The Prospective Joint Effects of Self-Regulation and Impulsive Processes on Early Adolescence Alcohol Use

ROISIN M. O'CONNOR, PH.D.,^{a,*} & CRAIG R. COLDER, PH.D.^b

^a*Department of Psychology, Concordia University, Montreal, Quebec, Canada*

^b*Department of Psychology, State University of New York at Buffalo, Buffalo, New York, USA*

ABSTRACT. Objective: Dual-process models propose that behavior is influenced by the interactive effect of impulsive (automatic) and self-regulatory (controlled) processes. Elaborations of this model posit that the effect of impulsive processes on alcohol use is influenced by capacity and motivation to self-regulate. The interactive effect of these three processes on drinking has not previously been tested. The goal of this study was to provide a developmental extension of this model to early adolescent alcohol use and to test the three-way interaction between impulsive processes (implicit alcohol cognition), self-regulatory capacity (inhibitory and activation control), and self-regulatory motivation (negative alcohol outcome expectancies [AOE]) in a 1-year prospective prediction of adolescent alcohol use. **Method:** Adolescents ($N = 325$; 54% girls, mean age = 13.6 years at baseline) completed the Single Cat-

egory Implicit Association Test and self-reports of alcohol expectancies and use. Inhibitory and activation control were based on parental report. **Results:** Negative AOE and inhibitory/activation control were supported as moderators of the effect of implicit alcohol cognition on 1-year prospective alcohol use. As expected, weak implicit negative alcohol cognition was associated with elevated alcohol use when both negative AOE and inhibitory control were low. Contrary to hypothesis, when activation control was high, weak implicit negative alcohol cognition was unrelated to alcohol use if negative AOE were high ($p = .72$) (vs. low, $p < .01$). Activation control may reflect the ability to plan ahead and act pro-socially. **Conclusions:** Our study supports current theory suggesting alcohol use is influenced by a complex interplay of impulsive and self-regulatory processes. (*J. Stud. Alcohol Drugs*, 76, 884–894, 2015)

DUAL-PROCESS MODELS POSIT that alcohol use is influenced by the joint effect of impulsive (reflexive, automatic) and self-regulatory (reflective, controlled) processes. Initial empirical work examining these two processes in the prediction of alcohol use focused primarily on comparing or pitting each against the other (e.g., O'Connor et al., 2007; Pieters et al., 2010; Thush & Wiers, 2007). However, many dual-process models propose interactive effects of impulsive and self-regulatory processes on alcohol use, and recent work has supported interactive effects (Lindgren et al., 2014; Pieters et al., 2012; Wiers et al., 2010). Most of this work has been done with late adolescent and young adult samples, although there are exceptions (Pieters et al., 2012). The goal of the current study was to extend this literature by testing whether multiple domains of self-regulatory capacity as well as motivation to regulate drinking operate as moderators of the impulse to drink in early adolescence.

Alcohol use is typically initiated and escalates during adolescence (Colder et al., 2002; Eaton et al., 2006), making this an important developmental period in which to examine alcohol use precursors. Many contemporary cognitive theories are dual-process models, incorporating two cognitive

systems. One system is primarily associative in nature and is characterized by impulsive and reflexive processes that involve automatic appraisal of the emotional and motivational significance of stimuli. As applied to alcohol use, this system includes alcohol associations that influence drinking when automatically activated (Moss & Albery, 2009; Stacy & Wiers, 2010). This system may be particularly relevant to adolescent alcohol use given that adolescents are susceptible to impulsive responding because of slow maturation of the prefrontal cortex (Casey et al., 2008). Implicit measures, such as computerized reaction time tasks (e.g., priming tasks; Implicit Association Test [IAT], Greenwald et al., 1998, and its variants) are thought to reflect automatically activated associations. The other system is primarily propositional in nature and is characterized by reflective, deliberative, and evaluative processes involving outcome expectancies that are available for introspection. Outcome expectancies, typically assessed using explicit self-reports, are thought to influence drinking through a controlled, self-regulatory process. According to dual-process models, both the content (i.e., association/expectancy valence) and activation of these processes are central to behavior (Stacy & Wiers, 2010). For example, if positive alcohol associations are activated, but broader experiences lead one to reflect on the high probability of negative outcomes of drinking, risk for alcohol use will depend on the strength and interplay of these two processes.

Wiers et al. (2007) proposed that behavior is influenced by the interactive effects of impulsive (implicit alcohol cognition) and self-regulatory processes, further elaborating how dual processes might influence drinking. Several stud-

Received: January 11, 2015. Revision: July 14, 2015.

This research was supported by National Institute on Drug Abuse Grant R01 DA020171 (awarded to Craig R. Colder). Roisin M. O'Connor was supported by a Canadian Institutes Health Research New Investigator award during completion of a portion of this work.

*Correspondence may be sent to Roisin M. O'Connor at the Department of Psychology, Concordia University, 7141 Sherbrooke St. West, PY 170-16, Montreal, QC, H4B 1R6, Canada, or via email at: Roisin.OConnor@Concordia.ca.

ies tested whether self-regulation moderated the association between implicit alcohol cognition and alcohol use (two-way interactions). Findings suggested that implicit alcohol cognition predicted drinking only when self-regulation—most commonly represented by working memory or executive control capacity (Grenard et al., 2008; Saleminck & Wiers, 2014; Thush et al., 2008; van Hemel-Ruiter et al., 2015) and self-control (i.e., ability to override a behavioral tendency) (Frieze & Hofmann, 2009; Ostafin et al., 2008)—was low (vs. high). However, other studies did not support these interactive effects predicting alcohol use (Lindgren et al., 2014; Pieters et al., 2012). In sum, there is mixed support for whether self-regulation moderates the association between implicit alcohol cognition and alcohol use.

Inconsistent support for the interactive effects between implicit alcohol cognition and self-regulation may stem from a failure to simultaneously consider both the capacity and motivation to regulate alcohol use. Wiers et al. (2007) proposed that two aspects of the deliberative and evaluative self-regulatory system—the capacity to self-regulate (e.g., executive functioning) and the motivation to regulate drinking—are important determinants of whether impulsive processes will lead to drinking. One possibility is that these factors operate in the form of a three-way interaction. That is, both high self-regulatory capacity and strong motivation to regulate drinking may be necessary to control the impulse to drink that emerges from implicit alcohol cognitions. Negative alcohol outcome expectancies (AOE) are propositional in nature and may be a particularly relevant aspect of the deliberative and evaluative system that provides motivation to avoid or regulate drinking (Jones & McMahon, 1998). In this study, we test a three-way interaction between implicit alcohol cognitions, self-regulation capacity, and negative AOE in the prospective prediction of early adolescent alcohol use. In considering this three-way interaction in our study, it is important to consider the developmental context of early adolescence.

Early adolescence is a period of initiation and experimentation with alcohol, and most dual-process models are oriented toward understanding later stages of drinking (e.g., escalation, maintenance of heavy drinking). The relevant impulsive and self-regulatory processes likely vary across developmental stages of alcohol use. What is true for later stage heavy drinking is unlikely to be applicable to earlier stage initiation. Hence, we take the central idea of these processes and provide a developmental extension to inform the etiology of early adolescent alcohol use. In our previous work (with the current sample), and consistent with Pieters et al. (2010), we found that early adolescents' implicit alcohol cognitions were negatively valenced. That is, the associations with alcohol that were automatically activated were negative; thus, risk for alcohol use was associated with having weak implicit alcohol cognitions. This is consistent with research demonstrating that although negative attitudes

about alcohol decline as adolescents approach the normative age of alcohol initiation, they remain dominant relative to positive attitudes (Bekman et al., 2011; Donovan et al., 2009). We hypothesized that whether weak negative associations will lead to drinking would depend on both the capacity to self-regulate and motivation to regulate drinking. A complication in considering this interactive model is that capacity to self-regulate is composed of several related but distinct facets whose relevance to drinking may vary across the spectrum of motivation to regulate drinking.

Ellis and Rothbart (2001) and Rothbart and Bates (2006) identified two domains of self-regulation—inhibitory and activation control—that are particularly relevant to our proposed model. Although both reflect volitional control of attention and behavior with links to neural circuitry involved in executive control (Rothbart & Rueda, 2005), they differ in important ways. Inhibitory control reflects the capacity to suppress inappropriate dominant responses (suppressing the impulse to cut in line instead of waiting your turn), whereas activation control reflects the capacity to engage in a behavior when there is a tendency to avoid it (starting a book report when the due date is far off). We consider the potential moderating role of each. One possibility is that weak implicit negative alcohol cognition in combination with low motivation to regulate drinking (low negative AOE) make alcohol use a dominant response. The relevant self-regulatory ability in this context is the capacity to inhibit the dominant response of drinking. In this case, drinking is likely to occur when inhibitory control is low. However, there is evidence that many adolescents drink despite maintaining strong negative AOE (Colder et al., 2014; Pieters et al., 2010). One possible explanation for this apparent contradiction is that for some youth strong negative AOE may co-occur with weak implicit negative alcohol cognition, creating conflict. The relevant regulatory capacity that might determine if drinking occurs in this case is activation control. Strong activation control may provide the capacity to engage in drinking despite the strong motivation to avoid it.

In sum, early adolescence is a period when alcohol use is most commonly initiated, suggesting broad developmental changes that support alcohol use. Some of these changes that are thought to increase motivation for alcohol use include an increased orientation toward peer relationships and desire to affiliate with and be accepted by peers, increased motivation to attain adult status and adopt adult behaviors, and increased sensation seeking (Steinberg, 2011). It is in this developmental context that we test the three-way interaction between the impulsive process, capacity to self-regulate, and motivation to regulate drinking in predicting level of alcohol use. We consider two domains of self-regulation capacity (inhibitory and activation control) using a 1-year prospective design that includes early to middle adolescence. We hypothesized that weak implicit negative alcohol cognition would predict increased alcohol use when negative AOE were low

and inhibitory control was low. Further, we hypothesized that weak implicit negative alcohol-related cognition would predict increased alcohol use when negative AOE were high and activation control was high.

Method

Participants

The community sample (from a longitudinal study) was recruited from Western New York (see Lopez-Vergara et al., 2012, and O'Connor et al., 2012). Recruitment began in April 2007 and was completed in February 2009. The sample at Wave 1 included 378 families (10- to 12-year-old adolescent, one caregiver). Because of low endorsement of alcohol use by children in the first two waves of data collection, only data from Wave 3 ($N = 354$) and Wave 4 ($N = 344$) were considered in this investigation. Retention was strong (94% Wave 3; 91% Wave 4). Missing cases were compared with those present at both assessments ($N = 335$). These comparisons suggested no differences on demographic (gender, age, race/ethnicity, family income) or current study variables (all $ps > .05$). Wave 3 and Wave 4 assessments are referred to, from this point forward, as Time 1 and Time 2.

Of those who completed the Time 2 assessment, 10 participants had incomplete data. The final sample included 325 families. The sample was almost evenly split on gender (54% girls). Mean ages were 13.62 ($SD = 0.88$) and 14.9 ($SD = 0.90$) years old at Time 1 and Time 2, respectively. The majority of the sample was White/non-Hispanic (76%), 15% were Black/African American, 3% Hispanic/Latino, 2% Asian/Pacific Islander, and 4% reported "other" (largely mixed race/ethnicity). Median family income was U.S. \$60,000.

Measures

Single Category Implicit Association Test (Time 1). The Single Category Implicit Association Test (SC-IAT; Karpinski & Steinman, 2006) is a modification of the widely used IAT (see Reich et al., 2010). Our SC-IAT (completed by the child) involved discriminating between an evaluative dimension (good and bad words) and an object category (pictures of alcohol). Words were selected to be at a fourth-grade reading level. The evaluative words were presented auditorily to decrease the lexical demand of the task, and object categories were presented on the computer screen in picture format. The task included two blocks, each consisting of 24 practice trials and 72 test trials. In one block, correct pairing included categorizing alcohol and negative stimuli together and positive stimuli separately. Object/evaluative pairings were reversed for the other block. A full description of this task can be found in our prior work (O'Connor et al., 2012).

The traditional index of automatically activated associations from the IAT (D-score) is influenced by cognitive processes in addition to automatic processes (Conrey et al., 2005). In prior work, we used the Quad Model, which is a multinomial processing tree model, to distinguish four cognitive processes that influence SC-IAT performance. This allowed us to extract a more "process pure" index of automatically activated substance use associations (O'Connor et al., 2012). We found that automatically activated alcohol associations were predominantly negative and distinguished from other processes (activation of positive category, guessing, overcoming bias, ability to detect stimulus). Results suggested that the Quad Model index of automatically activated negative alcohol associations provided better discrimination between young adolescent drinkers and abstainers than the traditional IAT D-score.

In the current study, we extended our estimated Quad Model to individual observed probabilities of making correct/incorrect responses using HMMTree software (Stahl & Klauer, 2007). The negative automatic alcohol association parameter was output for each participant. Values on this measure indicate the probability that the negative-alcohol automatic association (negative-alcohol AC) influenced SC-IAT responses. High values indicate strong negative alcohol associations. We output the other model parameters (automatic positive category [positive AC], guessing [G], overcoming bias [OB], and accurate detection [D]) and number of errors to be included as statistical control variables in analyses.

Alcohol outcome expectancies (Time 1). Adolescents used an 11-point response scale (0 = 0% no chance, 10 = 100% for sure) to rate perceived likelihood of experiencing positive (10 items; e.g., "I'll be able to have more fun with my friends") and negative (10 items; e.g., "I'll get sick") alcohol outcomes (O'Connor et al., 2007). Mean positive and negative AOE scale scores were computed. Internal consistencies were high for both the positive ($\alpha = .92$) and negative ($\alpha = .88$) AOE scales in our sample.

Inhibitory and activation control (Time 1). Parental-report inhibitory and activation control were assessed using the Early Adolescent Temperament Questionnaire-Revised (Ellis & Rothbart, 2001; adapted from Capaldi & Rothbart, 1992). The inhibitory subscale assesses the capacity to suppress inappropriate responses (5 items, e.g., "Is able to stop him/herself from laughing at inappropriate times"), and the activation control subscale assesses the capacity to perform an action when there is a strong tendency to avoid it (7 items, e.g., "If having a problem with someone, usually tries deal with it right away"). Items were rated on a 5-point response scale (1 = almost always untrue of your child, 5 = almost always true of your child). Mean subscale scores were computed. These subscales have demonstrated good convergent validity with responses on the Stop-Signal Task, which is a measure of child's temperament (Mazullo et al., 2009). Cronbach's α in our sample were .62

TABLE 1. Descriptive statistics and correlations

Variable (<i>N</i> = 325)	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. Gender (1 = boy, 2 = girl)	—													
Time 1 variables														
2. Age	.11	—												
3. Negative-alcohol automatic activation (AC)	-.15	.01	—											
4. Positive automatic activation (AC)	-.09	-.06	.23	—										
5. Guessing (G)	.11	.01	-.02	-.08	—									
6. Overcoming bias (OB)	-.03	-.03	-.16	.06	.14	—								
7. Accurate detection (D)	.11	.12	-.03	-.10	-.18	-.09	—							
8. Error rate on SC-IAT	-.15	-.12	.32	.30	.14	.01	-.94	—						
9. Negative AOE	-.11	-.12	-.06	-.05	-.03	.03	-.14	.10	—					
10. Positive AOE	-.00	.27	-.07	.02	-.09	-.00	.02	-.03	-.13	—				
11. Inhibitory control	-.01	.05	-.04	-.04	.02	-.00	.14	-.14	-.07	-.04	—			
12. Activation control	.23	-.06	-.14	-.06	.06	.00	.07	-.11	-.04	-.08	.52	—		
13. Alcohol use	.11	.19	-.03	-.07	-.03	-.05	.10	-.11	-.19	.23	-.01	-.05	—	
Time 2 variable														
14. Alcohol use	.02	.14	-.02	.01	-.07	-.07	.08	-.07	-.14	.16	-.03	-.07	.29	—
<i>M</i>	1.54	13.62	0.04	0.04	0.40	0.67	0.89	0.07	6.88	4.29	3.58	2.94	0.78	3.61
<i>SD</i>	0.50	0.88	0.05	0.06	0.30	0.45	0.10	0.05	1.90	2.04	0.64	0.87	2.78	17.56
Skew	—	-.003	1.51	1.86	0.25	-.074	-1.86	1.62	-.022	0.04	-.042	-.004	5.31	9.16
Kurtosis	—	-1.13	1.99	3.69	-0.66	-1.39	5.40	4.32	0.02	-0.87	0.26	-0.84	32.73	98.10

Notes: Unstandardized data presented; quad model parameters from the Single Category Implicit Association Test (SC-IAT) data include the following: AC, G, OB, D; AOE = alcohol outcome expectancies.

$|r| \geq .11$ statistically significant at $p < .05$; $|r| \geq .14$ statistically significant at $p < .01$.

and .85 for the inhibitory and activation control subscales, respectively.

Alcohol use (Times 1 and 2). Child-report alcohol use was assessed using two items (Elliott & Huizinga, 1983): frequency (“How many times in the past year have you used alcohol?”) and typical per-occasion quantity (“On the days you drink alcohol, about how many drinks do you have”) of alcohol use. A frequency-by-quantity index was computed, yielding a count of total number of drinks consumed in the past year.

Procedure

Time 1 assessment was completed in the laboratory. After completing the consent (caregiver; 82%–83% mother across waves) and assent (adolescent), the adolescent and caregiver were assessed in separate rooms. Families were compensated \$100. Time 2 included a brief telephone-administered audio-computer-assisted self-interview (CASI) with the adolescent. Adolescents received a \$15 gift card for audio-CASI completion. This study was approved by the University Institutional Review Board.

Data analytic overview

All analyses were conducted using SAS Version 9.4 (SAS Institute Inc., Cary, NC). Of interest was the effect of negative-alcohol AC (Time 1) on alcohol use (Time 2) as moderated by negative AOE, and inhibitory and activation control (all moderators Time 1), while controlling for gender and the following Time 1 variables: age, alcohol use, other

Quad Model parameters (positive AC, G, OB, D) from the SC-IAT, error rate on SC-IAT, and positive AOE. Controlling for Time 1 alcohol use allowed us to test a risk model of increased alcohol use over a 1-year period. Initial inspection of the data (Table 1) revealed that the outcome variable (Time 2 alcohol use) followed a nonnormal distribution and had a high proportion of zeroes, and the larger variance relative to mean suggested overdispersion. Following recommendations by Long (1997) and Cameron and Trivedi (1998) for count data, we considered zero-inflated Poisson regression (ZIP), negative binomial regression (NB), and zero-inflated negative binomial regression (ZINB) models. The Vuong (1989) and Clarke (2001, 2007) tests were used to compare non-nested models (ZIP vs. NB; ZINB vs. NB). The Akaike and Schwarz (Bayesian Information Criteria) adjusted Vuong and Clarke tests were used to compare the models with and without zero inflation. The Akaike and Schwarz criteria account for the bias (which favors zero-inflation models) inherent in comparing models with a different number of parameters (Desmarais & Harden, 2013).

Time 2 alcohol use was regressed on all first-order effects and covariates, all relevant two-way interaction terms, and the Negative-Alcohol AC $\times$ Negative AOE $\times$ Inhibitory Control and the Negative-Alcohol AC $\times$ Negative AOE $\times$ Activation Control three-way interaction terms. Predictor variables were standardized. Gender was dummy coded (0 = male, 1 = female). Statistically significant interaction terms were probed; the simple slopes of negative-alcohol AC on Time 2 alcohol use were conditioned at high (+1 *SD*) and low (-1 *SD*) negative AOE, inhibitory control, and activation control.

Results

Descriptives and zero-order correlations

The mean negative-alcohol AC was greater than zero, $t(324) = 14.73, p < .0001, d = 0.82$, suggesting that overall, this sample automatically activated a negative association with alcohol (Table 1). This is in line with what we found with this same sample at an earlier age (O'Connor et al., 2012). Mean values on the inhibitory and activation control scales are similar to what Ellis and Rothbart (2001) found for a similarly aged sample. As expected given the age of this sample, alcohol use was low at both Time 1 and Time 2, with 82% and 73% reporting no alcohol use at each time point, respectively. The statistically significant correlations between alcohol use and both gender and age supported controlling for these variables in the models. Negative-alcohol AC was not a statistically significant correlate of alcohol use at either time point, supporting investigation of moderators.

Moderation model

Preliminary analyses. Comparison of the NB and ZIP suggested that the NB model provided a better fit to the data (Akaike and Schwarz Adjusted Vuong: $Z = 4.12, Z = 4.35$, respectively; Akaike and Schwarz-adjusted Clarke: $Z = 35.50, Z = 81.50$, respectively; all $ps < .001$). Comparison of the NB and ZINB models suggested, for the most part, that the NB model provided a better fit to the data. Specifically, the Schwarz Adjusted Vuong ($Z = -2.32, p = .02$) and Clarke ($Z = -49.50, p < .001$) tests indicated that the NB model provided a statistically significant closer fit to the true model. However, the Akaike Adjusted Vuong ($Z = 1.73, p = .08$) and Clarke ($Z = 6.50, p = .51$) tests suggested equivalent fit of the two models. We retained the more parsimonious NB model.

We also tested potential interactions with positive AOE (Negative-Alcohol AC $\times$ Positive AOE $\times$ Inhibitory Control and Negative-Alcohol AC $\times$ Positive AOE $\times$ Activation Control and relevant two-ways). None were statistically significant (all $ps > .05$). However, positive AOE was a statistically significant correlate of both alcohol use and negative AOE (Table 1). Accordingly, the first-order effect of positive AOE was controlled for in our final model.

Hypothesis testing. A summary of the results of the NB regression model testing negative AOE and inhibitory and activation control as moderators of the effect of negative-alcohol AC on Time 2 alcohol use is presented in Table 2. The statistical significance of alpha (dispersion parameter > 0) confirms that the data were overdispersed and the appropriateness of NB regression. The three-way interaction terms were both statistically supported ($ps < .05$), suggesting that the combined effects of negative AOE and inhibitory

control, and negative AOE and activation control, moderated the effect of negative-alcohol AC on Time 2 alcohol use. Following recommendations of Zwilling (2013) and Hilbe (2011), model-based outliers were examined. Plotting the standardized Pearson residuals against the leverage statistics revealed that one observation was a potential influential outlier (standardized Pearson residual outside the range of ± 2 and high [> 0.1] leverage). Model results did not change with this observation deleted, suggesting that results are robust to the influence of potential outliers.

The simple slopes of Time 1 negative-alcohol AC predicting Time 2 alcohol use at high and low negative AOE and inhibitory control are presented in Figure 1. In support of our hypotheses, a weak negative-alcohol AC was associated with elevated alcohol use when both negative AOE and inhibitory control were low, $B = -2.81, SE = 1.03, t(1) = -2.73, p = .006$. Thus, as expected, weak negative alcohol associations coupled with low motivation to not drink seemed to give way to the dominant drinking response when the capacity to inhibit behavior was low. In contrast, negative-alcohol AC was not a statistically meaningful predictor of alcohol use at high negative AOE (strong motivation to not drink) and low inhibitory control, $B = -0.92, SE = 0.96, t(1) = -0.96, p = .34$. Consistent with prediction, a weak negative-alcohol AC was associated with elevated alcohol use when inhibitory control was high but negative AOE was low, $B = -2.45, SE = 0.86, t(1) = -2.85, p = .004$. Although a similar effect was found when both inhibitory control and negative AOE were high, $B = -2.49, SE = 0.97, t(1) = -2.56, p = .010$, the pattern of results suggests that a weak negative alcohol association is linked to increased drinking risk when a high capacity to inhibit behavior is not matched with a strong motivation to not drink.

The simple slopes of Time 1 negative-alcohol AC predicting Time 2 alcohol use at high and low negative AOE and activation control are presented in Figure 2. In contrast to hypotheses, a weak negative-alcohol AC did not predict elevated alcohol use when both negative AOE and activation control were high, $B = -0.37, SE = 1.03, t(1) = -0.36, p = .717$. This null association suggests that drinking risk associated with a weak negative-alcohol AC may be mitigated when one can overcome the impulse to drink and behave in line with controlled processes. A weak negative-alcohol AC was associated with elevated drinking at low activation control (weak self-regulation capacity), but this effect was stronger at high, $B = -3.03, SE = 0.99, t(1) = -3.05, p = .002$, compared with low, $B = -1.88, SE = 0.90, t(1) = -2.09, p = .004$, negative AOE. Similar to the findings with inhibitory control, a weak negative-alcohol AC was associated with elevated alcohol use when activation control was high but negative AOE was low, $B = -3.37, SE = 1.03, t(1) = -3.28, p = .001$, suggesting that having the capacity to self-regulate alone is insufficient if motivation to not drink is low.

TABLE 2. Summary of negative binomial regression: Testing moderators of the effect of Time 1 negative-alcohol automatic activation (AC) on Time 2 alcohol use

(N = 325) Predictors: Time 1	Criterion: Time 2 alcohol use			
	<i>B</i>	<i>SE B</i>	<i>t</i>	<i>p</i>
Intercept	-0.44	0.21	-2.13	.033
Gender	0.39	0.23	1.73	.083
Age	0.70	0.23	2.97	.003
Negative-alcohol automatic activation (AC)	-2.17	0.86	-2.52	.012
Positive automatic activation (AC)	-0.91	0.60	-1.52	.129
Guessing (G)	0.02	0.19	0.08	.934
Overcoming bias (OB)	0.54	0.26	2.11	.035
Accurate detection (D)	8.07	3.14	2.57	.010
Error rate on SC-IAT	8.22	3.43	2.40	.016
Negative AOE	-0.41	0.24	-1.70	.090
Positive AOE	1.31	0.24	5.37	<.001
Inhibitory control	-0.02	0.25	-0.09	.925
Activation control	-0.77	0.26	-2.97	.003
Alcohol use	0.42	0.22	1.89	.059
Negative-Alcohol Automatic Activation (AC) × Negative AOE	0.46	0.26	1.75	.080
Negative-Alcohol Automatic Activation (AC) × Inhibitory Control	-0.30	0.27	-1.13	.258
Negative-Alcohol Automatic Activation (AC) × Activation Control	0.29	0.24	1.22	.223
Negative AOE × Inhibitory Control	0.06	0.28	0.21	.837
Negative AOE × Activation Control	-0.41	0.28	-1.49	.137
Negative-Alcohol Automatic Activation (AC) × Negative AOE × Inhibitory Control	-0.48	0.20	-2.46	.014
Negative-Alcohol Automatic Activation (AC) × Negative AOE × Activation Control	1.04	0.34	3.04	.002
α	5.93	0.82	7.24	<.001

Notes: *B* = unstandardized parameter estimate (predicted logit of counts); predictor variables standardized (high value on gender indicates girls); quad model parameters from the Single Category Implicit Association Test (SC-IAT) data include the following: AC, G, OB, D; AOE = alcohol outcome expectancies. Log likelihood for the final model: -403.71. Additional analyses: block of two-way interaction terms did not contribute to model improvement (above first-order effects), $\Delta\chi^2(5) = 8.62, p = .12$, whereas the addition of the block of three-way interaction terms (above two-way interaction terms) did, $\Delta\chi^2(2) = 9.72, p < .01$.

Discussion

Informed by dual-process models (Deutsch & Strack, 2006), this study tested the prospective interactive effect of impulsive and self-regulatory processes on increases in early adolescent alcohol use over a 1-year period. This study provided a developmental extension to these models to early stages of alcohol use. Results supported the utility of decoupling the capacity and motivation to self-regulate drinking, as indicated by Wiers et al.'s (2007) model of alcohol use. Further, consistent with conceptualizations of self-regulatory capacity as multidimensional (Miyake et al., 2000; Rothbart & Rueda, 2005), results provided support for distinguishing facets of self-regulation in our risk model.

We proposed that alcohol use would emerge as the dominant response when the automatic activation of negative associations with alcohol is weak (weak implicit negative alcohol cognition) and when motivation to regulate drinking is low (low negative AOE). We hypothesized that poor inhibitory control would increase the likelihood of following this dominant response, leading to escalation of drinking. Our

results supported this hypothesis, suggesting that adolescent drinking increased when there was the impulse to drink combined with weak motivation to regulate drinking and limited capacity to inhibit behavior. This is in line with a central tenet of Wiers et al.'s (2007) model, namely that with limited capacity to self-regulate, impulsive processes influence behavior. This finding aligns with some previous research (Ostafin et al., 2008; Saleminck & Wiers, 2014; Sharbanee et al., 2013; van Hemel-Ruiter et al., 2015), which found that impulsive alcohol-related cognitive processes predicted alcohol use when working memory/executive control capacity was low.

However, this previous work only considered the moderating effect of self-regulatory capacity on the impulsive processes–substance use association. In contrast, we tested a three-way interaction that also included motivation to regulate as a moderator. This more complex model revealed a nuance to the interplay between automatic and controlled cognitive processing. Specifically, weak implicit negative alcohol cognition was unrelated to risk for drinking, even in the context of poor inhibitory control, if motivation to

FIGURE 1. Simple slopes of Time 1 negative-alcohol automatic activation (AC) predicting Time 2 alcohol use at high (+1 *SD*) and low (-1 *SD*) negative alcohol outcome expectancies (AOE) and high (+1 *SD*) and low (-1 *SD*) inhibitory control. No. = number.

* $p < .05$; ** $p < .01$.

regulate drinking was high. It is likely that in the face of cognitive conflict (i.e., where associative but not propositional alcohol cognitions favor drinking), there is no clear dominant response. The complex link between conflicting content of cognitive processes and behavior is evidenced in the literature (Breiner et al., 1999; Cameron et al., 2003). What emerges as the dominant response may not be tied to the impulsive process alone, at least among adolescents in the early stages of alcohol use. The balance between automatic and controlled alcohol-related cognitive processes in decision-making may be bound by developmental context. Alcohol use at Time 1 in our study was not yet a normative behavior, as only 18% of our sample reported past-year use, and this is consistent with rates of alcohol use in large epidemiological studies (Johnston et al., 2013). Perhaps contexts in which the social norm is to not drink render negative AOE a particularly potent influence.

The importance of motivation to regulate drinking is further highlighted in our test of the effect of weak negative

alcohol associations on drinking when inhibitory control is strong. Consistent with our hypothesis, individuals were disinclined to inhibit alcohol use when there was little motivation to do so (low negative AOE) even though inhibitory control was good. These findings are in line with the Wiers et al. (2007) model, while also offering some insight into the mixed findings arising from tests of this model (Pieters et al., 2012 vs. Thush et al., 2008). To our knowledge, previous work has not simultaneously considered self-regulatory capacity and motivation to regulate drinking as moderators of the effect of implicit alcohol cognition on alcohol use. Our results suggest that motivation to regulate drinking is important, and, by not considering such motivation, the effect of self-regulatory capacity on the link between impulsive processes and drinking may vary widely across studies.

Our measure of inhibitory control emphasized the capacity to inhibit a dominant response when it is prudent to do so, and this overlaps with measures of self-regulatory capacity that have been used in prior studies informed by

FIGURE 2. Simple slopes of Time 1 negative-alcohol automatic activation (AC) predicting Time 2 alcohol use at high (+ 1 SD) and low (- 1 SD) negative alcohol outcome expectancies (AOE) and high (+ 1 SD) and low (- 1 SD) activation control. No. = number.

* $p < .05$; ** $p < .01$.

Wiers et al.'s (2007) model and dual-process models more broadly. We also considered another aspect of self-regulation, activation control, which reflects the capacity to engage in a behavior when there is a tendency to avoid it. There is ample evidence that adolescents drink despite holding strong negative AOE (Cameron et al., 2003; O'Connor et al., 2007), suggesting that adolescents may be ambivalent about alcohol use, with strong opposing motivations to drink and to not drink (Colder et al., 2014). Specific to this developmental period, research supports several factors that increase motivation to drink, including real or perceived peer pressure to drink (Barnow et al., 2004), increased motivation to adopt adult-like behaviors (Jessor, 2014), and increased motivation for sensation seeking (Steinberg et al., 2008). We reasoned that strong activation control would enable adolescents to push past their ambivalence and/or negative alcohol attitudes and drink. This hypothesis was not supported. We found that the combination of weak implicit negative alcohol cognition and a conflicting motivation to avoid drinking (high negative

AOE) protected adolescents from drinking, if they also had strong activation control.

We conceptualized activation control as the ability to act in opposition of the tendency to avoid a behavior, whether that behavior was positive or negative (Ellis & Rothbart, 2001; Rothbart & Rueda, 2005). However, close inspection of our measure suggests that it focused on prosocial behaviors that, although not immediately rewarding, could lead to negative consequences if avoided (e.g., procrastinating homework, failure to meet short-term goals to achieve long-term outcome). Hence, our measure likely tapped the capacity to anticipate negative consequences and regulate and plan behavior accordingly. Consistent with this, correlation analyses in another unpublished data set from the second author's laboratory provide some evidence that activation control is positively associated with adolescents' prosocial activities (school clubs, sports) and planning ability, as measured on the Tower of London task. Reworking our hypothesis, the conflict relevant to our measure of activation control may be between the immediate,

automatically activated weak negative alcohol associations and the more long-term, future-oriented strong negative AOE (Breiner et al., 1999). Given this conflict between opposing forces to drink (immediate gain) and to not drink (long-term negative consequences), having weak activation control should lead to reduced capacity to plan and consider potential negative consequences, thus allowing impulsive processes to influence behavior. Further, strong activation control should lead to increased capacity to plan, and as such, the ability to consider potential negative consequences of drinking and behave in line with strong negative AOE. Our results fit with this post hoc explanation. Moreover, the opposite pattern of results was evident at low negative AOE. We suggest, somewhat speculatively, that when negative outcomes of alcohol are not anticipated (weak negative AOE), high activation control provides the capacity to pursue other future-oriented goals (e.g., drinking to achieve social status or facilitate entry into social groups) (Meisel & Colder, in press; Trucco et al., 2011).

In sum, high capacity to self-regulate alone was not sufficient to temper the effect of weak implicit negative alcohol cognition on alcohol use. Moreover, a reduced capacity to self-regulate did not, on its own, give way to implicit cognition predicting drinking. Results also suggest that it is important to consider multiple facets of self-regulation when developing and testing risk models of alcohol use.

There are limitations of this study. First, our sample included adolescents who were at the early stages of alcohol use (with low rates of alcohol use); thus, alcohol-related cognitions were likely somewhat ambivalent, the motivation to avoid alcohol likely somewhat weak, and the capacity to self-regulate unaffected by excessive drinking. It is unclear whether our results would generalize to high-risk problem drinkers. It is possible that different patterns of cognitive risk emerge as experience with alcohol increases; however, it is also possible that the patterns we observed in this study intensify. Second, consistent with similar tests of Wiers et al.'s (2007) model, we used negative AOE as an indicator of motivation to not drink. Although AOE reflect beliefs about alcohol, they do not provide a direct assessment of reflective motivation to not drink. Third, our prospective analysis was based on annual assessments. This may not be the most ideal time-lag to study the role of automatic and controlled cognitive processes. A shorter time lag may have yielded stronger associations than those reported here.

Our study supports the direction that theory is going, suggesting that alcohol use is influenced by a complex interplay of impulsive and self-regulatory processes. Although our findings suggest that nuances of the developmental context must be considered when extending these cognitive models, these models appear to be robust with far-reaching application, beyond just modeling risk for problematic drinking to include initiation as well. Our study offers direction for development and testing of etiological models of alcohol

risk, suggesting that the role of distinct alcohol-related cognitive processes may be obscured if examined in isolation. Extending our models to adult problem drinkers may point to intervention targets, including increasing motivation to abstain and the ability to plan.

Acknowledgments

The authors thank the UB Neighborhood and Family Development Project staff for their help with data collection, and all the families who participated in the study.

References

- Barnow, S., Schultz, G., Lucht, M., Ulrich, I., Preuss, U. W., & Freyberger, H. J. (2004). Do alcohol expectancies and peer delinquency/substance use mediate the relationship between impulsivity and drinking behaviour in adolescence? *Alcohol and Alcoholism*, 39, 213–219. doi:10.1093/alcalc/agh048.
- Bekman, N. M., Goldman, M. S., Worley, M. J., & Anderson, K. G. (2011). Pre-adolescent alcohol expectancies: Critical shifts and associated maturational processes. *Experimental and Clinical Psychopharmacology*, 19, 420–432. doi:10.1037/a0025373.
- Breiner, M. J., Stritzke, W. G. K., & Lang, A. R. (1999). Approaching avoidance: A step essential to the understanding of craving. *Alcohol Research & Health*, 23, 197–206.
- Cameron, C. A., Stritzke, W. G. K., & Durkin, K. (2003). Alcohol expectancies in late childhood: An ambivalence perspective on transitions toward alcohol use. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, 44, 687–698. doi:10.1111/1469-7610.00155.
- Cameron, A. C., & Trivedi, P. K. (1998). *Regression analysis of count data*. Cambridge, England: Cambridge University Press.
- Capaldi, D. M., & Rothbart, M. K. (1992). Development and validation of an early adolescent temperament measure. *Journal of Early Adolescence*, 12, 153–173. doi:10.1177/0272431692012002002.
- Casey, B. J., Jones, R. M., & Hare, T. A. (2008). The adolescent brain. *Annals of the New York Academy of Sciences*, 1124, 111–126. doi:10.1196/annals.1440.010.
- Clarke, K. A. (2001). Testing nonnested models of international relations: Reevaluating realism. *American Journal of Political Science*, 45, 724–744. doi:10.2307/2669248.
- Clarke, K. A. (2007). A simple distribution-free test for nonnested hypotheses. *Political Analysis*, 15, 1–17.
- Colder, C. R., Campbell, R. T., Ruel, E., Richardson, J. L., & Flay, B. R. (2002). A finite mixture model of growth trajectories of adolescent alcohol use: Predictors and consequences. *Journal of Consulting and Clinical Psychology*, 70, 976–985. doi:10.1037/0022-006X.70.4.976.
- Colder, C. R., O'Connor, R. M., Read, J. P., Eiden, R. D., Lengua, L. J., Hawk, L. W., Jr., & Wieczorek, W. F. (2014). Growth trajectories of alcohol information processing and associations with escalation of drinking in early adolescence. *Psychology of Addictive Behaviors*, 28, 659–670. doi:10.1037/a0035271.
- Conrey, F. R., Sherman, J. W., Gawronski, B., Hugenberg, K., & Groom, C. J. (2005). Separating multiple processes in implicit social cognition: The quad model of implicit task performance. *Journal of Personality and Social Psychology*, 89, 469–487. doi:10.1037/0022-3514.89.4.469.
- Desmarais, B. A., & Harden, J. J. (2013). Testing for zero-inflation in count models: Bias correction for the Vuong test. *The Stata Journal*, 13, 810–835.
- Deutsch, R., & Strack, F. (2006). Reflective and impulsive determinants of addictive behavior. In R. W. Wiers & A. W. Stacy (Eds.), *Handbook of implicit cognition and addiction* (pp. 45–57). Thousand Oaks, CA: Sage.

- Donovan, J. E., Molina, B. S. G., & Kelly, T. M. (2009). Alcohol outcome expectancies as socially shared and socialized beliefs. *Psychology of Addictive Behaviors*, 23, 248–259. doi:10.1037/a0015061.
- Eaton, D. K., Kann, L., Kinchen, S., Ross, J., Hawkins, J., Harris, W. A., . . . Wechsler, H. (2006, June 9). Youth risk behavior surveillance—United States, 2005. *MMWR Surveillance Summaries*, 55(5, SS05), 1–108. Retrieved from <http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5505a1.htm>
- Elliott, D. S., & Huizinga, D. (1983). Social class and delinquent behavior in a national youth panel: 1976–1980. *Criminology*, 21, 149–177. doi:10.1111/j.1745-9125.1983.tb00256.x.
- Ellis, L. K., & Rothbart, M. K. (2001, April). *Revision of the Early Adolescent Temperament Questionnaire*. Poster presented at the biennial meeting of the Society for Research in Child Development, Minneapolis, MN.
- Friese, M., & Hofmann, W. (2009). Control me or I will control you: Impulse, trait self-control, and the guidance of behavior. *Journal of Research in Personality*, 43, 795–805. doi:10.1016/j.jrp.2009.07.004.
- Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. K. (1998). Measuring individual differences in implicit cognition: The implicit association test. *Journal of Personality and Social Psychology*, 74, 1464–1480. doi:10.1037/0022-3514.74.6.1464.
- Grenard, J. L., Ames, S. L., Wiers, R. W., Thush, C., Sussman, S., & Stacy, A. W. (2008). Working memory capacity moderates the predictive effects of drug-related associations on substance use. *Psychology of Addictive Behaviors*, 22, 426–432. doi:10.1037/0893-164X.22.3.426.
- Hilbe, J. (2011). *Negative binomial regression* (2nd ed.). New York, NY: Cambridge University Press.
- Jessor, R. (2014). Problem behavior theory: A half-century of research on adolescent behavior and development. In R. M. Lerner, A. C. Petersen, R. K. Silbereisen, & J. Brooks-Gunn (Eds.), *The developmental science of adolescence: History through autobiography* (pp. 239–256). New York, NY: Psychology Press.
- Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2013). *Monitoring the Future national results on drug use: 2012 Overview, Key Findings on Adolescent Drug Use*. Ann Arbor, MI: Institute for Social Research, The University of Michigan.
- Jones, B. T., & McMahon, J. (1998). Alcohol motivations as outcome expectancies. In W. R. Miller & N. Heather (Eds.), *Treating addictive behaviors* (2nd ed.). Applied clinical psychology (pp. 75–91). New York, NY: Plenum Press.
- Karpinski, A., & Steinman, R. B. (2006). The single category implicit association test as a measure of implicit social cognition. *Journal of Personality and Social Psychology*, 91, 16–32. doi:10.1037/0022-3514.91.1.16.
- Lindgren, K. P., Neighbors, C., Westgate, E., & Salemin, E. (2014). Self-control and implicit drinking identity as predictors of alcohol consumption, problems, and cravings. *Journal of Studies on Alcohol and Drugs*, 75, 290–298. doi:10.15288/jsad.2014.75.290.
- Long, J. S. (1997). *Regression models for categorical and limited dependent variables*. Thousand Oaks, CA: Sage.
- Lopez-Vergara, H. I., Colder, C. R., Hawk, L. W., Jr., Wiczorek, W. F., Eiden, R. D., Lengua, L. J., & Read, J. P. (2012). Reinforcement sensitivity theory and alcohol outcome expectancies in early adolescence. *American Journal of Drug and Alcohol Abuse*, 38, 130–134. doi:10.3109/00952990.2011.643973.
- Mazzullo, R. J., Colder, C. R., Hawk, L. W., Jr., & Lengua, L. J. (April, 2009). *Incentive and the Stop-Signal Task and associations with temperament*. Poster presented at the biennial meeting of the Society for Research in Child Development, Denver, CO.
- Meisel, S. N., & Colder, C. R. (in press). Social goals and grade as moderators of social normative influences on adolescent alcohol use. *Alcoholism: Clinical and Experimental Research*.
- Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex “Frontal Lobe” tasks: A latent variable analysis. *Cognitive Psychology*, 41, 49–100. doi:10.1006/cogp.1999.0734.
- Moss, A. C., & Albery, I. P. (2009). A dual-process model of the alcohol-behavior link for social drinking. *Psychological Bulletin*, 135, 516–530. doi:10.1037/a0015991.
- O'Connor, R. M., Fite, P. J., Nowlin, P. R., & Colder, C. R. (2007). Children's beliefs about substance use: An examination of age differences in implicit and explicit cognitive precursors of substance use initiation. *Psychology of Addictive Behaviors*, 21, 525–533. doi:10.1037/0893-164X.21.4.525.
- O'Connor, R. M., Lopez-Vergara, H. I., & Colder, C. R. (2012). Implicit cognition and substance use: The role of controlled and automatic processes in children. *Journal of Studies on Alcohol and Drugs*, 73, 134–143. doi:10.15288/jsad.2012.73.134.
- Ostafin, B. D., Marlatt, G. A., & Greenwald, A. G. (2008). Drinking without thinking: An implicit measure of alcohol motivation predicts failure to control alcohol use. *Behaviour Research and Therapy*, 46, 1210–1219. doi:10.1016/j.brat.2008.08.003.
- Pieters, S., Burk, W. J., Van der Vorst, H., Wiers, R. W., & Engels, R. C. M. E. (2012). The moderating role of working memory capacity and alcohol-specific rule-setting on the relation between approach tendencies and alcohol use in young adolescents. *Alcoholism: Clinical and Experimental Research*, 36, 915–922. doi:10.1111/j.1530-0277.2011.01688.x.
- Pieters, S., van der Vorst, H., Engels, R. C. M. E., & Wiers, R. W. (2010). Implicit and explicit cognitions related to alcohol use in children. *Addictive Behaviors*, 35, 471–478. doi:10.1016/j.addbeh.2009.12.022.
- Reich, R. R., Below, M. C., & Goldman, M. S. (2010). Explicit and implicit measures of expectancy and related alcohol cognitions: A meta-analytic comparison. *Psychology of Addictive Behaviors*, 24, 13–25. doi:10.1037/a0016556.
- Rothbart, M. K., & Bates, J. E. (2006). Temperament. In N. Eisenberg, W. Damon, & R. M. Lerner (Eds.), *Handbook of child psychology* (6th ed., pp. 99–166). New York, NY: Wiley.
- Rothbart, M. K., & Rueda, M. R. (2005). The development of effortful control. In U. Mayr, E. Awh, & S. Keele (Eds.), *Developing individuality in the human brain: A tribute to Michael I. Posner* (pp. 167–188). Washington, D.C.: American Psychological Association.
- Salemin, E., & Wiers, R. W. (2014). Alcohol-related memory associations in positive and negative affect situations: Drinking motives, working memory capacity, and prospective drinking. *Psychology of Addictive Behaviors*, 28, 105–113. doi:10.1037/a0032806.
- Sharbanee, J. M., Stritzke, W. G., Wiers, R. W., Young, P., Rinck, M., & MacLeod, C. (2013). The interaction of approach-alcohol action tendencies, working memory capacity, and current task goals predicts the inability to regulate drinking behavior. *Psychology of Addictive Behaviors*, 27, 649–661. doi:10.1037/a0029982.
- Stacy, A. W., & Wiers, R. W. (2010). Implicit cognition and addiction: A tool for explaining paradoxical behavior. *Annual Review of Clinical Psychology*, 6, 551–575. doi:10.1146/annurev.clinpsy.121208.131444.
- Stahl, C., & Klauer, K. C. (2007). HMMTree: A computer program for latent-class hierarchical multinomial processing tree models. *Behavior Research Methods*, 39, 267–273. doi:10.3758/BF03193157.
- Steinberg, L. (2011). Adolescent risk taking: A social neuroscience perspective. In E. Amsel & J. G. Smetana (Eds.), *Adolescent vulnerabilities and opportunities: Developmental and constructivist perspectives* (pp. 41–64). New York, NY: Cambridge University Press.
- Steinberg, L., Albert, D., Cauffman, E., Banich, M., Graham, S., & Woolard, J. (2008). Age differences in sensation seeking and impulsivity as indexed by behavior and self-report: Evidence for a dual systems model. *Developmental Psychology*, 44, 1764–1778. doi:10.1037/a0012955.
- Thush, C., & Wiers, R. W. (2007). Explicit and implicit alcohol-related cognitions and the prediction of future drinking in adolescents. *Addictive Behaviors*, 32, 1367–1383. doi:10.1016/j.addbeh.2006.09.011.

- Thush, C., Wiers, R. W., Ames, S. L., Grenard, J. L., Sussman, S., & Stacy, A. W. (2008). Interactions between implicit and explicit cognition and working memory capacity in the prediction of alcohol use in at-risk adolescents. *Drug and Alcohol Dependence, 94*, 116–124. doi:10.1016/j.drugalcdep.2007.10.019.
- Trucco, E. M., Colder, C. R., Bowker, J. C., & Wieczorek, W. F. (2011). Interpersonal goals and susceptibility to peer influence: Risk factors for intentions to initiate substance use during early adolescence. *Journal of Early Adolescence, 31*, 526–547. doi:10.1177/0272431610366252.
- van Hemel-Ruiter, M. E., de Jong, P. J., Ostafin, B. D., & Wiers, R. W. (2015). Reward sensitivity, attentional bias, and executive control in early adolescent alcohol use. *Addictive Behaviors, 40*, 84–90.
- Vuong, Q. H. (1989). Likelihood ratio tests for model selection and non-nested hypotheses. *Econometrica: Journal of the Econometric Society, 57*, 307–333.
- Wiers, R. W., Ames, S. L., Hofmann, W., Krank, M., & Stacy, A. W. (2010). Impulsivity, impulsive and reflective processes and the development of alcohol use and misuse in adolescents and young adults. *Frontiers in Psychology, 1*, 1–12. doi:10.3389/fpsyg.2010.00144
- Wiers, R. W., Bartholow, B. D., van den Wildenberg, E., Thush, C., Engels, R. C. M. E., Sher, K. J., . . . Stacy, A. W. (2007). Automatic and controlled processes and the development of addictive behaviors in adolescents: A review and a model. *Pharmacology, Biochemistry, and Behavior, 86*, 263–283. doi:10.1016/j.pbb.2006.09.021.
- Zwilling, M. L. (2013). Negative binomial regression. *The Mathematical Journal, 15*, 1–18. doi:10.3888/tmj.15-6.