothbart & Rueda, 2005). An important feature of this model is that these systems likely interact to influence behavior. Specifically, the prefrontal cortex receives information from the amygdala and striatum, and consequently serves as a modulator/regulator of these structures. That is, one of the key roles of the prefrontal cortex is to assist the organism in behavioral regulation of emotional/motivational impulses. According to this model forwarded by Ernst and Fudge, and others (Beauchaine et al., 2007; Luciana, 2006; Spear, 2010), strong motivational tendencies may only come to be expressed as problem behavior when self-regulatory capacity is insufficient to regulate strong motivation. Moreover, regulatory capacity and motivation are believed to go through substantial reorganization during adolescence, suggesting that the relative imbalance between motivation and self-regulation, and the potential moderating role of self-regulation may be particularly important for understanding problem behavior during this developmental period (Somerville, Jones, & Casey, 2010; Spear, 2000).

To our knowledge, no studies have prospectively tested whether self-regulation moderates the association between motivation and problem behavior in adolescence. This is the goal of the current study. We hypothesize that high levels of approach motivation and low levels of avoidance motivation will be associated with increases in delinquency at low levels of self-regulation and that low levels of approach motivation and high levels of avoidance motivation will be associated with increases in depressive symptoms at low levels of self-regulation.

METHODS

Participants

Participants were 387 parent–child pairs recruited for a longitudinal study examining problem behavior and substance use. Children were required to be between the ages 11 and 12 years at time of recruitment. Parent–child pairs were recruited utilizing a random-digit-dial sample of telephone numbers from ASDE Survey Sampler, Inc., generated for Erie County, New York. Calls were made by trained recruiters utilizing scripts explaining study participation, eligibility criteria (English-speaking child without any physical impairments or cognitive deficits that would preclude completion of the interview and a caregiver willing to participate), and the level of compensation for participation. The participation rate was 52.7%, which is within the range found in population-based studies requiring extended and extensive levels of subject involvement (Galea & Tracy, 2007), such as the Behavioral Risk Factor Surveillance Survey (about 50%) and the Survey of Consumer Attitudes (48%). A few children had a birthday between recruitment and the first assessment; therefore, at the first assessment, adolescents were aged 11 to 13 ($M = 12.1$, $SD = .59$; refer to Table 1 for additional demographic information).

Two months prior to the year anniversary of the first assessment, families were contacted for participation in the second assessment. The majority of Time 2 assessments were conducted within 2 months of the year anniversary of the first assessment (93%). Retention was strong; only 14 families (4%) did not participate in the second assessment. Chi-square tests and analyses of variance demonstrated that participants with missing data did not significantly differ from those with complete data on any demographic variables (e.g., gender, age, race) or depression or delinquency at the first assessment ($ps > .35$).

TABLE 1
Descriptive Statistics for Selected Sample Characteristics at Time 1

Adolescents	
Gender	
% Female	55.0
Age	
M (*SD*)	12.10 (0.59)
Range	11–13
IQ Index Score	107.05 (12.51)
Puberty	2.29 (0.59)
Race	
% Caucasian	83.1
% African American	9.1
% Other Race	7.8
Caregivers	
Education	
% Some High School	2.8
% High School Graduate	14.2
% Technical School	2.9
% Some College	22.0
% College Graduate	38.1
% Graduate or Professional School	20.0
Family Characteristics	
Median Annual Family Income	$70,000.00
Family Composition	
% Two-Parent	76.0
% Divorced/Separated	12.1
% Single Parent/Never Married	9.8
% Other	2.1

Procedures

Before the interview, parents and adolescents gave informed consent and informed assent, respectively. Parents and adolescents were interviewed in separate rooms for 2.5 to 3 hr. Participants completed structured questionnaires and computer-based tasks administered by trained interviewers. Items were read aloud to participants, and responses were entered directly into a computer. Parent–child pairs were remunerated $75 at Time 1 and $85 at Time 2. Adolescents earned a small gift worth $5 at Time 1 and $10 at Time 2 (e.g., gift cards, colored pencil, lip gloss, basketball) for their participation.

Measures

The following measures were used in analyses and all laboratory tasks were programmed in E-Prime (Version 2.0).

Motivation (time 1). The revised Point Scoring Reaction Time Task (PSRTT-CR, see Figure 1a and 1b) was administered to adolescent participants to assess sensitivity to punishment (avoidance motivation) and sensitivity to reward (approach motivation; Colder & O'Connor, 2004; Colder et al., 2011). Participants were instructed to discriminate between two-digit odd and even numbers presented below a colored circle by

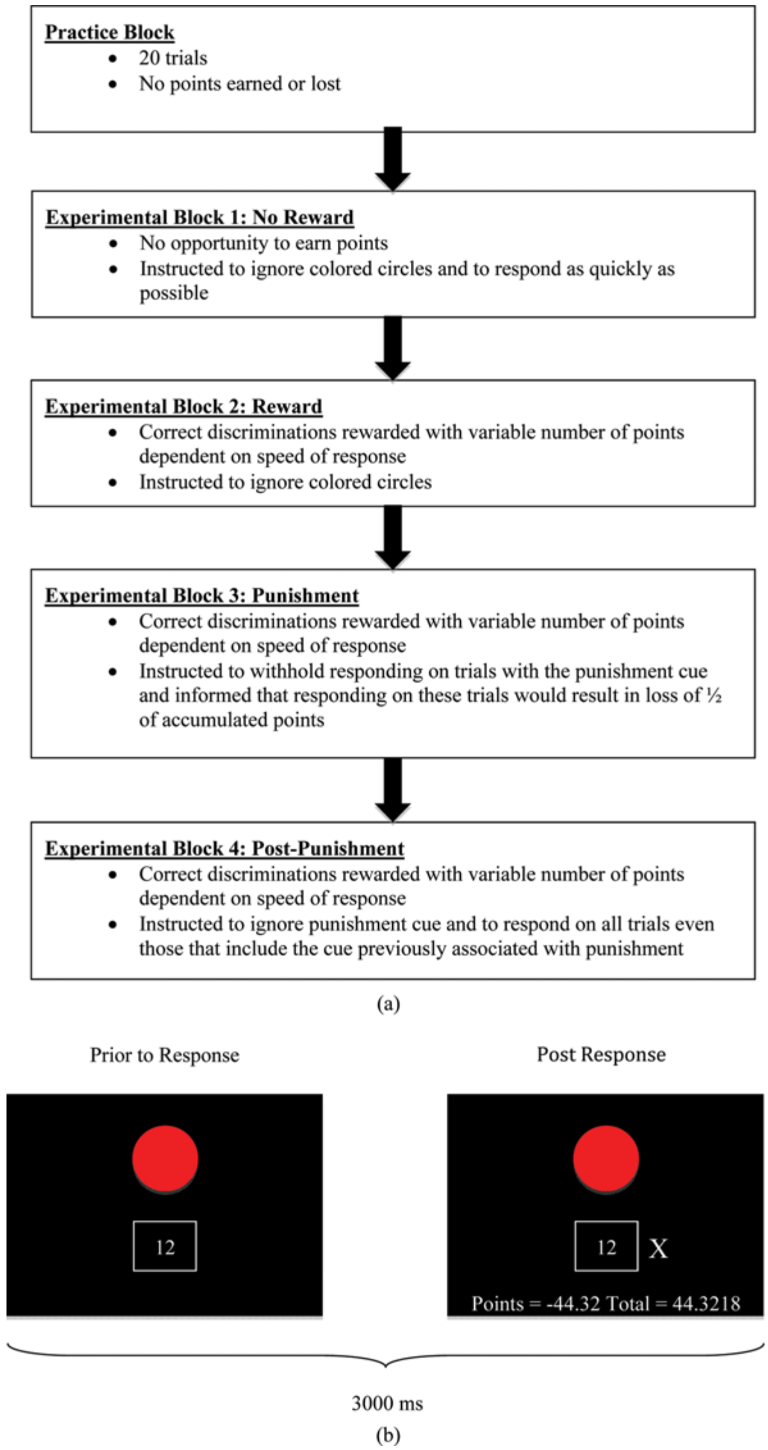

FIGURE 1 Design of the Point Scoring Reaction Time Task for Children Revised. (Figure appears in color online.)

pressing the appropriate button on a response box and to work as quickly and accurately as possible. Four experimental blocks were presented in a fixed order: practice, no-reward, reward/pre-punishment, reward/punishment, and reward/post-punishment. Participants received feedback after each trial in the form of an X (incorrect answer) or O (correct answer). The points earned per response and total accumulated points were displayed at the bottom of the computer screen at the end of each trial. During the no-reward block (Block 1), participants were told to respond as quickly as possible and that they would not earn points for correct responses but could lose 2 points for incorrect responses. Losing 2 points for incorrect discrimination remained in effect for all blocks, and participants were told this. During the reward block (Block 2), participants were told they would earn points for correct responses and more points could be earned for faster responses. During the punishment block (Block 3), participants were instructed to inhibit responding if a red circle appeared above the two-digit number and failures to inhibit would result in a loss of half of accumulated points. Instructions repeated those for Block 2 for non-red circle trials. During the postpunishment block (Block 4), participants were instructed to ignore the colored circles and respond on all trials, even trials with red circles. The rest of the instructions repeated those in Block 2.

Change in reaction time (RT) in the reward block (Block 2) compared to the no-reward block (Block 1)[1] indicates approach motivation, with relatively low RTs during the reward block indicative of strong approach motivation. Our behavioral measure of approach motivation was computed by subtracting average RT in the reward block from average RT in the no reward block (No reward RT–Reward RT). Higher scores represent faster responding during the reward block and strong approach motivation.

Red circles are established as a punishment cue (losing half of accumulated points) in the punishment block (Block 3). In the postpunishment block (Block 4), participants were instructed to respond on all trials (even those that included a red circle), and points could be earned on all trials, including red circle trials. Accordingly, red circles in the postpunishment block are expected to cause conflicting inputs (current reward and previous punishment) and thus lead to activation of avoidance/inhibition of behavior (increased RTs). The degree to which RTs increase on red circle trials compared to non-red circle trials in the postpunishment block represents the strength of avoidance motivation. RTs from the postpunishment block were used to compute a measure of avoidance motivation. Average RT of the non-red circle trials that immediately preceded a red circle trial were subtracted from the average RT of red circle trials (RT red circle trials – RT non-red circle trials). We used trials immediately preceding each red circle trial to make the number of trials comparable across trial types (non-red circle trials $n = 45$; red circle trials $n = 5$), as well as to control for serial position in the block. Specifically, because there is a general decline in RTs (attributed to a decay of the punishment cue) as one moves through the postpunishment block and because due to a pseudorandom order, non-red circle trials occurred on average three trials earlier than the red circle trials (23 vs. 26), non-red circle trials preceding red circle trials were used in an attempt to compare trials with analogous position within the block and to eliminate concerns regarding changes in RT following a psychologically interesting trial (i.e., trials following red circle trials). Higher scores represent slower responding to red circle trials in the postpunishment condition and strong avoidance motivation.

Computation of approach and avoidance indices included all trials (correct and incorrect responses) for two reasons. First, our postpunishment block was designed to create a response conflict (a cue previously associated with punishment comes to be associated with reward), and engagement of response conflict is expected to not only slow down responding but also increase error rates. Indeed error rates on red circle trials in the postpunishment block were 12% compared to 3% to 6% in the other experimental blocks. Thus, error trials are of interest. Second, including error trials maximized the number of RTs included in our computations, and this was particularly important for the avoidance index, as this measure was based on five trials in comparison and cued conditions (as noted next).[2]

Means for the approach and avoidance indices are presented in Table 2. On average, RTs were slower during the no-reward block compared to reward block, and RTs were slower during red circle compared to non-red circle trials during the postpunishment block (both means were significantly different from zero, $ps < .05$) suggesting the expected condition effects. Approach and avoidance motivation indices from the PSRTT-CR have been associated with questionnaire assessments of approach and avoidance motivation (Colder & O'Connor, 2004; Colder et al., 2011; Rhodes et al., 2011) and with problem behavior as expected (Colder & O'Connor, 2004).

Self-regulation (time 1). The stop signal task (SST; Logan, Schachar, & Tannock, 1997) was administered to participants to assess inhibitory control, a key component of self-regulation. The SST is a computerized task widely used to assess the inhibition of a prepotent response (Logan & Cowan, 1984; Lipszyc & Schachar, 2010; Oosterlaan, Logan, & Sergeant, 1998; Soreni,

[1]A potential concern of using fixed order for blocks is that our measure of approach behavior is potentially confounded with order effects (e.g., no reward always preceded reward). However, examination of trial-level data suggested no linear, quadratic, or cubic trend in change in RT across trials within the no-reward and reward blocks. This suggests that the fixed order is not associated with strong confounding effects on our index of approach.

[2]To examine the impact of including RTs from error trials in our approach and avoidance indices, we also computed these indices using RTs from correct trials only. Indices based on all trials and correct trials only were strongly correlated (approach $r = .99$; avoidance $r = .90$). Moreover, we ran our regression models using both sets of indices, and the pattern of findings was the same. Thus, the inclusion of error trials did not have a strong influence on our findings.

TABLE 2
Descriptive Statistics for All Study Variables

	M	SD	Correlations 1	2	3	4	5	6
1. Depression T2[a]	1.82	2.15						
2. Rule Breaking T2[a]	2.14	2.38	0.49**					
3. Depression T1	2.02	1.92	0.55**	0.37**				
4. Rule Breaking T1	1.73	2.11	0.39**	0.69**	0.41**			
5. SSRT T1	197.62	74. 59	0.02	0.11*	0.04	0.05		
6. AVM T1	100.75	161.56	0.09	0.04	0.08	0.06	0.05	
7. APM T1	109.61	120.91	−0.02	0.05	0.09	0.03	0.01	−0.07

Note. T2 = Time 2 variables; T1 = Time 1 variables; SSRT = stop signal reaction time; AVM = avoidance motivation; APM = approach approach motivation.
[a]Based on untransformed variables.
*$p < .05$. **$p < .001$.

Crosbie, Ickowicz, & Schachar, 2009). During the SST, participants attempt to respond quickly and accurately to a forced-choice RT task and to withhold responding when presented with a tone (the stop signal).

In the first practice block (32 trials), participants were trained to discriminate between an arrow pointing right or left (the go stimuli). Participants were told that an arrow would appear in the center of the computer screen and that they should push the corresponding button on the response box (the right or left button). Before presentation of the go stimulus, a fixation point (an asterisk) appeared in the center of the screen for 500 ms. The go stimuli were then presented for 1,000 ms. In the second practice block (32 trials), participants were taught to inhibit the prepotent response (responding to the go stimuli) when presented with an auditory stop signal.

Following the practice blocks, participants completed three experimental blocks consisting of 64 trials each. The stop signal was presented on 25% of trials. The stop signal delay was adjusted to participants' performance in inhibiting the prepotent response (Band, van der Molen, & Logan, 2003); an initial delay of 250 ms, with a 50 ms increase or decrease following successful or unsuccessful inhibition, respectively.

The primary dependent variable is the stop signal RT (SSRT). The SSRT is the latency of the stopping process and is computed by subtracting the mean stop signal delay (MSD) from the mean RT on "Go" trials (SSRT = MRT − MSD). Higher SSRT scores indicate less efficient inhibitory control.

Depression and delinquency (time 1 and 2). Adolescents completed the Anxious-Depressed, Withdrawn-Depressed, Aggression, and Delinquency scales for Youth Self Report (Achenbach & Rescorla, 2001), a widely used survey that assesses a range of problem behaviors in youth. Items reflect behavior in the past 6 months using a Likert scale from 0 (*not true*) to 2 (*very true*). For this study, two subscales were of particular interest: the Depressed-Withdrawn and Rule Breaking subscales. The former comprises eight items and was used to assess depression, whereas the latter comprises 17 items reflecting delinquency. Items across each subscale were summed to create a scale score for each time point. Internal consistencies based on polychoric correlations to adjust for the trichotomous response scale (Cronbach's alpha) were .85 (Time 1) and .90 (Time 2) for the Depressed-Withdrawn subscale and .89 (Time 1 and 2) for the Rule Breaking subscale. The mean (standard deviation) age-corrected *t* scores for the Depressed-Withdrawn subscale were 52.40 (4.07, Time 1) and 52.39 (4.75, Time 2). These scores are comparable to *t* scores of nonreferred youth samples (boys, 54.3 [6.1]; girls, 54.4 [5.9]; Achenbach & Rescorla, 2001). A small percentage of participants (3.9% and 3.8% at Times 1 and 2, respectively) scored in the borderline clinical or clinical range (≥65) for depressed-withdrawn behaviors. Mean (standard deviation) age-corrected *t* scores for the Rule Breaking subscale were 51.32 (3.02) and 51.83 (3.64) at Times 1 and 2, respectively. These scores are comparable to *t* scores of nonreferred youth samples (boys, 54.0 [5.6]; girls, 54.1 [5.5]; Achenbach & Rescorla, 2001). A small percentage (<1%) scored in the borderline clinical or clinical range (≥65) for rule-breaking behaviors at both time points.

Control variables. We considered gender, age, puberty, and intelligence quotient (IQ) as control variables. Age was computed based on birthdate and date of interview. Puberty was assessed using the Pubertal Development Scale (Peterson, Crockett, Richards, & Boxer, 1988), a 4-point Likert scale regarding a variety of pubertal changes (e.g., body hair, pimples, growth in height) with greater values reflecting later stages of pubertal development. IQ was assessed using the Reynolds Intelligence Screening Test (Reynolds & Kamphaus, 2003).

DATA PLAN

The two outcome variables, Time 2 depression and rule breaking, were not normally distributed; therefore, a square root transformation was performed on both variables (skewness = 0.26 and kurtosis = −0.88; skewness = 0.14 and kurtosis = −0.36, for the transformed variables, respectively) to meet the assumptions of regression analysis. First-order terms and outcomes were standardized to eliminate nonessential multicollinearity and to produce standardized regression coefficients (Aiken & West, 1991).

Ordinary least squares regression was run using the regression procedure in SAS 9.2 (SAS Institute Inc., 2008). Depression and rule breaking at Time 2 were the outcomes predicted in separate regression models, and the Time 1 measure of the outcome was included as a predictor. Child age at Time 1 was included as demographic control variable. Of interest were two two-way interaction terms (SSRT × Avoidance Motivation and SSRT × Approach Motivation). SSRT values corresponding to 1 standard deviation above and below the sample mean were used to probe each significant interaction according to Cohen and Cohen's (1983) recommended guideline. We probed marginally significant interaction terms ($p \leq .10$) because statistical interactions are often difficult to detect in social sciences (McClelland & Judd, 1993) and because we had a priori predictions about the nature of the interactions. Squared semipartial correlations (sr^2) were also calculated to provide information about effect sizes. We also considered gender as a moderator. IQ, age, and puberty were included as statistical control variables in the models.

RESULTS

In Table 2, the descriptive statistics for the study variables are presented. Within time correlations suggested that high levels of depression were associated with high levels of rule breaking. Both depression and rule breaking were moderately stable over the 1-year period. None of the correlations between avoidance motivation, approach motivation, and SSRT were statistically significant, suggesting that these are independent individual differences. The only statistically reliable association was between SSRT and rule breaking at Time 2, such that high levels of SSRT were associated with high levels of rule breaking. These zero-order correlations are not informative with respect to moderational hypotheses.

Regression Model for Depression

Results of the regression predicting depression are presented in Table 3. The model accounted for approximately 34% of the variance in depression at Time 2. The first-order effects suggested that earlier pubertal development was associated with increases in depression 1 year later. In addition, high levels of avoidance motivation and low levels of approach motivation at Time 1 were prospectively associated with increases in depression 1 year later. The effect of approach motivation was qualified by a statistically reliable SSRT × Approach Motivation interaction term as hypothesized. However, the nature of this interaction was not as expected. As depicted in Figure 2, the simple slope of approach motivation was statistically significant at *low* levels of SSRT (i.e., strong inhibitory control; $\beta = -0.140$, $p = .01$), but not at *high* levels of SSRT (i.e., weak inhibitory control; $\beta = -0.018$, *ns*).

TABLE 3
Standardized Regression Models for Depression

Model Predicting Depression at Time 2				
	Coefficient	*SE*	*t value*	sr^2
Intercept	1.037**	0.04	27.73	
Age	−0.042	0.04	−1.05	0.001
Gender	−0.072	0.04	−1.82	0.007
IQ Index Score	−0.005	0.04	−0.14	0.006
Puberty	0.147***	0.04	3.53	0.049
Depression at Time 1	0.477***	0.04	12.39	0.277
SSRT	−0.037	0.04	−1.00	0.001
AVM	0.085*	0.04	2.22	0.009
APM	−0.079*	0.04	−2.07	0.005
SSRT × AVM	−0.014	0.04	−0.36	0.000
SSRT × APM	0.061*	0.03	1.97	0.007

Note. sr^2 = squared semipartial correlation; SSRT = stop signal reaction time, AVM = avoidance motivation, APM = approach motivation.
*$p < .05$. ***$p < .001$.

Multiple Regression Model for Rule Breaking

Results of the regression model predicting rule breaking are presented in Table 4. The model accounted for approximately 41% of the variance in rule breaking at Time 2. Gender prospectively predicted rule breaking,

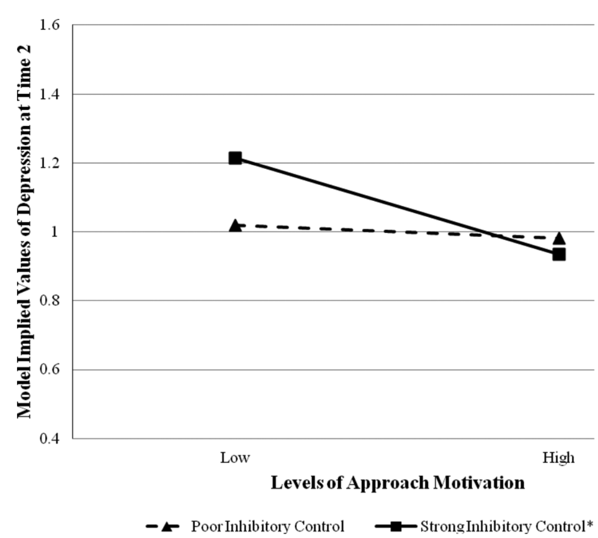

FIGURE 2 Approach motivation predicting depressive symptomatology.

TABLE 4
Standardized Regression Models for Rule Breaking

Model Predicting Rule Breaking at Time 2

	Coefficient	*SE*	*t Value*	sr^2
Intercept	1.170***	0.04	32.82	
Age	0.064	0.04	1.67	0.019
Gender	−0.103**	0.04	−2.62	0.063
IQ Index Score	−0.005	0.04	−0.13	0.002
Puberty	0.115**	0.04	2.87	0.038
Rule Breaking at Time 1	0.512***	0.04	13.33	0.288
SSRT	0.015	0.04	0.42	0.001
AVM	0.018	0.04	0.50	0.001
APM	0.036	0.04	0.98	0.003
SSRT × AVM	0.050	0.04	1.39	0.003
SSRT × APM	0.054†	0.03	1.79	0.005

Note. sr^2 = squared semipartial correlation; SSRT = stop signal reaction time; AVM = avoidance motivation; APM = approach motivation.
$^{**}p < .01$. $^{***}p < .001$. $^{\dagger}p < .10$.

such that boys were more likely to report rule-breaking behavior 1 year later. Similarly, first-order effects suggested that earlier pubertal development was associated with increases in rule breaking 1 year later. No other first-order effects were statistically reliable. However, the two-way SSRT × Approach Motivation interaction term ($p < .07$), though not statistically significant, approached conventional criteria for significance. As hypothesized, the simple slope of approach motivation was statistically significant at high levels of SSRT (weak inhibitory control; $\beta = 0.090, p < .05$) but not at low levels of SSRT (strong inhibitory control; $\beta = -0.000$, *ns*; see Figure 3). Contrary to hypotheses, avoidance did not enter into a statistically reliable interaction with SSRT to predict delinquency.

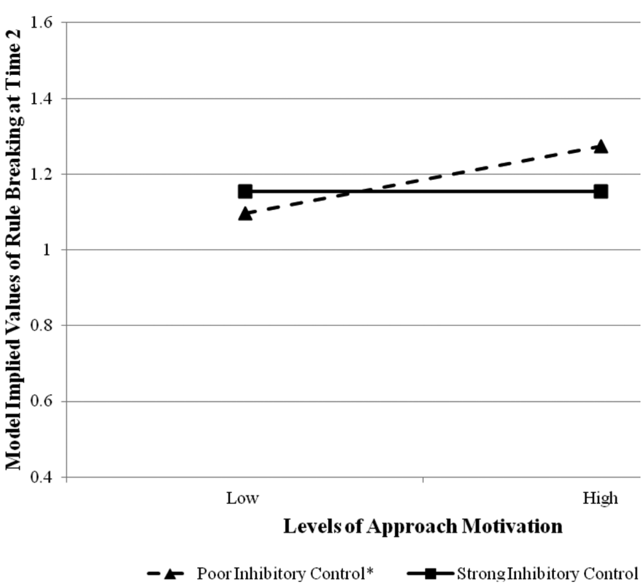

FIGURE 3 Approach motivation predicting rule breaking symptomatology.

DISCUSSION

The aim of the present study was to use a longitudinal design to test whether the interaction between self-regulation and motivation prospectively predicts depression and delinquency in adolescence. We hypothesized that individual differences in motivation would be associated with problem behavior, but only in the context of poor self-regulation. In the context of poor self-regulation, strong approach and weak avoidance motivation were expected to be associated with delinquency, and weak approach and strong avoidance were expected to be associated with depressive symptoms. Findings suggested mixed support for these hypotheses.

Consistent with prior studies (Depue et al., 1987; Kasch, Rottenberg, Arnow, & Gotlib, 2002; Kimbrel et al., 2007), we found that low levels of approach and high levels of avoidance were prospectively associated with increases in depressive symptoms. An underactive behavioral activation system is thought to predispose individuals to experience a lack of interest in pursuing pleasurable experiences, whereas an overactive behavioral inhibition system is thought to promote behavioral withdrawal. These behaviors are thought to increase vulnerability for depression (Fowles, 1994).

As expected, the effect of approach was qualified by an interaction with self-regulation. However, this interaction was the opposite of what was hypothesized. Low levels of approach prospectively predicted increases in depressive symptoms, but only at higher levels of self-regulation. This finding is surprising given that some prior studies have demonstrated that poor self-regulation has been broadly associated with internalizing problems including depression and anxiety (Muris et al., 2008). One explanation for this unexpected result is that high levels of self-regulation may represent overcontrol, particularly in the context of low approach motivation. The combination of overcontrol and low approach motivation may lead to maladaptive avoidant coping strategies (e.g., denial, emotional suppression, disengagement, escape) and symptoms of depression. This interpretation is supported by prior work suggesting that overcontrol in childhood (e.g., Eisenberg et al., 2001) and adolescence (Silk, Steinberg, & Morris, 2003) is associated with maladaptive coping and high levels of internalizing symptoms. Another possibility is that a strong capacity to inhibit prepotent responses (reflecting high regulation on our measure) when co-occurring with low approach motivation may increase risk for depressive symptoms because it reduces the likelihood of seeking out pleasurable or rewarding activities/stimuli. Both of these explanations align well with our measure of depression, which was taken from the Youth Self Report and includes sad affect and withdrawal. As noted earlier, self-regulation is a complex multidimensional construct that includes attention, activation control, and inhibition (Capaldi & Rothbart, 1992), and we examined only the latter. It will be important for future research to test our hypotheses with other facets of self-regulation as they may operate differently in the moderational model we have proposed.

It is notable that avoidance motivation did not enter into an interaction with self-regulation to predict depressive symptoms. We assessed inhibitory control using the SST (e.g., Lipszyc & Schachar, 2010; Oosterlaan et al., 1998; Soreni et al., 2009), but other domains of self-regulation, such as attentional control (e.g., shifting and sustaining attention), are plausible moderators of motivation. Rothbart and colleagues posited that attentional control reflects the capacity to direct attention away from upsetting and aversive stimuli and toward positive stimuli and represents an important aspect of coping with emotional distress (e.g., Derryberry & Rothbart, 1988; Posner & Rothbart, 1998; Posner & Rothbart, 2000; Rueda et al., 2004). Thus, other domains of self-regulation (e.g., attentional control) may moderate avoidance motivation, as well as approach motivation, in the prediction of depressive symptoms.

With respect to delinquency, we found that strong motivational approach prospectively predicted increases in delinquency (rule breaking), but only under conditions of poor self-regulation. Approach motivation has been consistently linked to delinquency and more broadly to externalizing behavior (Iaboni, Douglas, & Baker, 1995; Matthys, van Goozen, deVries, Cohen-Kettenis, & van Engeland, 1998; O'Brien & Frick, 1996; O'Brien, Frick, & Lyman, 1994; Oosterlaan & Sergeant, 1998). Our findings extend this literature by showing that this link depends on levels of self-regulation. Under conditions of strong approach motivation, an adolescent will be oriented toward reward and as activation of the approach system increases, so does goal-directed or reward-focused behavior (Gray & McNaughton, 2000). With sufficient regulatory capacity, this motivational style does not seem to lead to high levels of delinquency. However, poor self-regulation makes it hard to control strong reward-driven impulses, resulting in delinquent behavior.

Contrary to our hypotheses, avoidance motivation did not interact with self-regulation to predict delinquency. Although this finding was surprising, the lack of an interaction between avoidance motivation and externalizing behaviors is consistent with some prior research suggesting avoidance motivation is not germane to externalizing behavior problems (Quay, 1993). Avoidance motivation is thought to be managed by the behavioral inhibition system (e.g., Gray & McNaughton, 2000) that mediates responses to conflicting reward and punishment cues. Of interest, a limited capacity to inhibit behavior in contexts with mixed incentives has been specifically associated with psychopathy (e.g., Baskin-Sommers, Wallace, MacCoon, Curtain, & Newman, 2010; Fowles, 1980; Newman, MacCoon, Vaughn, & Sadeh, 2005). This suggests that avoidance motivation may be more relevant to specific forms of delinquent or antisocial behavior like psychopathy, rather than general delinquency. Thus, the expected avoidance motivation by self-regulation interactions may be limited to more severe forms of antisocial behavior that were not assessed in the present study. Alternatively, as previously discussed, other aspects of self-regulation (e.g., attentional control) may be more central to modulating avoidance motivation.

Although this study has made an important contribution to our understanding of how motivation and self-regulation increase vulnerability for problem behavior, it is important to consider its limitations. The sample consisted of mostly Caucasian adolescents between the ages of 11 and 13 (at the time of the first assessment), whose parents tended to be well educated. Our findings should not be generalized to other developmental periods or samples with different demographic characteristics. With respect to age, evidence suggests that features of both self-regulation and motivation continue to mature into early adulthood (e.g., Ernst & Fudge, 2009; Spear, 2010), and it will be important for future research to test our moderational models across a wide range of ages to examine potential developmental trends. Notably, gender did not predict depression in this study, and it is possible that the age of the sample may have impacted gender effects on depression, as epidemiological data suggest that gender differences in depression get stronger with age (e.g., Hankin et al., 1998; Wade, Cairney, & Pevalin, 2002). One advantage of the current sample is that it includes typically developing adolescents; thus we examined problem behavior on a continuum. Whether our findings will generalize to clinical samples requires future replication. Although this study sought to use behavioral assessments of self-regulation and motivation, the tasks used require consideration. For example, as previously described, the SST assesses only one domain of self-regulation (i.e., inhibitory control), and it is possible that other aspects of self-regulation will operate differently with motivation. The PSRTT-CR included a response cost implemented throughout the task. Accordingly, it assesses behavioral responses in the context of mixed incentives (both punishment and reward) with the relative weight of each manipulated across blocks. Mixed incentives enhance ecological validity, in that most contexts individuals experience include both potential rewards and punishments. Contexts in which only reward or punishment is available are arguably rare in typical day-to-day experiences. Nonetheless, it is important to consider this feature of the PSRTT-CR when interpreting the results. Last, we examined symptoms of delinquency and depression, as these are common problems in adolescence that are of major public health concern with links to self-regulation and motivation. However, there are other domains of psychopathology that warrant investigation with respect to potential interactions between self-regulation and motivation (e.g., attention deficit/hyperactivity disorder, anxiety, aggression, substance use).

Despite these limitations, the present work is the first study to our knowledge to utilize a longitudinal design and laboratory assessments to test whether the interaction between self-regulation and motivation prospectively predicts problem behavior in early adolescence. Previous studies have typically looked at these processes as predictors of problem behavior and psychopathology either in isolation of one another or as simple additive effects. However, current neural-based theories of problem behavior suggest that motivation and regulation may operate interactively (Ernst & Fudge, 2009; Luciana, 2006; Spear, 2010). Moreover, the development of multiple neural systems during adolescence may result in changes in both regulation and motivation (Somerville, Jones, & Casey, 2010; Spear, 2000) and such interactions may be particularly characteristic of adolescent problem behavior. Our findings support this conceptualization and suggest that motivational individual differences are associated with problem behavior when at the extremes of self-regulation, overregulation with respect to depression and underregulation with respect to delinquency. It will be important for studies examining motivation and self-regulation to move beyond testing one in isolation of the other or testing only simple additive effects and consider how multiple systems operate jointly in accordance with contemporary neuroscience accounts of problem behavior.

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