



UvA-DARE (Digital Academic Repository)

Implicit alcohol-relaxation associations in frequently drinking adolescents with high levels of neuroticism

Salemink, E.; van Lier, P.A.C.; Meeus, W.; Raaijmakers, S.F.; Wiers, R.W.

DOI

[10.1016/j.addbeh.2015.01.002](https://doi.org/10.1016/j.addbeh.2015.01.002)

Publication date

2015

Document Version

Final published version

Published in

Addictive Behaviors

License

Article 25fa Dutch Copyright Act

[Link to publication](#)

Citation for published version (APA):

Salemink, E., van Lier, P. A. C., Meeus, W., Raaijmakers, S. F., & Wiers, R. W. (2015). Implicit alcohol-relaxation associations in frequently drinking adolescents with high levels of neuroticism. *Addictive Behaviors*, 45, 8-13. <https://doi.org/10.1016/j.addbeh.2015.01.002>

General rights

It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations

If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: <https://uba.uva.nl/en/contact>, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.

UvA-DARE is a service provided by the library of the University of Amsterdam (<https://dare.uva.nl>)



Implicit alcohol–relaxation associations in frequently drinking adolescents with high levels of neuroticism



E. Salemink^{a,*}, P.A.C. van Lier^b, W. Meeus^{c,d}, S.F. Raaijmakers^{a,1}, R.W. Wiers^a

^a Addiction, Development and Psychopathology (ADAPT) Lab, Research Priority Areas Amsterdam Brain and Cognition, and Yield, University of Amsterdam, The Netherlands

^b Department of Developmental Psychology, VU University, Amsterdam, The Netherlands

^c Research Centre of Adolescent Development, University of Utrecht, The Netherlands

^d Department of Developmental Psychology, Tilburg University, The Netherlands

HIGHLIGHTS

- Implicit processes play, especially in adolescence, an important role in drinking.
- Knowledge of antecedents of implicit alcohol associations is limited.
- The current study examined personality-related antecedents in adolescents.
- Strongest alcohol–relaxation associations for neuroticism with frequent drinking.
- Precursors of implicit processes allow identification of risk groups.

ARTICLE INFO

Available online 14 January 2015

Keywords:

Implicit alcohol associations
Alcohol use
Adolescents
Neuroticism
Extraversion

ABSTRACT

Introduction: Most individuals start drinking during adolescence, a period in which automatically activated or implicit cognitive processes play an important role in drinking behavior. The aim of this study was to examine personality-related antecedents of implicit associations between alcohol and positive or negative reinforcement motives in adolescents. It was hypothesized that frequent alcohol consumption in combination with specific personality traits (neuroticism for negative reinforcement and extraversion for positive reinforcement) could predict specific implicit alcohol–relaxation and arousal associations.

Methods: Participants completed a brief Big Five Questionnaire and alcohol use questions at T1. Approximately eight months later (T2), two Brief Implicit Association Tests were completed to assess alcohol–relaxation (negative reinforcement, $n = 222$) and alcohol–arousal (positive reinforcement, $n = 248$) associations.

Results: Results indicated that frequently drinking adolescents who scored high on neuroticism had the strongest alcohol–relaxation associations eight months later. No significant predictors were observed for alcohol–arousal associations.

Conclusions: The current study identified precursors of strong implicit alcohol–relaxation associations (i.e., high levels of neuroticism in combination with frequent alcohol consumption) which can inform future prevention and intervention studies.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

Implicit alcohol associations play an important role in alcohol use, and especially in adolescence (Rooke & Hine, 2011; Rooke, Hine, & Thorsteinsson, 2008). Both for theoretical and prevention reasons, it is important to identify precursors of these implicit alcohol associations in

adolescents. However, at the moment we know little about such precursors. Therefore, the aim of the current prospective study was to examine personality-related antecedents of implicit alcohol associations regarding both positive and negative reinforcement motives in adolescents.

Alcohol misuse is associated with a range of negative consequences such as damage to the self (e.g., personal injuries, unintended and unprotected sexual activities, suicide), to others (e.g., physical and sexual violence), and institutional costs (Perkins, 2002). Most individuals initiate alcohol consumption and binge drinking during adolescence (Tucker, Orlando, & Ellickson, 2003). In such an early stage, alcohol consumption is considered occasional with positive reinforcement processes often driving consumption. The subsequent development of alcohol addiction

* Corresponding author at: Department of Developmental Psychology, University of Amsterdam, Weesperplein 4, 1018 XA Amsterdam, The Netherlands. Tel.: +31 205258663; fax: +31 206390279.

E-mail address: E.Salemink@uva.nl (E. Salemink).

¹ SR is now at Institute of Psychology, Erasmus University Rotterdam, The Netherlands.

(a chronically relapsing disorder) in a subgroup has been associated with a transition from impulsivity to compulsivity and more negative reinforcement and automaticity driving the consumption (Koob & Volkow, 2010).

Cognitive factors have been put forward in different models as playing an important role in the development of addictive behaviors. In traditional psychological models of addiction, explicit, rational decision making processes have been described, such as cost–benefit analysis to decide whether or not to use alcohol. In more recent cognitive models, the additional role of automatically activated processes in addictive behaviors is emphasized (Bechara, 2005; Wiers et al., 2007). An important example concerns automatically activated or implicit alcohol memory associations. It has been shown, for example, that implicit alcohol associations predicted alcohol use prospectively, when controlling for previous alcohol use and explicit processes (Stacy, 1997). Consistent with this, a meta-analysis, including 89 effect sizes, concluded that such implicit cognitions were reliably associated with alcohol use, in both adolescents and adults (Rooke et al., 2008). Furthermore, it has been suggested that this association between implicit cognitions and alcohol use might be particularly strong in adolescents as, for example, impulse control processes are not fully developed, while more emotional and reward-seeking processes (i.e., related to automatic processes) are most active in this period (e.g., Krank & Goldstein, 2006; Wiers et al., 2007). Indeed, the relationship between implicit drinking associations and binge drinking was stronger in adolescents than in adults (Rooke & Hine, 2011). Thus, there are strong indications that implicit alcohol associations are an important factor in the prediction of alcohol use and problems, especially in adolescence.

Two types of reinforcement processes have been identified in alcohol use: positive reinforcement (alcohol use will result in a more positive affect; enhancement motive) and negative reinforcement (alcohol use will result in alleviation of negative affect; coping motive) (Cox & Klinger, 1988). It has consistently been shown that explicit assessment of these outcomes is associated with different aspects of drinking behavior; enhancement motives with heavy drinking and coping motives particularly with alcohol-related problems (Kuntsche, Knibbe, Gmel, & Engels, 2005). Importantly, while this distinction between positive and negative reinforcing outcomes has mainly been studied in explicit cognitions, it can also be differentiated in more implicit associations (cf. Salemink & Wiers, 2014). For example, it has been shown that both implicit *alcohol–positive arousal* and *alcohol–relaxation* associations were associated with drinking outcomes respectively (Hendershot, Lindgren, Liang, & Hutchison, 2012; Thush et al., 2008). Thus, both at explicit and implicit levels, positive and negative reinforcement processes can be distinguished, with the latter being most often associated with drinking problems.

Thus, it is currently known that adolescence is a crucial starting point for drinking behavior and that within this period, implicit alcohol associations play an important role. From a prevention perspective, it would be useful to know *who* develops such associations as this allows the identification of specific risk groups. Up to now however, studies examining antecedents of implicit alcohol associations are limited and the aim of the current study is to examine personality factors that influence those associations in adolescents. In the field of explicit cognitions, specific associations between personality types and drinking motives have been shown (Kuntsche, Knibbe, Gmel, & Engels, 2006); neuroticism is associated with drinking to cope and extraversion with enhancement drinking (Cooper, Frone, Russell, & Mudar, 1995; Kuntsche et al., 2006). We hypothesized that the personality constructs of neuroticism and extraversion, in combination with frequent alcohol consumption, could also predict specific *implicit* alcohol associations. That is, frequent alcohol use in adolescents scoring high on neuroticism (T1) could result in strong alcohol–relaxation associations (T2, eight months later) and that such use in adolescents scoring high on extraversion (T1) could result in strong alcohol–arousal associations (T2). To test these

hypotheses, personality characteristics and frequency of alcohol consumption were assessed in adolescents at T1 and eight months later implicit alcohol associations were assessed (T2). This study is unique in evaluating the role of personality characteristics as antecedents of implicit alcohol associations in the crucial period of adolescence.

2. Method

2.1. Participants and procedure

Participants are a subsample from a larger longitudinal project for Research on Adolescent Development and Relationships, younger cohort (RADAR-Y; Van Lier et al., submitted for publication), which was approved by the Medical–Ethical Committee of University Medical Centre Utrecht. The adolescents were recruited from various Dutch elementary schools. A description of the study was sent to the home address, and parents and adolescents provided informed consent to participate. In the current study, data from the fifth wave was used; both the annual assessment data (March 2010, T1) and the internet assessment eight months later (November 2010, T2). Adolescents filled out the personality and drinking questionnaire during the annual assessment conducted at home, and supervised by trained research assistants. Eight months later, the alcohol–relaxation and alcohol–arousal associations were assessed on separate days during the online internet assessment. Participants received €100 for participation in the (full family) annual assessment and an additional €10 for participation in the internet assessment.

For the current sample, adolescents were selected who indicated having drunk alcohol, at least once, in the past and who completed at least one implicit alcohol association task. As the alcohol associations task were completed on separate days, sample sizes differ slightly between the tasks due to differences in attendance rate, technical problems, etc. After identifying unique participants, applying the improved scoring algorithm for the implicit association test (Greenwald, Nosek, & Banaji, 2003), removing multivariate outliers ($n = 2$ relaxation associations, $n = 3$ for arousal associations), the final sample for the alcohol–relaxation associations was $n = 219$ (M age = 17.0, $SD = 0.6$; 111 males) and for alcohol–arousal associations $n = 245$ (M age = 17.0, $SD = 0.5$; 132 males). There are 97 participants overlapping in the two groups.

2.2. Materials

2.2.1. Brief Implicit Association Test (BIAT)

Adolescents completed two Brief Implicit Association Tests (BIATs, Sriram & Greenwald, 2009) to assess the strength of implicit alcohol–relaxation and alcohol–arousal associations. The BIAT uses a briefer format than the Implicit Association Test (IAT, Greenwald, McGhee, & Schwartz, 1998) and does not make the contrast category explicit. Participants were instructed to focus on a category or two categories, and these were presented at the top of the screen. In the middle of the

Table 1

Structure of the relaxation and arousal Brief Implicit Association Test (BIAT).

Blocks	No. of trials	Function	Focal category	
			Relaxation BIAT	Arousal BIAT
1	12	Practice	Relaxed	Alcohol
2	12	Practice	Alcohol	Active
3	12	Combination 1	Relaxed + alcohol	Alcohol + active
4	24	Combination 1	Relaxed + alcohol	Alcohol + active
5	12	Practice	Soda	Miserable
6	12	Combination 2	Relaxed + soda	Alcohol + miserable
7	24	Combination 2	Relaxed + soda	Alcohol + miserable

Note. For half of the participants, the positions of Blocks 2, 3, and 4 are switched with those of Blocks 5, 6, and 7, respectively.

screen, word stimuli were presented and participants had to rapidly categorize whether they belonged to the designated category/categories or not (press “i” key for ‘in’, press “e” key for ‘out’ respectively). If participants made a mistake or pressed an invalid key, a red cross appeared and participants had to press the correct key to proceed to the next trial.

The BIATs consisted of a seven block design (Lindgren et al., 2013). In the relaxation BIAT, *Relaxed* was always the focal category (items: quiet, tranquil, calm; items from the unlabeled category were firm, big, huge). It was paired with *Alcohol* (items: beer, wine, breezer) or with *Soda* (items: cola, fanta, ice-tea). In the arousal BIAT, *Alcohol* was always the focal category and it was paired with *Active* (items: cheerful, energetic, enthusiastic) or with *Miserable* (items: sick, lousy, nauseous) (Houben, Nosek, & Wiers, 2010; Rather & Goldman, 1994). An overview of the relaxation and arousal BIAT can be found in Table 1.

The order of the relaxation and arousal BIAT was counterbalanced across participants. A BIAT-index was calculated using the D1 improved scoring algorithm (Greenwald et al., 2003) with a build-in error penalty. Internal consistencies were examined by calculating the correlation between two D scores (from the first, 3 and 6, and second, 4 and 7, combination blocks) (Greenwald et al., 2003). After correcting for test length using the Spearman–Brown prophecy formula, the internal consistency for the alcohol–relaxation BIAT was .64 and for the alcohol–arousal BIAT .70. These consistencies are marginal at best, though falling within the range observed for most IATs (Greenwald et al., 2003).

2.2.2. Big Five Personality Questionnaire

Adolescents' personality was assessed using a shortened Dutch version of Goldberg's Big Five Questionnaire, which has adequate reliability and validity (Branje, van Lieshout, & Gerris, 2007; Goldberg, 1992). Using 30 Big Five personality markers, five personality dimensions (each with six items) were assessed: Extraversion (e.g., talkative), agreeableness, conscientiousness, neuroticism (e.g., worried, reverse-scored), and Openness to experience. The adolescents rated the adjectives on a 7-point Likert scale, ranging from 1 (*very untrue*) to 7 (*very true*). The Extraversion and Neuroticism subscales are the means of the item responses.

2.2.3. Alcohol use questions

During T1 assessment, the adolescents completed three questions about alcohol use. First, it was asked whether they had ever drunk any alcohol (*yes* or *no*). Second, it was asked how often they had drunk alcohol in the past four weeks. The adolescents responded on a 6-point Likert scale, with *no alcohol* (0), *1–3 days in 4 weeks* (1), *1–2 days per week* (2), *3–4 days per week* (3), *5–6 days per week* (4), or *every day* (5). Finally, it was asked how often they had drunk more than six glasses of alcohol in the past four weeks using the same 6-point Likert scale (adapted version Engels, Knibbe, & Drop, 1999). The T2 assessment only contained the question about frequency of alcohol use in the past four weeks.

Table 2

Correlations between alcohol use, neuroticism, and alcohol–relaxation associations (n = 219).

	1.	2.	3.	4.	5.
1. T1 frequency alcohol use	–				
2. T1 neuroticism	–.18*	–			
3. T2 frequency alcohol use ^a	.57**	–.18*	–		
4. T2 alcohol–relaxation associations	.11 [†]	.04	.14 [†]	–	
5. Gender	.36**	–.25**	.28**	.06 ^a	–
M	1.4	3.7	2.4	–0.1	
SD	0.8	1.2	0.9	0.4	
Range	0–4	1–6.5	1–5	–1.4–1.0	108f/111 m

Note. T2 assessment is eight months after T1 assessment.

[†] $p < .10$.

* $p < .05$.

** $p < .001$.

^a Sample size $n = 210$.

Table 3

Correlations between frequency of alcohol use, extraversion, and alcohol–arousal associations (n = 245).

	1.	2.	3.	4.	5.
1. T1 frequency alcohol use	–				
2. T1 extraversion	.18*	–			
3. T2 frequency alcohol use ^a	.60**	.24**	–		
4. T2 alcohol–arousal associations	.10	.04	.10	–	
5. Gender	.26**	–.03	.31**	.004 ^a	–
M	1.4	5.0	2.4	–0.06	
SD	0.8	1.2	0.9	0.5	
Range	0–4	2–7	1–5	–1.2–1.1	113f/132 m

Note. T2 assessment is eight months after T1 assessment.

* $p < .05$.

** $p < .001$.

^a Sample size $n = 224$.

3. Results

3.1. Analytic plan

We employed multiple moderated regression analyses to examine whether alcohol use (T1) in combination with neuroticism or extraversion predicted the strength of implicit alcohol–relaxation or arousal associations (T2). The BIAT data was normally distributed. All variables were z-standardized before inclusion in the regression analyses and interaction terms were created using these standardized variables (Aiken & West, 1991). To examine whether the order of the relaxation and arousal BIATs influenced the results, we repeated the analyses with the variable Order added. No significant effects were observed for this variable, and for ease of interpretation it is therefore left out of the analyses.

3.2. Correlations between main variables

Zero-order correlations were computed between frequency of alcohol use, neuroticism, alcohol–relaxation associations, and gender (see Table 2). Frequency of alcohol use at T1 and T2 were significantly positively correlated. Neuroticism was significantly negatively correlated with frequency of alcohol use at T1 and T2, indicating that adolescents who scored high on neuroticism drank alcohol less often. There was a non-significant trend for a correlation between alcohol–relaxation associations and frequency of alcohol use (both T1 and T2); more frequent alcohol use tended to be associated with stronger alcohol–relaxation associations. Male gender was associated with more frequent alcohol consumption and less neuroticism. Those correlations were also calculated for alcohol use, extraversion, alcohol–arousal associations, and gender (see Table 3). Extraversion was significantly positively correlated with frequency of use (both T1 and T2); thus more extravert adolescents drank alcohol more often. Alcohol–arousal associations were not significantly correlated with alcohol-use, nor with extraversion.

3.3. Predicting alcohol–relaxation associations

Frequency of alcohol use (T1), neuroticism, and the interaction between alcohol use and neuroticism were entered as predictors in the moderated regression analysis^{2,3} with implicit alcohol–relaxation associations (T2) as the dependent variable to examine the antecedents

² The analysis was repeated with the Gender included as an additional predictor and in interaction with other variables (moderator). The regression model was not significant.

³ The analysis was repeated with frequency of binge drinking at T1. The model was not significant ($R^2 = .025$, adjusted $R^2 = .012$, $F(3, 216) = 1.86$, $p = .14$). There was a non-significant trend for the binge drinking \times neuroticism interaction effect, $\beta = 0.13$, $p = .076$, with frequency of binge drinking significantly predicting the strength of implicit alcohol–relaxation associations in adolescents scoring high on neuroticism, $\beta = .24$, $p = .026$, whereas it did not predict in adolescents scoring low on neuroticism, $\beta = -.03$, $p = .79$.

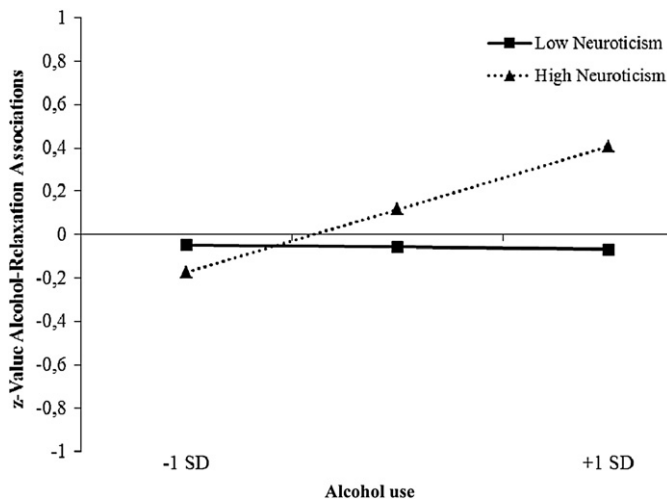


Fig. 1. Strongest influence of drinking frequency on alcohol–relaxation associations in adolescents scoring high on neuroticism.

of these implicit alcohol–relaxation associations. The regression model was significant, $R^2 = .036$ (adjusted $R^2 = .023$), $F(3, 215) = 2.7$, $p = .046$. The analysis yielded a significant main effect of alcohol use, $\beta = 0.14$, $p = .042$, and consistent with predictions, a significant alcohol use \times neuroticism interaction effect, $\beta = 0.15$, $p = .036$. This indicated that the impact of alcohol use on alcohol–relaxation associations was moderated by level of neuroticism. This interaction effect is depicted in Fig. 1 by plotting the prediction of alcohol–relaxation associations for individuals whose frequency of alcohol consumption is low (-1 SD) and high ($+1$ SD) depending on low (-1 SD) and high ($+1$ SD) levels of neuroticism. Simple slope tests (Aiken & West, 1991) revealed that, as expected, alcohol use predicted the strength of implicit alcohol–relaxation associations in adolescents scoring high on neuroticism, $\beta = .29$, $p = .006$, whereas it did not predict in adolescents scoring low on neuroticism, $\beta = -.01$, $p = .92$. In other words, the adolescents who reported frequent drinking and scored high on neuroticism had the strongest alcohol–relaxation associations eight months later.

3.4. Predicting alcohol–arousal associations

Frequency of alcohol use (T1), extraversion, and the interaction between alcohol use and extraversion were entered as predictors in the moderated regression analysis^{2,4} with implicit alcohol–arousal associations as the dependent variable to examine antecedents of alcohol–arousal associations. This model was not significant ($R^2 = .012$, adjusted $R^2 = -.001$, $F(3, 241) = 0.942$, $p = .421$), and none of the predictors were significant (including the alcohol use \times extraversion interaction effect, $\beta = -0.04$, $p = .543$). These results revealed that neither the frequency of drinking, extraversion, nor the combination of both predict the strength of alcohol–arousal associations eight months later.

4. Discussion

Implicit alcohol associations play an important role in alcohol-related behavior, especially in adolescence (Rooke & Hine, 2011; Rooke et al., 2008). The aim of this study was to examine personality-related precursors of alcohol–relaxation and alcohol–arousal associations in adolescents. The results revealed that frequent alcohol consumption in combination with higher levels of neuroticism were associated

with the strongest alcohol–relaxation associations eight months later. No significant predictors were observed for alcohol–arousal associations.

The current findings on neuroticism and implicit alcohol–relaxation associations point in the same direction as previous findings concerning explicit coping motives for drinking (Cooper et al., 1995; Kuntsche et al., 2006); higher levels of neuroticism (in combination with frequent alcohol consumption) are associated with both higher levels of explicit and implicit alcohol coping motives. This is consistent with the findings in adults that higher levels of neuroticism or anxiety are associated with heavy and problematic alcohol use and that anxiety disorders are highly comorbid with alcohol use disorders (Stewart & Conrod, 2008). Thus, higher levels of neuroticism or anxiety seem a vulnerability factor. However, note that we observed a significant *negative* correlation between neuroticism and alcohol use, indicating that adolescents scoring high on neuroticism drank alcohol less frequently. This negative association between anxiety and alcohol use in adolescence has been observed previously (Castellanos-Ryan, O’Leary-Barrett, Sully, & Conrod, 2013; Krank et al., 2011). This might suggest that higher levels of anxiety or neuroticism are initially a protective factor that postpones the initiation of alcohol use and reduces the frequency of alcohol consumption in early to middle adolescence. However, once alcohol use has initiated, these adolescents will likely experience dampening of their anxious feelings, and have explicit and implicit coping associations (current findings) and this might then, in turn, increase the risk for future alcohol-related problems. These findings highlight the relevance of studying developmental patterns in adolescence; an initially protective personality (higher levels of neuroticism or anxiety) could later turn into a risk personality when combined with (heavy) alcohol consumption.

Perhaps surprisingly, no significant predictors were observed for alcohol–arousal associations. As extraversion has been associated with explicit enhancement motives (Kuntsche et al., 2006) and with alcohol use (Hittner & Swickert, 2006), we expected this personality characteristic to be associated with *implicit* arousal associations. These expected results were not found. It is possible that the personality trait extraversion is too general and that more specific personality constructs directly related to alcohol use should be assessed (cf. Woicik, Stewart, Pihl, & Conrod, 2009). Indeed, a brief personality scale has been designed to measure four dimensions of personality that have particular relevance to substance use vulnerability (Substance Use Risk Profile Scale, Woicik et al., 2009). In the context of alcohol–arousal associations, two of those dimensions might be relevant: sensation seeking and impulsivity. Sensation seeking has been linked to explicit enhancement motives for adolescent alcohol use (Comeau, Stewart, & Loba, 2001; Cooper et al., 1995; Magid, MacLean, & Colder, 2007) and more alcohol intake in adolescence (Castellanos-Ryan et al., 2013; Krank et al., 2011; Woicik et al., 2009). While it has been shown that sensation seeking is positively, but moderately correlated with the general trait of extraversion (Aluja, García, & García, 2003), it might be that particularly sensation seeking (and its increase in adolescence, Steinberg et al., 2008) is relevant for implicit alcohol–arousal associations and alcohol use. Impulsivity might be the other relevant personality dimension. It is also associated with alcohol-related behaviors (Castellanos-Ryan et al., 2013; Krank et al., 2011; Woicik et al., 2009) and distinct from sensation seeking, both regarding the developmental pattern in adolescence (Steinberg et al., 2008) and its relationship with drinking motives and alcohol (mis-) use (Magid et al., 2007). Future research might include sensation seeking and impulsivity as personality-related antecedents of implicit alcohol–arousal associations.

Some study limitations should be acknowledged. Because we added the implicit measure to an ongoing longitudinal study not specifically focused on the development of cognitive processes in alcohol use, some measures were missing such as a more complete quantity and frequency index of alcohol use; anxiety sensitivity, sensation seeking, and impulsivity characteristics (Woicik et al., 2009); and explicit drinking motives (Cooper et al., 1995). This might be related to the limited explained percentage of variance in implicit associations. Another

⁴ The analysis was repeated with frequency of binge drinking at T1 instead of alcohol use. The model was not significant ($R^2 = .002$, adjusted $R^2 = -.010$, $F(3, 241) = 0.187$, $p = .905$), and none of the predictors were significant (including the interaction effect, $\beta = -0.008$, $p = .909$).

limitation is the use of the Brief Big Five Questionnaire, and the conservative influence of parental consent. Furthermore, a BIAT was used to assess implicit alcohol associations (Sriram & Greenwald, 2009). This decision was driven by the wish to have a task that was not too difficult for adolescents (i.e., focus on two instead of four categories) and circumvent difficulties of natural contrast categories (i.e., contrast category is not explicitly labeled in a BIAT, cf. Lindgren et al., 2013). And promising, internal consistencies of the current two BIATs fall within the .5 to .7 range observed for most IATs (Greenwald et al., 2003). However, it is a relatively new task that has been subject to some debate (e.g., Friese & Fiedler, 2010; Rothermund & Wentura, 2010) and, just as the standard IAT, the BIAT is a relative measure, thus the current findings should be interpreted in the light of the contrast categories. Finally, the measures of implicit associations were obtained only once, thus limiting the design and conclusions.

Our study revealed that high levels of neuroticism in combination with heavy alcohol consumption were associated with the strongest alcohol–relaxation associations eight months later. No significant predictors were observed for alcohol–arousal associations. As implicit associations play an important role in (escalation of) drinking, the identification of personality-based precursors of implicit alcohol–relaxation associations allows prevention programs to select specific risk groups. Indeed, recent selective prevention programs focus on adolescents with risk personality profiles and provide personality-matched interventions (e.g., Conrod, Castellanos, & Mackie, 2008).

Role of funding sources

Funding for this study was provided by the Dutch National Science Foundation, N.W.O. (respectively VENI 451-10-029 and VICI 453-08-001). Data of the RADAR study were used. RADAR has been financially supported by main grants from the Netherlands Organisation for Scientific Research (GB-MAGW 480-03-005, GB-MAGW 480-08-006), Stichting Achmea Slachtoffer en Samenleving (SASS, March 2004 and July 2008) to RADAR PI 's, and a Gravitation grant from the Netherlands Organisation for Scientific Research to the Consortium Individual Development (CID) (024.001.003).

These agencies had no role in the study design, collection, analysis or interpretation of the data, writing the manuscript, or the decision to submit the paper for publication.

Contributors

All authors contributed to the manuscript. ES, RW, and PvL designed the study. ES and SR conducted the data analysis and ES wrote the first draft of the manuscript. All authors have approved the final manuscript.

Conflict of interest

All authors declare that they have no conflicts of interest.

References

- Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Thousand Oaks, CA: Sage.
- Aluja, A., García, Ó., & García, L. F. (2003). Relationships among extraversion, openness to experience, and sensation seeking. *Personality and Individual Differences*, 35, 671–680. [http://dx.doi.org/10.1016/S0191-8869\(02\)00244-1](http://dx.doi.org/10.1016/S0191-8869(02)00244-1).
- Bechara, A. (2005). Decision making, impulse control and loss of willpower to resist drugs: A neurocognitive perspective. *Nature Neuroscience*, 8, 1458–1463. <http://dx.doi.org/10.1038/nn1584>.
- Branje, S. J. T., van Lieshout, C. F. M., & Gerris, J. R. M. (2007). Big Five personality development in adolescence and adulthood. *European Journal of Personality*, 21, 45–62. <http://dx.doi.org/10.1002/per.596>.
- Castellanos-Ryan, N., O'Leary-Barrett, M., Sully, L., & Conrod, P. (2013). Sensitivity and specificity of a brief personality screening instrument in predicting future substance use, emotional, and behavioral problems: 18-Month predictive validity of the substance use risk profile scale. *Alcoholism: Clinical and Experimental Research*, 37, E281–E290. <http://dx.doi.org/10.1111/j.1530-0277.2012.01931>.
- Comeau, N., Stewart, S. H., & Loba, P. (2001). The relations of trait anxiety, anxiety sensitivity, and sensation seeking to adolescents' motivations for alcohol, cigarette, and marijuana use. *Addictive Behaviors*, 26, 803–825. [http://dx.doi.org/10.1016/S0306-4603\(01\)00238-6](http://dx.doi.org/10.1016/S0306-4603(01)00238-6).
- Conrod, P. J., Castellanos, N., & Mackie, C. (2008). Personality-targeted interventions delay the growth of adolescent drinking and binge drinking. *Journal of Child Psychology and Psychiatry*, 49, 181–190. <http://dx.doi.org/10.1111/j.1469-7610.2007.01826>.
- Cooper, M. L., Frone, M. R., Russell, M., & Mudar, P. (1995). Drinking to regulate positive and negative emotions: A motivational model of alcohol use. *Journal of Personality and Social Psychology*, 69, 990–1005. <http://dx.doi.org/10.1037/0022-3514.69.5.990>.
- Cox, W. M., & Klinger, E. (1988). A motivational model of alcohol use. *Journal of Abnormal Psychology*, 97, 168–180. <http://dx.doi.org/10.1037/0021-843X.97.2.168>.
- Engels, R. C., Knibbe, R. A., & Drop, M. J. (1999). Visiting public drinking places: An explorative study into the functions of pub-going for late adolescents. *Substance Use & Misuse*, 34, 1261–1280. <http://dx.doi.org/10.3109/10826089909039408>.
- Friese, M., & Fiedler, K. (2010). Being on the lookout for validity: Comment on Sriram and Greenwald (2009). *Experimental Psychology*, 57, 228–232. <http://dx.doi.org/10.1027/1618-3169/a000051>.
- Goldberg, L. R. (1992). The development of markers of the Big-Five factor structure. *Psychological Assessment*, 4, 26–42.
- Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. (1998). Measuring individual differences in implicit cognition: The implicit association test. *Journal of Personality and Social Psychology*, 74, 1464–1480. <http://dx.doi.org/10.1037/0022-3514.74.6.1464>.
- Greenwald, A. G., Nosek, B. A., & Banaji, M. R. (2003). Understanding and using the implicit association test: I. An improved scoring algorithm. *Journal of Personality and Social Psychology*, 85, 197–216. <http://dx.doi.org/10.1037/0022-3514.85.2.197>.
- Hendershot, C. S., Lindgren, K. P., Liang, T., & Hutchison, K. E. (2012). COMT and ALDH2 polymorphisms moderate associations of implicit drinking motives with alcohol use. *Addiction Biology*, 17, 192–201. <http://dx.doi.org/10.1111/j.1369-1600.2010.00286>.
- Hittner, J. B., & Swickert, R. (2006). Sensation seeking and alcohol use: A meta-analytic review. *Addictive Behaviors*, 31, 1383–1401. <http://dx.doi.org/10.1016/j.addbeh.2005.11.004>.
- Houben, K., Nosek, B. A., & Wiers, R. W. (2010). Seeing the forest through the trees: A comparison of different IAT variants measuring implicit alcohol associations. *Drug and Alcohol Dependence*, 106, 204–211. <http://dx.doi.org/10.1016/j.drugalcdep.2009.08.016>.
- Koob, G. F., & Volkow, N. D. (2010). Neurocircuitry of addiction. *Neuropsychopharmacology*, 35, 217–238. <http://dx.doi.org/10.1038/npp.2009.110>.
- Krank, M. D., & Goldstein, A. L. (2006). Adolescent changes in implicit cognitions and prevention of substance abuse. In R. W. Wiers, & A. W. Stacy (Eds.), *Handbook of implicit cognition and addiction* (pp. 439–453). Thousand Oaks: Sage Publications.
- Krank, M., Stewart, S. H., O'Connor, R., Woicik, P. B., Wall, A. M., & Conrod, P. J. (2011). Structural, concurrent, and predictive validity of the Substance Use Risk Profile Scale in early adolescence. *Addictive Behaviors*, 36, 37–46. <http://dx.doi.org/10.1016/j.addbeh.2010.08.010>.
- Kuntsche, E., Knibbe, R., Gmel, G., & Engels, R. (2005). Why do young people drink? A review of drinking motives. *Clinical Psychology Review*, 25, 841–861. <http://dx.doi.org/10.1016/j.cpr.2005.06.002>.
- Kuntsche, E., Knibbe, R., Gmel, G., & Engels, R. (2006). Who drinks and why? A review of socio-demographic, personality, and contextual issues behind the drinking motives in young people. *Addictive Behaviors*, 31, 1844–1857. <http://dx.doi.org/10.1016/j.addbeh.2005.12.028>.
- Lindgren, K. P., Neighbors, C., Teachman, B. A., Wiers, R. W., Westgate, E., & Greenwald, A. G. (2013). I drink therefore I am: Validating alcohol-related implicit association tests. *Psychology of Addictive Behaviors*, 27, 1–13. <http://dx.doi.org/10.1037/a0027640>.
- Magid, V., MacLean, M. G., & Colder, C. R. (2007). Differentiating between sensation seeking and impulsivity through their mediated relations with alcohol use and problems. *Addictive Behaviors*, 32, 2046–2061. <http://dx.doi.org/10.1016/j.addbeh.2007.01.015>.
- Perkins, H. (2002). Surveying the damage: A review of research on consequences of alcohol misuse in college populations. *Journal of Studies on Alcohol and Drugs*, 14, 91–100.
- Rather, B. C., & Goldman, M. S. (1994). Drinking-related differences in the memory organization of alcohol expectancies. *Experimental and Clinical Psychopharmacology*, 2, 167–183.
- Rooke, S. E., & Hine, D. W. (2011). A dual process account of adolescent and adult binge drinking. *Addictive Behaviors*, 36, 341–346. <http://dx.doi.org/10.1016/j.addbeh.2010.12.008>.
- Rooke, S. E., Hine, D. W., & Thorsteinsson, E. B. (2008). Implicit cognition and substance use: A meta-analysis. *Addictive Behaviors*, 33, 1314–1328. <http://dx.doi.org/10.1016/j.addbeh.2008.06.009>.
- Rothermund, K., & Wentura, D. (2010). It's brief but is it better? An evaluation of the Brief Implicit Association Test. *Experimental Psychology*, 57, 233–237. <http://dx.doi.org/10.1027/1618-3169/a000060>.
- Salemink, 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. <http://dx.doi.org/10.1037/a0032806>.
- Sriram, N., & Greenwald, A. G. (2009). The Brief Implicit Association Test. *Experimental Psychology*, 56, 283–294. <http://dx.doi.org/10.1027/1618-3169.56.4.283>.
- Stacy, A. W. (1997). Memory activation and expectancy as prospective predictors of alcohol and marijuana use. *Journal of Abnormal Psychology*, 106, 61–73.
- 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. <http://dx.doi.org/10.1037/a0012955>.
- Stewart, S. H., & Conrod, P. J. (2008). Anxiety disorder and substance use disorder comorbidity: Common themes and future directions. *Anxiety and substance use disorders* (pp. 239–257). US: Springer.
- 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. <http://dx.doi.org/10.1016/j.drugalcdep.2007.10.019>.
- Tucker, J. S., Orlando, M., & Ellickson, P. L. (2003). Patterns and correlates of binge drinking trajectories from early adolescence to young adulthood. *Health Psychology*, 22, 79–87. <http://dx.doi.org/10.1037/0278-6133.22.1.79>.
- Van Lier, P. A. C., Frijns, T., Neumann, A., den Exter Blokland, E., Koot, H. M., & Meeus, W. (2011). The RADAR study: Design, description of sample, and validation of cohort assignment. (Unpublished Manuscript).

- Wiers, R. W., Bartholow, B. D., van den Wildenberg, E., Thush, C., Engels, R. C., Sher, K. J., et al. (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. <http://dx.doi.org/10.1016/j.pbb.2006.09.021>.
- Woicik, P. A., Stewart, S. H., Pihl, R. O., & Conrod, P. J. (2009). The substance use risk profile scale: A scale measuring traits linked to reinforcement-specific substance use profiles. *Addictive Behaviors*, 34, 1042–1055. <http://dx.doi.org/10.1016/j.addbeh.2009.07.001>.