The Moderating Role of Working Memory Capacity and Alcohol-Specific Rule-Setting on the Relation Between Approach Tendencies and Alcohol Use in Young Adolescents

Sara Pieters, William J. Burk, Haske Van der Vorst, Reinout W. Wiers, and Rutger C. M. E. Engels

Background: Dual process models of alcohol addiction propose that the transition from normative alcohol consumption to heavy drinking is the result of an imbalance in interplay between relatively impulsive or automatic and reflective or controlled processes. The current study examines whether impulsive and reflective processes are also detectable in a sample of adolescents with limited alcohol use.

Methods: Specifically, we tested the interaction between alcohol approach tendencies and 2 types of reflective processes, working memory capacity (WMC) and alcohol-specific rule-setting, on changes in alcohol use of 238 young adolescents (mean age: 13.82 years). Gender differences in these associations were also explored.

Results: Results showed that WMC did not moderate the relation between approach tendencies and subsequent alcohol use, whereas rule-setting did, with stronger associations between approach tendencies and alcohol use for male adolescents reporting more permissive parents than male adolescents with parents enforcing stricter rules involving alcohol use. Associations between approach tendencies and subsequent alcohol use did not emerge for female adolescents.

Conclusions: Results indicate that even in a sample of adolescents with limited drinking experience, automatic processes are positively associated with alcohol use for male adolescents that are not motivated by parents to control their drinking.

Key Words: Alcohol Use, Young Adolescents, Approach Avoidance, Working Memory, Parenting.

ALCOHOL MISUSE AMONG young adolescents is common and its prevalence is increasing. A recent Health Behavior in School-aged Children survey among 35 countries indicated that among 11 year olds, approximately 7.3% of boys and 3% of girls drank alcohol on a weekly basis. At the age of 15, these percentages increased to 34.3% and 23.9%, respectively (Currie et al., 2004). The Netherlands is one of the countries with the highest rates of alcohol use. That alcohol misuse among adolescents is an increasing health concern becomes evident from recent studies that indicate that the number of adolescents who are admitted to the hospital with alcohol intoxications is rising (Van Hoof et al., 2011). Studies have shown that adolescents who drink alcohol at a fairly young age are more likely to develop an alcohol use disorder later in life than those who initiate drinking at a later age (e.g., Hingson et al., 2006).

In an effort to elucidate factors that might explain the initiation and continuation of alcohol use, dual process models of addiction propose that the transition from normative alcohol consumption to heavy drinking is the result of an imbalance in interplay between impulsive or relatively automatic and reflective or controlled processes (Deutsch and Strack, 2006; Stacy et al., 2004; Wiers et al., 2007). On one hand, dopaminergic projections in the reward system become hypersensitive to alcohol and alcohol cues with repeated alcohol use, a process called sensitization (Robinson and Berridge, 1993, 2003). This results in alcohol cues becoming highly salient and processed relatively automatically (Robinson and Berridge, 1993, 2003). Reflective processes, on the other hand, have the power to override these automatic motivational tendencies toward alcohol. For reflective processes to control impulsive reactions to alcohol, an individual should be both capable and motivated to control behavior. The main aim of the current study is to examine aspects of the dual process model in a sample of young adolescents.

Figure 1 depicts the theoretical framework for the current study, which was adapted from the dual process model by Wiers and colleagues (2007). The lower part of the figure

From the Radboud University Nijmegen (SP, WJB, HVDV, RCMEE), Nijmegen, The Netherlands; and University of Amsterdam (RWW), Amsterdam, The Netherlands.

Received for publication March 22, 2011; accepted September 27, 2011.

Reprint requests: Sara Pieters, MSc, Behavioural Science Institute, Radboud University Nijmegen, PO Box 9104, 6500 HE Nijmegen, The Netherlands; Tel.: +31 0 243612140; Fax: +31 0 243615937; E-mail: sarapieters@gmail.com

DOI: 10.1111/j.1530-0277.2011.01688.x

describes impulsive or automatic processes. Central to these processes is the ability of cues to elicit certain impulsive reactions that steer further alcohol use. One assumption that is made is that these processes are fueled by alcohol use itself; that is, neural sensitization is thought to take place as a result of the pharmacological properties of alcohol. In early adolescence, alcohol use is sometimes limited, which leads to the question whether neural sensitization and related processes are already activated. Although we are not aware of any direct evidence of neural sensitization to alcohol in young adolescents, studies examining alcohol-related memory associations and related constructs do provide some indirect evidence that impulsive reactions to alcohol may be detected in samples with limited substance use experiences. That is, Thush and Wiers (2007) found that binge drinking was associated with more implicit arousal associations in adolescents with limited drinking experience. This finding corresponds with theories on neural sensitization (e.g., Robinson and Berridge, 1993). Some of our recent work indicates that children with no or limited drinking experience already have alcohol-related memory associations (Pieters et al., 2010a). We also found that alcohol-related memory associations of children who did not drink predict subsequent alcohol involvement 1 year later (Van der Vorst et al., unpublished data). In addition, accumulating evidence shows that motivational brain circuits are undergoing significant changes associated with puberty, which might fuel these processes as well (Forbes and Dahl, 2010). Animal studies have also indicated stronger sensitization in adolescents (e.g., rats) compared with adults (e.g., Adriani et al., 1998).

The aspects of impulsive reactions to alcohol that is the focus of the current study are approach tendencies, meaning that an individual is inclined to automatically approach cues that have been associated with alcohol and drug use (Stacy and Wiers, 2010; Wiers et al., 2007, 2009). An approach bias can be assessed in the laboratory using indirect measures that track reaction times of approaching alcohol versus control pictures or associations between alcohol and approach behaviors. One task often used in alcohol and drug research is the relevant Stimulus Response Compatibility (SRC) Task (Field et al., 2008, 2011; Mogg et al., 2003). In this task, reaction times are recorded when individuals approach or avoid alcohol cues (e.g., manikin moving toward a picture or away from it). It has been shown that heavy, but not light, drinkers were reasonably faster to approach alcohol cues compared with avoiding them in an SRC Task, and that this bias was associated with alcohol craving in social drinkers and with both craving and alcohol use in heavy drinkers (Field et al., 2005, 2008). This approach bias has also been demonstrated in smokers (Mogg et al., 2003) and cannabis users (Field et al., 2006). In addition to the SRC, other tasks have been used to assess an approach bias, such as the Implicit Association Test (Palfai and Ostafin, 2003), which showed that various measures of problem drinking were associated with an implicit association between "alcohol" and "approach" versus "avoidance" concepts. In addition, using a Simon task, it has been shown that heavy drinkers with at least 1 copy of the OPRM1 G-allele were faster to approach than avoid alcohol pictures with a joystick (Wiers et al., 2009). In Simon tasks, participants respond to stimuli in terms of irrelevant features (e.g., portrait vs. landscape). Van Hemel-Ruiter and colleagues (2011) could not demonstrate an approach bias in "heavier" drinking adolescents using a Simon task. Another recent study combining a "relevant" SRC with a Simon task showed that heavy versus light drinkers were faster to approach alcohol on a "relevant" SRC, but not on a Simon task (Field et al., 2011), which was interpreted as if the SRC would tap automatic approach tendencies more thoroughly. Nevertheless, other scholars state that irrelevant feature tasks would be more *indirect* compared with relevant ones and therefore better match the definition of implicit cognitions (e.g., De Houwer, 2003).

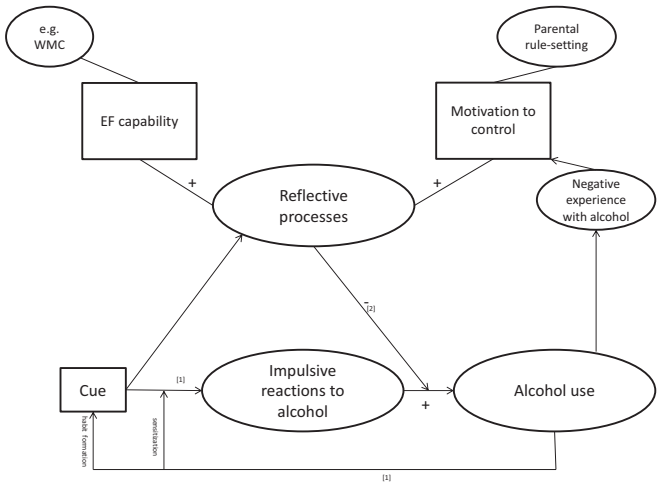

Fig. 1. Aspects from the dual process model adapted from Wiers and colleagues (2007) form the theoretical framework for the current study. EF capability, executive functioning capability.

The upper part of Fig. 1 describes reflective or controlled processes. The dual process model points out that to outweigh automatic processes, adolescents should have both the capability and the motivation to do so. Recent neurocognitive research and theorizing has indicated that motivation and ability to control co-develop and appear to be more intimately related than previously thought (Gladwin et al., 2011). The capability to inhibit automatic processes is largely dependent on executive functions, which are associated with the prefrontal cortex, a brain area that is not fully matured until early adulthood and is negatively affected by alcohol use (Spear, 2002). A related concept is working memory capacity (WMC), defined as the ability to keep information in an active state and to control, or re-direct attention (Engle, 2002). Not only is WMC bi-directionally associated with alcohol use, WMC has also been proposed as a moderator on the relation between automatic processes and alcohol use. It has been shown that implicit alcohol-related cognitions were predictive of alcohol use only in at-risk adolescents with poor WMC (Grenard et al., 2008; Thush et al., 2008). Although evidence supporting this moderating effect of WMC on the

relation between automatic processes and alcohol use is accumulating in young adults (Friese et al., 2010; Houben and Wiers, 2009), it remains unclear whether these findings generalize to younger adolescents without an at-risk status. In addition, studies examining this relation in a longitudinal design are scarce.

The motivation to override impulsive tendencies (Wiers et al., 2007) is thought to be low in adolescents, because adolescents often do not seem to be aware of the fact that their behavior is problematic in any way. At first glance, this reasoning may seem difficult to translate to adolescents with limited drinking experience. However, we propose that the motivation to control behavior may also be modulated by external forces, such as parents. That is, it has been well established that parents can delay the age of onset of drinking as well as lowering the amounts of use by using alcohol-specific socialization strategies (e.g., Van den Eijnden et al., 2011; Van der Vorst et al., 2009). Alcohol-specific socialization refers to parenting strategies specifically meant to prevent adolescent alcohol use, such as setting strict rules about drinking (Jackson et al., 1999; Van der Vorst et al., 2005). Prospective research has shown that parents who set strict rules concerning alcohol use prevent the initiation and the escalation of adolescent alcohol use (e.g., Van der Vorst et al., 2006, 2007; Yu, 2003), even in late adolescence and emerging adulthood (e.g., Abar et al., 2009; Mares et al., 2011; Turrisi and Ray, 2010; Wood et al., 2004). Moreover, strict alcohol-specific rules seem to be important for at-risk youth such as adolescents genetically vulnerable for alcohol (Pieters et al., 2011, unpublished data; Van der Zwaluw et al., 2010), following special education (Van Zundert et al., 2006), and from low socioeconomic backgrounds (Spijkerman et al., 2008). This suggests that adolescents internalize the alcohol-specific rules of their parents, referred to as injunctive norms (e.g., Turner, 1991), which cause the robust preventive influence of this parenting practice. Nevertheless, because parents really have to actively enforce these rules, we consider alcohol-specific rules as an external control mechanism affecting the motivation of adolescents to reflect. Accordingly, we put forward that parental rule-setting might also function as a moderator on the relation between impulsive or automatic processes and alcohol use.

In sum, we expect that approach tendencies toward alcohol will be related to higher levels of alcohol use in young adolescents, especially when levels of WMC are low. In addition, we expect that stricter rules endorsed by parents will function as a protective factor in the relation between approach tendencies and alcohol use. In addition, we explore gender differences in the proposed relations.

MATERIALS AND METHODS

Participants

For the current article, data were used from 238 young adolescents (49.6% boys; M_{age} = 13.82, SD = 0.81). A total of 87.9% of the participants were Caucasian (both parents Caucasian); the remainder had at least 1 non-Caucasian parent. Early adolescents came from both urban and rural areas. Concerning educational track, 46.2% had a college-preparatory level, 31.5% an intermediate or basic level, and 7.9% of participants had a vocational level, 14.3% of participants did not provide a definitive educational track, as it is not obliged to choose a definitive educational track in the Netherlands before second grade. A total of 73.5% of participants reported to have drunk alcohol at least once in their lives.

Procedure

Data were derived from the first 2 waves of a longitudinal study (*c.* 1 year interval) assessing risk factors related to adolescent alcohol use. A total of 725 of the 1,215 adolescents that were contacted by mail for participation, agreed to take part in this study by returning an informed consent form signed by their parents and themselves. Additional information about the study was included with the mail as well. Data collection took place for 2 days. On the first day, adolescents completed computer tasks assessing cognitive risk factors (e.g., SRC Task). On the second day, participants completed questionnaires assessing demographics, alcohol use, and parental rule-setting. On both testing days, trained research assistants supervised the data collection and explained that data would be handled confidentially. A subject number was assigned to each participant to guarantee privacy. In both waves, participants completed questionnaires and computerized tasks at school, under the supervision of trained research assistants. For a more detailed description of the procedure, see Pieters and colleagues (2010a,b).

As the focus of the current study is on adolescents, data were used from participants aged 12 to 16 years of age (n = 556). At T1, 292 of these adolescents completed the SRC. A total of 25 participants were excluded because of incomplete survey measures at T1, and an additional 29 students were excluded due to missingness on the alcohol use measure at T2. This resulted in a total sample of 238 adolescents. t-Tests revealed differences between our final sample and the original 556 sample on age ($t(538) = 3.57$, $p < 0.001$, excluded participants were slightly older), education ($t(551) = -9.02$, $p < 0.001$, excluded had a lower level of education), alcohol use frequency at T1 ($t(544) = 2.88$, $p = 0.004$, excluded drank more), and alcohol use frequency at T2, $t(469) = 3.89$, $p < 0.001$. Participants did not differ with regard to gender ($\chi^2 = 0.34$, $p = 0.56$).

Measures

Alcohol Use. Young adolescents were asked to report how often they drank alcohol in the past 4 weeks, at T1 and T2 (Engels and Knibbe, 2000). Answer categories to this item were: (1) "I did not drink alcohol in the past 4 weeks," (2) "I drank alcohol 1 to 3 times in the past 4 weeks," (3) "I drank alcohol 1 to 2 times per week in the past 4 weeks," (4) "I drank alcohol 3 to 4 times per week in the past 4 weeks," (5) "I drank alcohol 5 to 6 times per week in the past 4 weeks," (6) "I drank alcohol every day in the past 4 weeks."

SRC Task. The SRC Task (Field et al., 2008; Mogg et al., 2003) was designed to measure approach tendencies toward alcohol cues. In this reaction time task that was completed at T1, participants were instructed to either approach or avoid pictures with an alcoholic content in 2 blocks of 40 trials (each block preceded by 8 practice trials that were excluded from the analyses). Each trial commenced with a blank screen that was presented for 1,000 ms. Subsequently, a picture containing either an alcoholic drink (from a pool of 18 pictures) or a soft drink (from a pool of 18 pictures) was presented in the middle of the screen and a manikin was presented below or above it. Depending on instructions, participants had to move the manikin toward or away from the picture by button-press. For example, if the manikin was positioned above an alcohol picture in an "approach alcohol" trial, participants had to press the arrow pointing downward (vs. upward) on their keyboards. If participants responded correctly, the

manikin moved toward the picture. If they made an erroneous response, a large red X appeared over the picture. There was a 500 ms interval between all trials. The order of the blocks (approach vs. avoid alcohol) was counterbalanced across subjects. The mean reaction time on "approach alcohol trials" was subtracted from the mean reaction time on "avoid alcohol trials," resulting in 1 deviation score per participant. A higher score was indicative of a relative approach preference to alcohol pictures. The SRC was elected as a measure of approach tendencies, given its previous use in a sample of adolescents and young adults and its sufficient psychometric properties (e.g., Field et al., 2005, 2008).

A total of 23 participants were discarded from further analyses because of error scores exceeding 20% of the trials (more than 16 errors in 80 trials). Main analyses were therefore conducted on 215 participants. Of these, 5 participants had extremely high deviation scores (> 3 SD). These scores were drawn back to standardized values of 2.96. A *t*-test revealed an effect of order of blocks on the SRC deviation score, $t(213) = 2.14$, $p = 0.033$, therefore order was included as a control variable in the regression analysis.

Working Memory Capacity. A computerized version of the Self-ordered pointing task (SOPT) was used based on the original task (Petrides and Milner, 1982). Four different versions of the task were utilized: 9 abstract pictures (grey abstract images), 9 concrete pictures (pictures of people performing different sports), 12 abstract pictures (grey abstract images), and 12 concrete pictures (pictures of farm animals). In each version, subjects were instructed to select a picture from a matrix of pictures in each trial. When the matrix consisted of 9 pictures, participants had to select a different picture on a different location in 9 trials. The location of the pictures changed in every trial. For each version, the percentage of correct trials was computed; a mean percentage over all 4 versions was used as the outcome score. Higher scores reflected better WMC. The internal consistency of the 4 versions was good (Cronbach's alpha = 0.87). The SOPT was administered because it is easy to administer to children and young adolescents. Furthermore, its psychometric properties are sufficient (Ross et al., 2007). In addition, this measure was used before in testing WMC moderation related to dual process model in previous research (e.g., Grenard et al., 2008; Thush et al., 2008).

Parental Rule-Setting. We asked early adolescents about their perception of the rules that their parents set regarding alcohol use at T1 using 10 items (Van der Vorst et al., 2005, 2006, 2007). For example, participants were asked whether they were allowed to drink an alcoholic beverage at home if their parents are absent. Answers were given on a 5-point scale: (1) "Not applicable to my situation at all," (2) "Hardly applicable to my situation," (3) "Somewhat applicable to my situation," (4) "Applicable to my situation," (5) "Definitely applicable to my situation." Means were calculated and higher scores reflected a stricter parental attitude toward alcohol use by their offspring, as perceived by their child. Alpha was very high (0.94).

Parental Alcohol Use. In 2 items, adolescents were asked about their father's and mother's frequency of alcohol use in the past 4 weeks. These items were based on the item previously described measuring the frequency of alcohol use by the adolescents (Engels and Knibbe, 2000). Answers were given on a 6-point scale: (1) "My father/mother did not drink alcohol in the past 4 weeks," (2) "My father/mother drank alcohol 1 to 3 times in the past 4 weeks," (3) "My father/mother drank alcohol 1 to 2 times per week in the past 4 weeks," (4) "My father/mother drank alcohol 3 to 4 times per week in the past 4 weeks," (5) "My father/mother drank alcohol 5 to 6 times per week in the past 4 weeks," (6) "My father/mother drank alcohol every day in the past 4 weeks." An average score reflecting parental alcohol use was calculated over the 2 items. Alpha was sufficient (0.79).

RESULTS

Descriptives

A repeated measure analysis of variance with gender as a between-subject factor, time (T1, T2) as a within-subject factor and alcohol use frequency in the past 4 weeks as a dependent variable showed that, on average, participants drank alcohol more often at T2 than T1, $F(1,229) = 7.30$, $p = 0.007$. At T1, 76.9% of the early adolescents did not drink in the month preceding the study, 18.1% drank 1 to 3 times in the past 4 weeks, 2.5% drank 1 to 2 times per week in the past 4 weeks, 2.1% drank 3 to 4 times per week in the past 4 weeks, and 4% drank alcohol each day in the past 4 weeks. At T2, these figures were 64.5, 26.4, 6.9, 1.7, and 0.4%, respectively. No main effect of gender, $F(1,229) = 0.23$, $p = 0.636$, or an interaction between time and gender, $F(1,229) = 0.02$, $p = 0.881$, was found.

Correlations

Pearson correlation coefficients are shown in Table 1. The SRC difference score correlated negatively with parental alcohol use, suggesting that higher levels of parental alcohol use are related to less approach tendencies toward alcohol. Parental rule-setting correlated negatively with parental alcohol use and adolescent alcohol at T1 and T2, indicating that stricter rules are related to less parental and adolescent alcohol use. Alcohol use at T1 correlated positively with alcohol use at T2 and parental alcohol use. Alcohol use at T2 correlated positively with parental alcohol use. Age correlated significantly with parental rule-setting and alcohol use at T1. All other correlations were nonsignificant.

Linear Regression Analysis

In Step 1 of a regression analysis, gender, age, parental alcohol use, T1 alcohol use, WMC, parental rule-setting, the SRC difference score, and the SRC order of blocks were entered. Three interactions were entered in the second step: SRC difference score by WMC, SRC difference score by parental rule-setting, and WMC by alcohol-specific rule-setting. In Step 3, all 2- and 3-way interactions with gender were entered. Results are shown in Table 2. The adjusted R^2 from the main effects model was 0.15, $\Delta F = 5.542$, $p < 0.001$; the adjusted R^2 from model 2 was 0.20, $\Delta F = 5.004$, $p = 0.002$; the adjusted R^2 from model 3 was 0.26, $\Delta F = 3.871$, $p = 0.001$.[1]

[1]Based on the notion that neural sensitization is dependent on the pharmacological properties of alcohol, we repeated the regression analysis on a subsample of adolescents who reported to have drunk alcohol at least once in their lives (73.5%). The pattern of results was very similar to the results presented in the main text and in Table 2. That is, we found an interaction between the SRC and parental rule-setting on alcohol use at T2 (and a 3-way interaction between gender, SRC, and parental rule-setting), but we did not find an interaction between the SRC and WMC.

Table 1. Pearson Correlations Between All Study Variables

	1	2	3	4	5	6	7	8
1. Gender								
2. Age	−0.10							
3. WMC	−0.03	0.01						
4. Rules	0.01	−0.28***	0.05					
5. SRC	−0.09	−0.02	0.01	0.08				
6. Alc 1	−0.07	0.12	−0.08	−0.32***	−0.11			
7. Alc 2	−0.06	0.16*	−0.06	−0.27***	0.10	0.33***		
8. P Alc	0.12	0.00	−0.12	−0.25***	−0.14*	0.20**	0.16*	
Mean		13.81	78.74	4.54	61.69	1.29	1.46	2.86
SD		0.78	18.82	0.69	976.08	0.67	0.77	1.48

WMC, working memory capacity; SRC, Stimulus Response Compatibility.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$ 2-tailed tests.
Gender was coded as 0 = male, 1 = female. Positive numbers on parental rule-setting (rules) reflect stricter rule-setting. Positive numbers on the SRC difference score (SRC) reflect relatively smaller average reaction times on approach alcohol versus avoid alcohol trials. Alc 1 and alc 2 reflect alcohol use frequency at T1 and T2. P Alc reflects parental alcohol use.

Table 2. Hierarchical Multiple Regression Analysis Predicting Alcohol Use at T2

	Model 1			Model 2			Model 3		
	B	SE	*p*	*B*	SE	*p*	*B*	SE	*p*
Gender	−0.06	0.10	0.58	−0.10	0.10	0.31	−0.16	0.10	0.10
Age	0.07	0.07	0.25	0.08	0.06	0.24	0.07	0.06	0.26
SRC	0.16	0.06	0.01	0.18	0.06	0.00	0.38	0.09	0.00
Parental rule-setting	−0.12	0.06	0.05	−0.12	0.06	0.04	−0.28	0.08	0.00
WMC	−0.01	0.06	0.81	−0.03	0.06	0.66	−0.01	0.09	0.92
Parental alcohol use	0.05	0.04	0.15	0.07	0.04	0.05	0.06	0.03	0.06
Alcohol use T1	0.29	0.08	0.00	0.31	0.08	0.00	0.28	0.08	0.00
SRC order of blocks	0.16	0.10	0.12	0.15	0.10	0.12	0.12	0.10	0.23
SRC × WMC				0.02	0.08	0.79	−0.06	0.13	0.63
SRC × parental rule-setting				−0.30	0.08	0.00	−0.76	0.14	0.00
WMC × parental rule-setting				−0.01	0.06	0.86	−0.05	0.10	0.63
Gender × SRC							−0.34	0.12	0.01
Gender × WMC							−0.05	0.11	0.64
Gender × parental rule-setting							0.15	0.10	0.15
Gender × SRC × WMC							0.04	0.17	0.80
Gender × SRC × parental rule-setting							0.65	0.17	0.00
Gender × WMC × parental rule-setting							0.09	0.13	0.46
Adjusted R^2	0.15			0.20			0.26		
ΔF	5.524			5.004			3.871		
p	<0.001			0.002			0.001		

SRC, Stimulus Response Compatibility; WMC, working memory capacity (*Z*-scores were used).
Positive numbers on the SRC difference score (SRC) reflect relatively smaller average reaction times on approach alcohol versus avoid alcohol trials (*Z*-scores were used).

Results indicated that the significant 2-way interactions between SRC and parental rule-setting and between gender and SRC were qualified by a significant 3-way interaction between gender, SRC, and parental rule-setting. Follow-up analyses (Hayes and Matthes, 2009) indicated that the interaction between SRC and parental rule-setting was significant only for male adolescents ($B = 0.57$, SE $= 0.12$, $p < 0.001$), not for female adolescents ($B = 0.07$, SE $= 0.08$, $p = 0.38$). Simple slopes for male adolescents are presented in Fig. 2. The association between SRC and alcohol use was stronger for male adolescents with permissive parents ($B = 1.16$, SE $= 0.18$, $p < 0.001$) than for intermediate parents ($B = 0.42$, SE $= 0.09$, $p < 0.001$). The association between SRC and alcohol use was negative for male adolescents with strict parents ($B = -0.32$, SE $= 0.15$, $p = 0.03$).

DISCUSSION

The main aim of the current study was to examine the moderating effect of WMC and alcohol-specific rule-setting on the relation between alcohol approach tendencies and adolescent alcohol use. Results showed that WMC did not moderate this relation whereas alcohol-specific rule-setting did, for male adolescents. When parents were strict, the relation between alcohol approach tendencies and alcohol use over time was negative. However, when parents were intermediately strict or permissive with regard to their offspring's alcohol use, the relation between approach tendencies and alcohol use was positive. The strongest positive relation was found for adolescents with permissive parents.

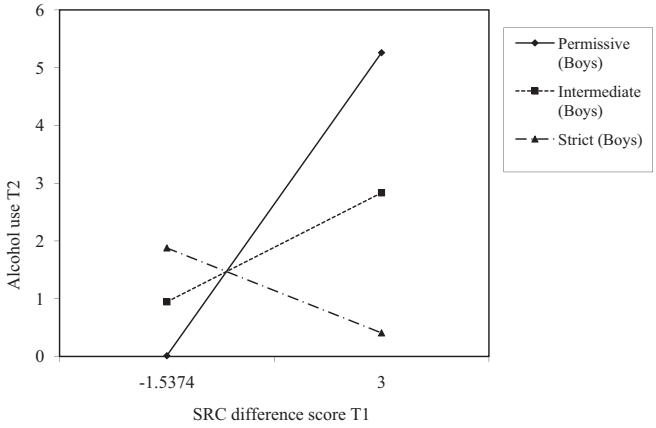

Fig. 2. Positive numbers on the SRC difference score reflect relatively smaller average reaction times on approach alcohol versus avoid alcohol trials (*Z*-scores were used). Separate lines represent indices of alcohol-specific rule-setting: permissive, intermediate, or strict regarding their children's drinking behavior. SRC, Stimulus Response Compatibility.

The finding that WMC did not interact with alcohol approach tendencies in explaining alcohol use does not correspond with some of the previous research (e.g., Grenard et al., 2008; Houben and Wiers, 2009; Thush et al., 2008). According to dual process models, both the capability and the motivation to control behavior should be present to a certain level for reflective processes to function as a brake on the effect of automatic processes. If WMC would not be sufficient at all, motivation to inhibit would not lead to an inhibition of impulsive tendencies toward alcohol. We studied an (relatively) average (compared to at-risk) Dutch adolescent sample, who have, in our view, sufficient capability to inhibit behavior (e.g., a sufficient WMC). However, not all adolescents have the motivation to do so. In our study, this translates to parental rule-setting. To be more concise, you may have the ability to control behavior (and if your ability is medium high or very high is not that important), but if you do not know why you should control your behavior, you will not attempt to. When parents endorse strict rules concerning alcohol use, these may be internalized and function as a moderator on developing automatic tendencies toward alcohol, if the capability is sufficient (the latter, in our opinion, is the case for the adolescents in our sample). Second, the alcohol measure in our sample has limited variance. Where previous studies used samples of at-risk adolescents, we used a sample of average Dutch adolescents, with obviously less variance in alcohol use. Third, we used a different indirect measure compared with other studies. Although Thush and Wiers (2007) and Grenard and colleagues (2008) have used tests of memory associations as indirect measure, we used approach tendencies. Our findings are more in agreement with Van Hemel-Ruiter and colleagues (2011) who did not find an interaction with the Affective Simon Task and the Random Number Generation Task. However, Van Hemel-Ruiter and colleagues (2011) found a negative relation between the Simon Task and alcohol use, where we found a positive one, which potentially could also be due to differences between our SRC (relevant feature) and their Simon Task (irrelevant feature). Finally, the SOPT we used is conceptually different from the one that is employed by Thush and Wiers (2007), who used 3 versions of the SOPT, all with 12 trials, but all with pictures of concrete items (e.g., a calculator, bus, stopwatch). Grenard and colleagues (2008) state that they used 6 versions of the SOPT, all with 12 trials. Nothing was specifically declared about the content of the pictures. Our SOPT consisted of 4 versions, 2 of 9 trials (abstract and concrete pictures, respectively), and 2 of 12 trials (abstract [grayscale images] and concrete, respectively).

Figure 1 displays our opinion on the position parental rule-setting may have in the (simplified) dual process model (adapted from Wiers et al., 2007). Parental rules are shown as a factor associated with the motivation to control behavior. We speculate that internalized parental rules (we asked adolescents after their perception of parental rules with regard to alcohol) might correlate with the motivation to inhibit behavior. This study has several limitations. First, only 1 aspect of automatic processing was measured, approach tendencies. It would be valuable to assess other implicit alcohol cognitions, such as alcohol-related memory associations (e.g., Grenard et al., 2008; Thush et al., 2008). Second, due to power problems, we were not able to compare different educational levels, while effects seem to be most profound in low-level students (e.g., Grenard et al., 2008; Thush et al., 2008). Third, although this study made use of a longitudinal design, the interval between assessments was relatively short (i.e., about 1 year). It would be interesting to examine how approach tendencies develop over time and how they are influenced by parents, from late childhood on, when drinking is probably not yet initiated, to early adulthood. For instance, in the current study, a negative association was found between parental alcohol use and approach tendencies, suggesting that the more parents drink, the less approach tendencies their offspring has. An explanation for this effect could be that those adolescents with parents who drink less are more prone to the novelty aspect of alcohol cues, thereby increasing their reaction times. However, it could also be that offspring from parents who drink a lot have negative associations with alcohol, because they do not like their parents' behavior in response to alcohol, thereby decreasing their reaction times to alcohol cues. Unfortunately, the current data does not provide conclusive evidence for these speculations. We chose to examine frequency of parental drinking, because this measure was closely related to our adolescent alcohol measure. Future research should also include measures of quantity of parental alcohol use and parental problem drinking to understand better this observed relation.

In sum, although this study has a few limitations, it is the first to examine the association between alcohol approach tendencies and alcohol use prospectively in a relatively normative adolescent sample. Furthermore, parents have been added to the dual process model as an external marker of motivation to abstain for drinking. A study by Koning and colleagues (2011) found that both young adolescents and their parents should be targeted in alcohol prevention. They

indicated that an intervention program for both parents and their offspring delayed the onset of weekly drinking by increasing adolescent self-control and strict perceived parental rule-setting. Our results point in the same direction, suggesting that parental rule-setting might increase the motivation to control impulsive reactions to alcohol. Furthermore, this implies that retraining procedures, in which people are implicitly trained to avoid alcohol (e.g., Wiers et al., 2010), might be suitable for male adolescents with permissive parents.

ACKNOWLEDGMENTS

The authors would like to thank Dr. Matt Field and Dr. Tim Schoenmakers for their assistance in the programming and analysis of the Stimulus Response Compatibility Task.

REFERENCES

Abar C, Abar B, Turrisi R (2009) The impact of parental modeling and permissibility on alcohol use and experienced negative drinking consequences in college. Addict Behav 34:542–547.

Adriani W, Chiarotti F, Laviola G (1998) Elevated novelty seeking and peculiar D-amphetamine sensitization in periadolescent mice compared with adult mice. Behav Neurosci 112:1152–1166.

Currie C, Roberts C, Morgan A, Smith R, Settertobulte W, Samdal O, Barnekow Rasmussen V (2004) Young people's health in context. Health behavior in school-aged children (HBSC) study: international report from the 2001/2002 survey. Health policy for children and adolescents, no. 4. WHO Regional Office for Europe, Copenhagen.

De Houwer J (2003) A structural analysis of indirect measures of attitudes, in *The Psychology of Evaluation: Affective Processes in Cognition and Emotion* (Musch J, Klauer KC eds), pp 219–244. Erlbaum, Mahwah, NJ.

Deutsch R, Strack F (2006) Reflective and impulsive determinants of addictive behavior, in *Handbook of Implicit Cognition and Addiction* (Wiers RW, Stacy AW eds), pp 45–57. SAGE, Thousand Oaks, CA.

Engels RCME, Knibbe RA (2000) Alcohol use and intimate relationships in adolescence: when love comes to town. Addict Behav 25:435–439.

Engle RW (2002) Working memory capacity as executive attention. Curr Dir Psychol Sci 11:19–23.

Field M, Caren R, Fernie G, De Houwer J (in press) Alcohol approach tendencies in heavy drinkers: comparison of effects in a Relevant Stimulus Response Compatibility task and an approach/avoidance Simon task. Psychol Addict Behav [Epub ahead of print].

Field M, Eastwood B, Bradley BP, Mogg K (2006) Selective processing of cannabis cues in regular cannabis users. Drug Alcohol Depend 85:75–82.

Field M, Kiernan A, Eastwood B, Child R (2008) Rapid approach responses to alcohol cues in heavy drinkers. J Behav Ther Exp Psychiatry 39:209–218.

Field M, Mogg K, Bradley BP (2005) Craving and cognitive biases for alcohol cues in social drinkers. Alcohol Alcohol 40:504–510.

Forbes EE, Dahl RE (2010) Pubertal development and behavior: hormonal activation of social and motivational tendencies. Brain Cogn 72:66–72.

Friese M, Bargas-Avila J, Hofmann W, Wiers RW (2010) Here's looking at you bud: alcohol-related memory structures predict eye movements for social drinkers with low executive control. Soc Psychol Personal Sci 1:143–151.

Gladwin TE, Figner B, Crone EA, Wiers RW (2011) Addiction, adolescence, and the integration of control and motivation. Dev Cogn Neurosci 1:364–376.

Grenard JL, Ames SL, Wiers RW, Thush C, Sussman S, Stacy AW (2008) Working memory capacity moderates the predictive effects of drug-related associations on substance use. Psychol Addict Behav 22:426–432.

Hayes AF, Matthes J (2009) Computational procedures for probing interactions in linear and logistic regression: SPSS and SAS implementations. Behav Res Methods 41:924–936.

Hingson RW, Heeren T, Winter MR (2006) Age at drinking onset and alcohol dependence: age at onset, duration, and severity. Arch Pediatr Adolesc Med 160:739–746.

Houben K, Wiers RW (2009) Response inhibition moderates the relationship between implicit associations and drinking behavior. Alcohol Clin Exp Res 33:626–633.

Jackson C, Henriksen L, Dickinson D (1999) Alcohol-specific socialization, parenting behaviors and alcohol use by children. J Stud Alcohol 60:362–367.

Koning IM, Van den Eijnden RJ, Engels RC, Verdurmen JE, Vollebergh WA (2011) Why target early adolescents and parents in alcohol prevention? The mediating effects of self-control, rules and attitudes about alcohol use. Addiction 106:538–546.

Mares SH, Van der Vorst H, Engels RC, Lichtwarck-Aschoff A (2011) Parental alcohol use, alcohol-related problems, and alcohol-specific attitudes, alcohol-specific communication, and adolescent excessive alcohol use and alcohol-related problems: an indirect path model. Addict Behav 36:209–216.

Mogg K, Bradley BP, Field M, De Houwer J (2003) Eye movements to smoking-related pictures in smokers: relationship between attentional biases and implicit and explicit measures of stimulus valence. Addiction 98:825–836.

Palfai TP, Ostafin BD (2003) Alcohol-related motivational tendencies in hazardous drinkers: assessing implicit response tendencies using the modified-IAT. Behav Res Ther 41:1149–1162.

Petrides M, Milner B (1982) Deficits on subject-ordered tasks after frontal- and temporal-lobe lesions in man. Neuropsychologia 20:249–262.

Pieters S, Van der Vorst H, Burk WJ, Wiers RW, Engels RCME (2010b) Puberty-dependent sleep regulation and alcohol use in early adolescents. Alcohol Clin Exp Res 34:1–7.

Pieters S, Van der Vorst H, Engels RC, Wiers RW (2010a) Implicit and explicit cognitions related to alcohol use in children. Addict Behav 35:471–478.

Robinson TE, Berridge KC (1993) The neural basis of drug craving. An incentive-sensitization theory of addiction. Brain Res Rev 18:247–291.

Robinson TE, Berridge KC (2003) Addiction. Annu Rev Psychol 54:25–53.

Ross TP, Hanouskova E, Giarla K, Calhoun E, Tucker M (2007) The reliability and validity of the self-ordered pointing task. Arch Clin Neuropsycol 22:449–458.

Spear LP (2002) The adolescent brain and the college drinker: biological basis of propensity to use and misuse alcohol. J Stud Alcohol 14:71–81.

Spijkerman R, Van den Eijnden RJ, Huiberts A (2008) Socioeconomic differences in alcohol-specific parenting practices and adolescents'drinking patterns. Eur Addict Res 14:26–37.

Stacy AW, Ames SL, Knowlton BJ (2004) Neurologically plausible distinctions in cognition relevant to drug use etiology and prevention. Subst Use Misuse 39:1571–1623.

Stacy AW, Wiers RW (2010) Implicit cognition and addiction: a tool for explaining paradoxical behavior. Annu Rev Clin Psychol 27:551–575.

Thush C, Wiers RW (2007) Explicit and implicit alcohol-related cognitions and the prediction of future drinking in adolescents. Addict Behav 32:1367–1383.

Thush C, Wiers RW, Ames SL, Grenard JL, Stacy AW (2008) Interactions between implicit and explicit cognition and working memory capacity in the prediction of alcohol use in at-risk adolescents. Drug Alcohol Depend 94:116–124.

Turner JC (1991) Social Influence. Brooks/Coole Publishing Co., Pacific Grove, CA.

Turrisi R, Ray A (2010) Sustained parenting and college drinking in first-year students. Dev Psychobiol 52:286–294.

Van den Eijnden R, Van de Mheen D, Vet R, Vermulst AD (2011) Alcohol-specific parenting and adolescents' alcohol-related problems: the interacting role of alcohol availability at home and parental rules. J Stud Alcohol Drugs 72:408–417.

Van der Vorst H, Engels RCME, Dekovic M, Meeus W, Vermulst AA (2007) Alcohol-specific rules, personality and adolescents alcohol use: a longitudinal person-environment study. Addiction 102:1064–1075.

Van der Vorst H, Engels RCME, Meeus W, Dekovic M (2006) The impact of alcohol-specific rules, parental norms about early drinking and parental alcohol use on adolescents' drinking behavior. J Child Psychol Psychiatry 47:1299–1306.

Van der Vorst H, Engels RCME, Meeus W, Dekovic M, Van Leeuwe J (2005) The role of alcohol-specific socialization in adolescents' drinking behavior. Addiction 100:1464–1476.

Van der Vorst H, Vermulst AA, Meeus WHJ, Deković M, Engels RCME (2009) Identification and prediction of drinking trajectories in early and mid-adolescence. J Clin Child Adolesc Psychol 38:329–341.

Van der Zwaluw CS, Engels RCME, Vermulst AA, Franke B, Buitelaar J, Verkes RJ, Scholte RHJ (2010) Interaction between dopamine D2 receptor genotype and parental rule-setting in adolescent alcohol use: evidence for a gene–parenting interaction. Mol Psychiatry 15:727–735.

Van Hemel-Ruiter ME, De Jong PJ, Wiers RW (2011) Appetitive and regulatory processes in young adolescent drinkers. Addict Behav 36:18–26.

Van Hoof JJ, Van Der Lely N, Bouthoorn SH, Van Dalen WE, Pereira RR (2011) Adolescent alcohol intoxication in the Dutch hospital departments of pediatrics: a 2-year comparison study. J Adolesc Health 48:212–214.

Van Zundert RM, Van der Vorst H, Vermulst AA, Engels RC (2006) Pathways to alcohol use among Dutch students in regular education and education for adolescents with behavioral problems: the role of parental alcohol use, general parenting practices, and alcohol-specific parenting practices. J Fam Psychol 20:456–467.

Wiers RW, Bartholow BD, Van Den Wildenberg E, Thush C, Engels RCME, Sher KJ, Grenard J, Ames SL, Stacy AW (2007) Automatic and controlled processes and the development of addictive behaviors in adolescence: a review and a model. Pharmacol Biochem Behav 86:263–283.

Wiers RW, Rinck M, Dictus M, Van Den Wildenberg E (2009) Relatively strong automatic appetitive action-tendencies in male carriers of the OPRM1 G-allele. Genes Brain Behav 8:101–106.

Wiers RW, Rinck M, Kordts R, Houben K, Strack F (2010) Retraining automatic action-tendencies to approach alcohol in hazardous drinkers. Addiction 105:279–287.

Wood MD, Read JP, Mitchell RE, Brand NH (2004) Do parents still matter? Parent and peer influences on alcohol involvement among recent high school graduates. Psychol Addict Behav 18:19–30.

Yu J (2003) The association between parental alcohol-related behaviors and children's drinking. Drug Alcohol Depend 69:253–262.