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Automatic Processes and the Drinking Behavior in Early Adolescence: A Prospective Study

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Background: This study examined the bi-directional prospective link between automatic alcohol-approach tendencies and alcohol use in a group of young adolescents (mean age = 13.6 years). The adolescents in the present study were assumed to be at-risk of early alcohol use and later problem drinking. It was hypothesized that alcohol use and automatic approach tendencies would reinforce one another particularly in the absence of well-developed inhibition skills.

Methods: A total of 347 adolescents (N = 279 at follow-up) from special secondary education, a risk group for the development of substance use problems, participated in the study. Automatic approach tendencies were assessed with the alcohol-approach avoidance task, inhibition skills were assessed with the Stroop task, and alcohol used was measured using a self-report measure.

Results: Zero-inflated Poisson analysis revealed a significant effect of automatic approach tendencies predicting alcohol use 6 months later, although only for adolescents with weaker inhibition skills.

Conclusions: Automatic approach tendencies predict future drinking behavior of young adolescents with relatively weak inhibition skills. The findings of the present study have important implications for alcohol interventions for adolescents. Results are discussed in terms of risk factors for the development of problematic alcohol use in young adolescents.

Key Words: Alcohol, Adolescents, Alcohol-Approach Tendencies, Response Inhibition, Problem Drinking.

RECENTLY, STUDIES ON substance use by young adolescents have evaluated and examined the relevance of dual processing in risky health behavior (Grenard et al., 2008; Thush et al., 2008). Research suggests that 2 systems of information processing are responsible for behavioral outcomes (Deutsch and Strack, 2006; Strack and Deutsch, 2004). The reflective system, a slow and controlled system, elicits deliberated responses and a fast and automatic system evokes impulsive responses (Fazio and Towles-Schwen, 1999). Recently, there is some discussion about the neural implementation and psychological reality of dual process models (cf., Gladwin et al., 2011; Keren and Schul, 2009; Kruglanski and Dechesne, 2006).

Studies have revealed that automatic processes predict future smoking behavior (Chassin et al., 2010) and escalation of cannabis use (Cousijn et al., 2011) in (young) adults. In adolescents, cross-sectional relations have been identified between alcohol use and automatic processes (Rooke et al., 2008). In our previous cross-sectional study, for instance (Peeters et al., 2012), it was found that automatic processes were associated with current drinking behavior in young at-risk adolescents. However, to date, this relationship has not been studied in a longitudinal design; therefore, it is unclear if automatic processes and drinking behavior of young adolescents influence each other over time. It might be that early formed alcohol associations affect future drinking behavior of young adolescents and that alcohol use strengthens the association, which subsequently enhances the likelihood of automatic processing. Thereby, automatic processes might play an important role in the escalation of alcohol use.

APPROACH TENDENCIES

It has been suggested that there is an automatic approach orientation toward positively evaluated stimuli. According to Robinson and Berridge (1993, 2008), this automatically activated approach bias is a behavioral response activated by an incentive motivational process. Many learned associations automatically trigger appropriate and relevant behavior (e.g., washing hands after a visit to the toilet). However, learned associations can also trigger inappropriate responses resulting for instance in compulsive behavior, like with

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addiction. Robinson and Berridge (1993, 2008) argue that besides associative learning, an incentive motivational process underlies compulsive behavioral responses, which the authors define as "wanting." Two different appetitive processes, "liking" and "wanting," can operate in parallel; however, with respect to addictive behavior, learned associations can trigger "wanting" responses even in the absence of a "liking" component. This "wanting" component can automatically trigger an attentional bias or approach tendency for the substance (Robinson and Berridge, 2008). For instance, with respect to heavy drinking behavior, there is a strong automatic action tendency to approach an alcohol stimulus rather than avoiding it (Wiers et al., 2010). Field and colleagues (2008a) examined automatic approach tendencies in heavy and light drinkers. Results indicated that heavy drinkers had stronger approach tendencies for alcohol stimuli. Similar results were found by Palfai and Ostafin (2003), who studied the relation between binge episodes and automatic approach tendencies. It was found that strong automatic approach associations were associated with higher alcohol consumption. Both studies found a cross-sectional relation between automatic approach tendencies and alcohol use. An effect over time between substance use and automatic approach tendencies was found by Cousijn and colleagues (2011). Results indicated that strong automatic approach tendencies predicted changes in cannabis use by heavy users, 6 months later. These results, in combination with the assumption that learned alcohol associations are strengthened by the repeated use of alcohol (Gladwin et al., 2011; Robinson and Berridge, 2003), seem to indicate a reciprocal relation between automatic processes and early alcohol use which might affect behavior as adolescents mature.

RESPONSE INHIBITION

Deficits in the regulation of behavior have been associated with problematic substance use (Sher et al., 2000) and with an increased risk of alcohol abuse and alcohol dependence (Finn et al., 2000). Impairment or reduced functioning of regulatory skills will interfere with the execution of more reflective and controlled responses. Especially in adolescence, when the (pre)frontal cortex is not yet fully developed (Blakemore and Choudhury, 2006) and perhaps less reinforcement of reflective behavior has been experienced, there tends to be a bias toward fast and automatically generated responses versus slow and deliberated responses (Gladwin et al., 2011).

Recent studies indicate that relatively poor executive functioning and more specifically, relatively poor inhibition skills increase the chance of automatic information processing resulting in more automatic behavior (Field et al., 2008b; Houben and Wiers, 2009). Particularly, in the absence of good self-regulatory skills, control over drinking behavior seems to be weakened by strong alcohol associations (Ostafin et al., 2008). Response inhibition may therefore be an important factor in the development of problem drinking.

THE PRESENT STUDY

The aim of the present study was to examine the prospective and reciprocal effects of alcohol use and automatic approach tendencies in a sample of young at-risk adolescents (Kepper et al., 2011). Since previous studies suggest that strong alcohol associations affect drinking behavior particularly in the absence of good inhibition skills (Field et al., 2008a,b; Houben and Wiers, 2009), it was assumed that automatic approach tendencies at baseline would predict future alcohol use and that alcohol use at baseline would predict automatic approach tendencies at follow-up, especially among adolescents with relatively poor inhibition skills. We tested our hypotheses in a latent cross-lagged panel model.

MATERIALS AND METHODS

Participants

A total of 374 students (330 boys, 44 girls) from 17 different secondary special education schools (cluster four) in the Netherlands with a mean age of M = 13.6 (SD = 0.9) participated in the study. Special education (cluster four) is for adolescents who are not able to participate in mainstream education because of their externalizing behavioral problems (attention deficit-hyperactivity disorder (ADHD)/conduct disorder). The gender disparity (88% boys) in the present study is similar to that in the overall population of special education students (Valdes, 1990). Due to incomplete data at the first wave, 27 students were excluded from the analysis, resulting in a sample of 347 students. In the follow-up study 6 months later, 279 students participated (response rate = 75%). Twenty-nine adolescents did not participate in both parts of the data collection due to illness or absence or had incomplete data sets and were therefore excluded from the analysis resulting in a sample of 250 students (223 boys, 27 girls, M = 14.1; SD = 0.9), with complete data on both data waves. Adolescents who dropped out of the study did not differ on the study variables, age, or gender, from the study sample.

In accordance with Dutch ethical standards, anonymity was ensured and adolescents were informed about the voluntary nature of participation. Because adolescents were underage, passive parental permission was obtained through an informative letter about the purpose of the study. In total, 15 parents (3.8%) and 7 students (1.7%) declined to participate in the study. Adolescents first individually completed some tasks at the computer under supervision of a trained research assistant. After that adolescents completed a questionnaire. Six months later during follow-up, this assessment procedure was repeated and the same tasks and questionnaire were completed by the adolescents.

Measures

Alcohol Use and Problem Drinking. The frequency of alcohol use was measured with a 14-item rating scale (ranging from "never" to "10 times, and 3 ratings consisting of aggregate scores; 11 to 19, 21 to 39, 40 times or more"; O'Malley et al., 1983). Participants were asked on how many occasions they had consumed alcohol in the last month. The quantity of regular alcohol use was assessed by ratings of drinking days during the week (i.e., Monday to Thursday) and weekend (i.e., Friday to Sunday; Engels and Knibbe, 2000) and the average number of alcoholic drinks consumed on weekdays and during the weekend (Engels et al., 1999). Responses could range from zero glasses to 20 glasses or more. Next, the quantity of alcohol use was computed by multiplying drinking days by alcoholic drinks (Koning et al., 2009). Problem drinking was measured with the CRAFFT; an alcohol screening instrument that includes 6 items (e.g., "Do you drink alcohol when you are by yourself"?) with a "yes" or "no" response categories (Knight et al., 1999). The internal consistency of the scale was acceptable (Cronbach's Alpha = 0.74).

Approach Avoidance Task. Wiers and colleagues (2009b) adapted the approach avoidance task (AAT) as a measure for alcohol-approach tendencies, and it has recently successfully been applied in a sample of young adolescents (Peeters et al., 2012). In the present study, participants were instructed to *push* or *pull* a certain picture (i.e., 40 alcohol and 40 soft-drink pictures), by using the arrows on the keyboard (i.e., arrow up for pushing the picture, arrow down for pulling the picture). Note that in the original AAT, a joystick was used as response device. Participants were asked to respond as quickly as possible and to press the correct arrow 3 times to make the picture disappear. Picture sizes increased and decreased to give participants the impression they were pulling or pushing the target stimuli. In the first condition, participants received the instruction to pull the picture when it was left skewed (i.e., 3° left rotated); in the second condition, participants had to pull when pictures were right skewed (i.e., 3° right rotated). Twenty unique alcohol pictures and 20 unique soft drink pictures appeared twice on the screen (in random order): once left rotated and once right rotated. The instructions shifted attention from the content of the picture (i.e., soft drink or alcohol) to the appearance of the picture (i.e., right or left rotated; Cousijn et al., 2011), which has been assumed to result in better assessment of automatic processes (De Houwer, 2003).

For all trials, the last key press was assessed and difference scores for the alcohol category were measured (i.e., *push* minus *pull* with positive scores indicating a faster approach for alcohol stimuli). The response times were measured in milliseconds, which resulted in large variances; therefore, we divided each trial by 1,000.

Response Inhibition. The Stroop color naming task (Stroop, 1935) was used to assess level of response inhibition (Miyake et al., 2000). The Stroop task as a measure for response inhibition has successfully been used as moderator in previous studies (Houben and Wiers, 2009; Wiers et al., 2009a). Participants were instructed to indicate the color of the word (i.e., red, green, blue, or yellow) that appeared on the screen by pressing the corresponding key on the keyboard, while ignoring the meaning of the word. Participants started with a practice block which consisted of 40 trials with symbols (e.g., @@@@ or &&&&). The practice block was followed by a test block with 28 trials. Trials could be either congruent (i.e., meaning of the word matches the color), neutral (i.e., colored symbols instead of words), or incongruent (i.e., meaning of the word differs from the color) and were presented in random order between participants. Each trial was repeated until a correct answer was given. An incorrect response was followed by an error message including a description of the keys used and their corresponding color. The mean score for each block (i.e., congruent, incongruent, and neutral) was calculated, as well as a difference score between incongruent and neutral stimuli, with higher scores indicating greater inhibition problems. The test–retest reliability of the task was acceptable (r = 0.73).

Data Analysis

First, the descriptions of the relevant variables are provided (Table 1). Second, to test whether there was an underlying factor (alcohol use index; hereinafter referred to as alcohol use) with respect to the 3 alcohol measures (alcohol frequency, drinks per week, and problem drinking), we applied a confirmatory factor analysis (CFA). The results of the measurement model are discussed in Fig. 1. Likewise, a CFA was applied using the 20

Table 1. Descriptive Statistics of the Alcohol Use Index Indicators and Alcohol-AAT at Baseline and Follow-Up

	T1 (N = 347)	T2 (N = 250)
Percentage drinkers	47.0%	51.2%
Total sample		
1. Alcohol use last month	1.45 (2.97)	1.57 (3.06)
2. Drinks per week	3.35 (8.00)	3.68 (8.79)
3. Problem drinking	0.83 (1.32)	0.82 (1.28)
4. Approach bias parcel 1	0.03 (0.57)	0.01 (0.42)
5. Approach bias parcel 2	−0.01 (0.42)	−0.04 (0.45)
6. Approach bias parcel 3	−0.02 (0.60)	0.02 (0.49)
	M (SD) (N = 187)	M (SD) (N = 137)
Good inhibition skills		
1. Alcohol use last month	1.20 (2.59)	1.43 (2.65)
2. Drinks per week	2.98 (7.11)	3.23 (6.78)
3. Problem drinking	0.74 (1.23)	0.73 (1.20)
4. Approach bias parcel 1	0.02 (0.61)	−0.01 (0.35)
5. Approach bias parcel 2	−0.01 (0.41)	−0.04 (0.39)
6. Approach bias parcel 3	−0.04 (0.56)	0.03 (0.36)
	M (SD) (N = 160)	M (SD) (N = 113)
Poor inhibition skills		
1. Alcohol use last month	1.74 (3.33)	1.68 (3.46)
2. Drinks per week	3.80 (8.99)	4.21 (10.75)
3. Problem drinking	0.93 (1.42)	0.93 (1.37)
4. Approach bias parcel 1	0.05 (0.52)	0.03 (0.50)
5. Approach bias parcel 2	−0.02 (0.44)	−0.04 (0.51)
6. Approach bias parcel 3	0.00 (0.64)	0.01 (0.61)

AAT, approach avoidance task.

AAT-trials. Three indicators for our latent factor AAT revealed low reliability and were removed from further analysis, the other 17 trials were used for creating 3 parcels using the loadings of the items as guide for creating parcels (Little et al., 2002) The 3 parcels served as indicators for the latent construct of the AAT, (cf., Cunningham et al., 2001, 2004; McCarthy and Thompsen, 2006). Third, results of the cross-lagged panel design are presented. Stability and cross-lagged paths are shown in Fig. 2*A*. Based on the mean on the Stroop task (i.e., above and below the mean), 2 groups were identified. A t-test revealed that the groups significantly differed from each other, $t(281) = 21.56$. The group with high scores represented the adolescents with weaker inhibition skills, while the group with low scores represented adolescents with stronger inhibition skills. A multigroup analysis was conducted with low and high Stroop scores as the group indicator (Fig. 2*B*). A Zero-inflated Poisson (ZIP) regression was applied for the analysis in the present study. First, because there was overdispersion (i.e., variances exceed the mean) of the dependent variable (i.e., alcohol) in our study. Second, the 3 indicators of alcohol were not distributed normally and revealed a typical ZIP distribution (i.e., left skewed with many zero-counts). If the sample includes many zero-counts, the mean of the sample will reflect the zeros and provide a less accurate representation of the sample statistics for the nonzero-counts (Liu and Powers, 2007). Using a mixture distribution method such as a ZIP model solves the problem of inflation and prevents the zero-counts from dominating the distribution (for a more detailed description of ZIP-regression, see Peeters and colleagues, 2012). In ZIP models, standard correlations (as with continuous-normal variables) between the study variables are not available; therefore, only means and standard deviations are provided in Table 1. The ZIP model was estimated with Mplus

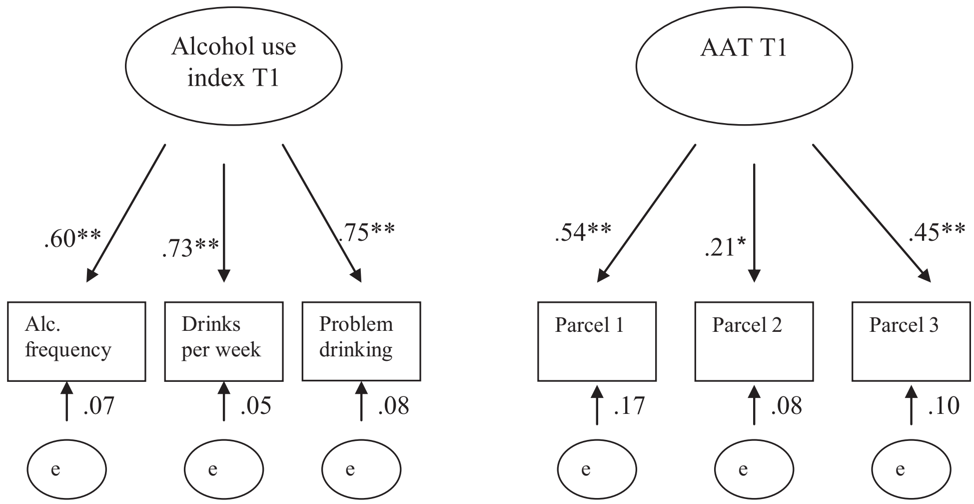

Fig. 1. Measurement model with factor loadings for alcohol use index and approach avoidance task (AAT) at baseline. Because measurement invariance was ensured, only confirmatory factor analysis (CFA) results for baseline are presented. *$p < 0.05$, **$p < 0.01$.

Version 6.0 (Muthén and Muthén, 1998–2010) using the maximum-likelihood estimation method with robust standard errors. Full-information maximum likelihood (FIML) was used to deal with missing data that allowed us to include all participants in the cross-lagged analysis. FIML uses all available information instead of deleting cases with missing variables. That is, in case of missing values, parameter estimation is based on "borrowed" information of other correlated observed values. In this way, all missing cases can be included in the analysis with actually imputing the missing values. Compared with traditional approaches (e.g., listwise/pairwise deleting), FIML has been found to be the most reliable and efficient approach and equally reliable as multiple imputation (Enders and Bandalos, 2001; Newman, 2003).

The multigroup option in Mplus required no missingness on the grouping variable *response inhibition*, resulting in a sample of 347 adolescents for the cross-lagged analysis. Participants in our study were nested within schools. To account for clustering effects, Mplus provides the option to adjust the chi-square test of model fit and standard errors in nested samples. We corrected for clustering effects in all our analyses.

RESULTS

Descriptives

Table 1 presents the mean scores and standard deviations for the 3 indicators for alcohol and for the AAT task for both groups (i.e., stronger and weaker response inhibition) and both measurements (i.e., baseline and follow-up) separately. Important to note is the fact that the descriptives in Table 1 represent both the drinkers and nondrinkers in our sample, and thus, the actual alcohol consumption among the drinkers, and more important, the increase in alcohol consumption between the 2 waves, will be higher. Using a ZIP model allows one to analyze the nonzero-counts (drinkers) separately from the zero-counts (nondrinkers) and thereby controlling for the influence of nondrinkers. However, this analytical strategy is not processed in the descriptive table, and we therefore added the percentage of drinkers (i.e., scoring one or more on of the 3 alcohol indicators) in Table 1.

Measurement Model

Analyses revealed significant factor loadings for all 3 indicators of the alcohol use index (i.e., frequency, drinks per week, and problem drinking) that were stable over time (see Fig. 1). There was a significant correlation between alcohol use at baseline and alcohol use 6 months later ($R = 0.87$, $p < 0.001$).

Since we assessed alcohol use and approach tendencies over time, it was necessary to ensure that both factors measured the same underlying construct at baseline as well as at follow-up. Therefore, we assumed measurement invariance over time. To test this assumption, we constrained both the factor loadings and the intercepts to be equal over time. For both alcohol and AAT, there was a decrease in Bayesian information criterion (BIC) after adding constraints (alcohol; BIC unconstrained: 4,713 (19) vs. BIC constrained 4,630 (14), AAT; BIC unconstrained: 1,948 (19) vs. BIC constrained: 1,923 (14)), suggesting better model fit for the more restricted model and thus indicating that both factors are time invariant.

Cross-Lagged Panel Design

Figure 2*A* presents the stability paths and cross-lagged paths without accounting for group differences in inhibition skills. All estimated parameters were constrained to be equal among adolescents with stronger inhibition skills and adolescents with weaker inhibition skills. Stability paths for both latent factors were significant (alcohol; $\beta = 0.90$, $p < 0.01$; approach tendencies; $\beta = 0.66$, $p < 0.01$). No cross-lagged

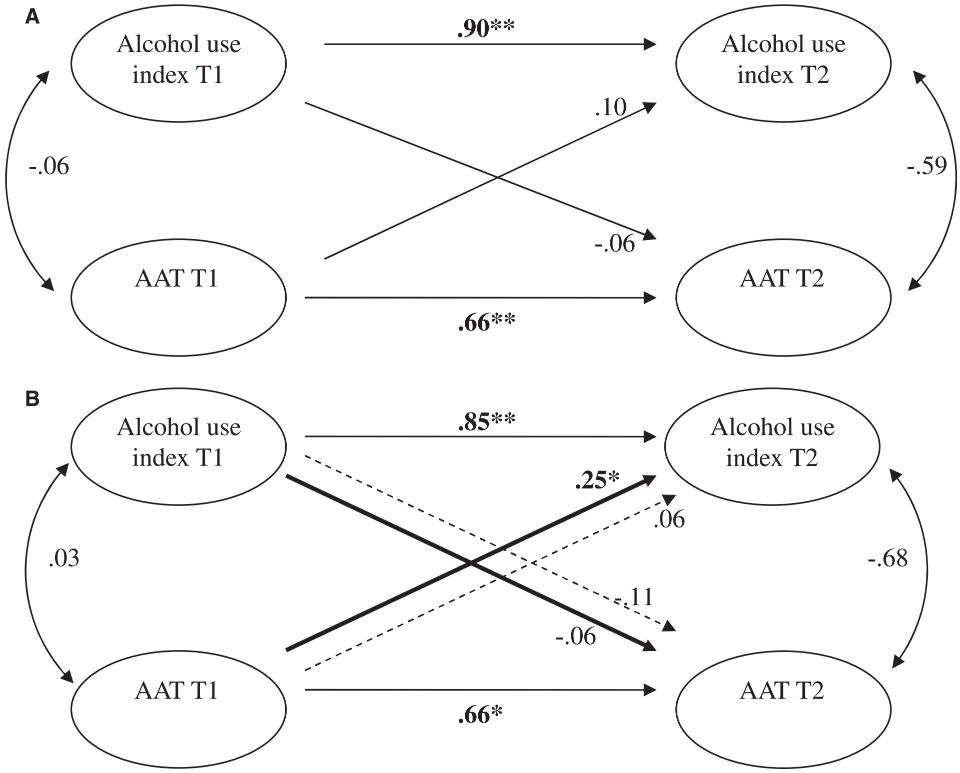

Fig. 2. (**A**) Zero-inflated Poisson (ZIP) model without multiple groups (Bayesian information criterion, (BIC) = 8,883 (37)). *$p < 0.05$, **$p < 0.01$. (**B**) ZIP model with multiple groups (i.e., high vs. low Stroop score). Straight bold lines represent results for adolescents with weaker inhibition skills (BIC = 7,500 (39)). *$p < 0.05$, **$p < 0.01$.

relation was found between alcohol use at baseline and alcohol-approach tendencies 6 months later and vice versa.[1]

In the second model (Fig. 2*B*), we went a step further and unconstrained the cross-lagged path, which allowed the relation between alcohol use at baseline and approach tendencies at follow-up, as well as that between approach tendencies at baseline and alcohol use at follow-up to vary for adolescents with stronger inhibition skills and for adolescents with weaker inhibition skills. The second model, which accounted for group differences, showed significantly better model fit (BIC: 7,500 (39) vs. 8,883 (37); $R^2 = 0.73$ for alcohol, $R^2 = 0.45$ for alcohol-AAT). In this multigroup model, stability paths for alcohol ($\beta = 0.85$, $p < 0.01$) and approach tendencies ($\beta = 0.66$, $p < 0.05$) were significant. The correlations at baseline and at follow-up between alcohol use and approach tendencies were both nonsignificant. The cross-lagged relation between alcohol use at baseline and approach tendencies 6 months later were not significant for adolescents with relatively weak as well as for adolescents with relatively good inhibitions skills ($\beta = -0.06$, $p > 0.05$ and $\beta = -0.11$ $p > 0.05$). We did find a significant cross-lagged relation between alcohol-approach tendencies at baseline and alcohol use at follow-up ($\beta = 0.25$, $p < 0.05$) for adolescents with relatively weak inhibition skills, but not for adolescents with relatively good inhibition skills ($\beta = 0.06$, $p > 0.05$).

[1]The nonsignificant baseline relation between alcohol and approach bias does not correspond with previous work (see for instance Peeters et al., 2012). One explanation is that the effect over time is stronger than the cross-sectional effect. This assumption was supported by an additional analysis. We repeated the multigroup analysis cross-sectionally, and results revealed a significant correlation between AAT and alcohol for those with relatively poor inhibition skills, a finding previously found in this sample without using a latent construct for the AAT (Peeters et al., 2012).

DISCUSSION

The present study examined the bi-directional prospective relationship of automatic approach tendencies and alcohol use in a group of young adolescents who are at-risk of developing problematic alcohol use. We hypothesized that stronger approach tendencies and alcohol use would predict heavier alcohol use 6 months later and vice versa. It was anticipated that the cross-lagged relation would be particularly strong for adolescents with relatively poor inhibition skills. The analysis revealed that stronger automatic approach tendencies did indeed predict future alcohol use, but only in adolescents with weaker inhibition skills. No predictive effects were found for adolescents with relatively good inhibition skills. We did not find any significant effect of alcohol use in predicting future approach tendencies.

The findings of the present study are in line with previous research examining the influence of automatic processes on alcohol use in young adolescents (Grenard et al., 2008; Thush and Wiers, 2007). The results add to previous studies by establishing not only a cross-sectional relationship (Field et al., 2008a; Palfai and Ostafin, 2003; Peeters et al., 2012), but also a prospective effect of automatic approach tendencies on the drinking behavior of young at-risk adolescents. Furthermore, while Thush and colleagues (2008) demonstrated short-term effects of alcohol associations predicting alcohol use, that is, over 1 month, the present study showed that these effects are maintained over a period of 6 months. Grenard and colleagues (2008) and Thush and colleagues (2008) found that working memory moderated the relationship between alcohol use and alcohol associations in young (at-risk) adolescents. In the present study, we demonstrated the moderating effect of another type of executive functioning, that is, response inhibition. The results suggest that particularly the drinking behavior of at-risk adolescents who have weaker self-regulatory skills is susceptible to the influence of automatic processes. This would imply that reflective processing is an important element in controlling drinking behavior. Once drinking has been initiated, adolescents with relatively poor inhibition skills might be less able to avert strong automatic responses and therefore consume more alcohol than their peers with relatively good inhibition skills who are able to inhibit these strong alcohol-associated responses. In a sample of adolescents assumed to have relatively good self-regulatory skills and not specifically at-risk of alcohol use, Pieters and colleagues (2012), indeed, found no support for working memory as moderator in the relation between alcohol use and alcohol-approach tendencies. It appeared that rule setting by parents regarding alcohol use was a more important moderator for adolescents with relatively good self-regulatory skills. Taken together, these results (cf., Grenard et al., 2008; Pieters et al., 2012; Thush et al., 2008; and the present study) suggest that in the presence of strong alcohol-associated responses, the ability to regulate behavior significantly affects drinking behavior in young adolescents.

We did not find any effect of alcohol use predicting automatic approach tendencies 6 months later. Perhaps, a possible explanation is that automatic approach tendencies are strengthened by drinking behavior at the onset of alcohol use but become stable as a regular drinking pattern has developed. In the present sample, most adolescents were already drinking regularly at baseline and only a small proportion of adolescents initiated alcohol use during follow-up. It would be interesting to test this effect in a sample of largely non-drinking adolescents who initiate alcohol use during the study follow-up.

The findings of this study have important implications for interventions aiming to reduce alcohol use in young adolescents, the present study emphasizes 2 issues. First, it seems that approach behavior is an important factor in predicting alcohol use by young adolescents. Therefore, weakening strong automatic approach responses might be a means to reduce alcohol use. Previous findings indicate that automatic approach responses can be re-trained (Wiers et al., 2010, 2011). Second, intervention seems to be especially important for adolescents with weaker inhibition skills (cf., Salemink and Wiers, 2011). Reflective processing could be impaired through depleted regulatory skills. A combination of increasing self-regulatory behavior in adolescents (for training working memory and response inhibition, see Houben et al., 2011a,b) and intensified external control for instance rule setting by parents (Pieters et al., 2012), might be the most effective approach to reduce alcohol use in young adolescents. This is also supported by the results of a recent effectiveness study, showing that a combined intervention, aimed at both parents and adolescents, was effective in delaying the age of onset of alcohol, while the parent and adolescent intervention separately were not (Koning et al., 2011).

The findings of the present study should be interpreted with some caution. First, we examined the relationship between alcohol use and automatic approach tendencies in a sample of adolescents at-risk of early alcohol use, and thus, our findings may not generalize to other groups. Second, a 2-wave cross-lagged model was used to test the reciprocal relationship between alcohol use and automatic approach tendencies. This model allows inferences on directionality; nevertheless, it is necessary to include more waves to examine change over time or development. The results support a unidirectional relation between approach tendencies and alcohol use; however, additional time points could provide a better understanding of the development of the relationship between alcohol-approach tendencies and alcohol use which might have a bi-directional instead of a unidirectional character earlier or later in the adolescent development. Third, one of the factor loadings of the parcels of the alcohol-AAT was small (i.e., 0.21). However, the overall model fit of the CFA of the AAT was satisfactory (comparative fit index (CFI) = 0.98, root mean square error of approximation (RMSEA) = 0.02), and the factor loading was significant. Therefore, we decided to proceed with this parcel and include it in the final model. Furthermore, a well-known phenomenon in measuring automatic processes is the error variance associated with the implicit reaction time tasks (Egloff and Schmukle, 2002). We attempted to reduce the measurement error by using a latent construct for the AAT. In comparison with self-report measures, the reliability of the AAT is modest; however, implicit measures, particularly, irrelevant feature measures assess different processes than explicit measures. Reliability reduces when participants are asked to respond to different features than the one of interest (Krieglmeyer and Deutsch, 2010). A trade-off between reliability and better assessment of automatic processes by using an irrelevant feature task was made in the present study. Previous reliability studies of implicit reaction measures present similar stability estimates. For instance, Cunningham and colleagues (2001) found a stability of 0.46 for the implicit association test (IAT) and

Egloff and Schmukle (2002) reported a stability estimate of 0.57 for the IAT. Cousijn and colleagues (2011) found an internal consistency of Cronbach's $\alpha = 0.68$ for the AAT task. Therefore, the stability coefficient of 0.66 in the present study should be regarded as acceptable.

Despite these limitations, the present study is the first to demonstrate that alcohol-approach tendencies predict future drinking behavior of young at-risk adolescents with relatively weak inhibition skills. The earlier the use of alcohol, the earlier the development of automatic approach tendencies which may continue to reinforce alcohol use as adolescents mature. In combination with relatively poor inhibition skills, alcohol-approach tendencies may cover the underlying working mechanism responsible for the escalation of drinking behavior and thereby highly relevant in the etiology of alcohol addiction.

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