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# Explicit and implicit alcohol-related cognitions and the prediction of future drinking in adolescents

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**Abstract**

Both implicit and explicit alcohol-related cognitions might play a role in the early development of addictive behaviors. In this study, the association between both current and prospective alcohol use and implicit and explicit alcohol-related cognitions were measured in two different adolescent age groups ($N$=100; 51 twelve year olds, 49 fifteen year olds). Alcohol-related cognitions were measured on two dimensions (valence and arousal). A new measure, the unipolar Single Target Implicit Association Test (ST-IAT), was used as the implicit measure. A unipolar expectancy questionnaire was used as the explicit measure. Current alcohol use and alcohol use after one year were measured with an alcohol use questionnaire. Abstainers and drinkers differed in both their explicit and implicit alcohol-related cognitions moderated by age and gender. Additionally, a hierarchical regression analysis showed that implicit associations with alcohol added significantly to the prediction of prospective binge drinking, when controlling for grade, gender and explicit alcohol expectancies These results indicate the importance of taking implicit alcohol-related cognitions into account when intervention methods are developed.


*Keywords:* Implicit cognition; Explicit cognition; Adolescence; Alcohol use; IAT

## 1. Introduction

Alcohol-related cognition has been proposed to play an important role in the development and maintenance of addictive behaviors. Explicit alcohol outcome expectancies have shown to be strongly

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correlated with current alcohol use, predicting up to half of the variance in concurrent alcohol use in cross-sectional studies (Goldman, Del Boca, & Darkes, 1999; Wiers, Hoogeveen, Sergeant, & Gunning, 1997). Explicit alcohol outcome expectancies have also been shown to be predictive of prospective alcohol use (e.g. Goldman & Darkes, 2004; Stacy, 1997; Stacy, Newcomb, & Bentler, 1991), however it must be noted that the proportion of explained variance is much smaller than in studies that examined concurrent alcohol use (see Jones, Corbin, & Fromme, 2001). Although explicit alcohol expectancies have been proven successful in predicting future alcohol use and abuse, their assessment has been criticized on a number of methodological and conceptual grounds (Leigh, 1989). Measuring explicit alcohol expectancies requires participants to rely on introspection; however, the question remains whether participants are willing and able to articulate the underlying motivational processes of their behavior (Stacy, 1997; Wiers, van Woerden, Smulders, & De Jong, 2002; cf. Nisbett & Wilson, 1977). Consequently, several authors proposed the use of implicit or indirect measures (Stacy, 1997; cf. Greenwald & Banaji, 1995). These implicit measures do not rely on introspective awareness of ones reasons for engaging in certain behavior and are supposed to tap into more automatic underlying motivational processes (Greenwald & Banaji, 1995; Greenwald, McGhee, & Schwartz, 1998).

Recently, there has been a growing interest into the role of implicit cognitions in the development of addictive behaviors. Implicit cognitions are traces of past experience that mediate behavior in a relatively automatic fashion, whereas explicit cognitions are introspectively accessible cognitions related to more slow deliberate choices (Greenwald & Banaji, 1995; Strack & Deutsch, 2004). It is likely that both explicit and implicit alcohol-related cognitions play an important role in the development of addictive behavior, since both implicit and explicit alcohol-related cognitions have been shown to predict a unique part of the variance in current and prospective alcohol use (e.g. Jajodia & Earleywine, 2003; Stacy, 1997; Wiers et al., 2002). Moreover, implicit and explicit attitudes could originate from different sources. Implicit attitudes may be related to early and affective experiences, whereas explicit attitudes may be based more on recent events (Rudman, 2004).

Until now, research has mainly focused on the development of explicit alcohol cognitions in the early stages of alcohol consumption. It has been proposed that children may have a 'critical period' around the age of 10 in the process of developing outcome expectancies towards alcohol. Around this age, children's expectancies towards alcohol have been shown to shift from primarily negative to a primarily positive point of view (Dunn & Goldman, 1996, 1998, 2000). This bipolar shift in alcohol expectancies seems to mark the beginning of the initiation of alcohol consumption (Wiers, Gunning, & Sergeant, 1998). Later research indicated that positive and negative expectancies may develop in a more parallel fashion (Cameron, Stritzke, & Durkin, 2003). Children seem to hold both positive and negative alcohol expectancies simultaneously. When children are young, they primarily report negative alcohol expectancies although they already hold positive alcohol expectancies as well. When children grow older, they report more positive alcohol expectancies next to the negative alcohol expectancies they already had. In other words, children seem to become more ambivalent towards alcohol because of a relative increase in the activation of positive expectancies, which resulted in a balance between the activation of positive and negative expectancies (Cameron et al., 2003).

So far only few scientific attempts have been made at investigating the development of implicit alcohol-related cognitions in the early stages of alcohol consumption. However, we do know more about implicit alcohol-related cognitions once drinking alcohol has become common practice. Using an implicit memory task, implicit alcohol-related cognition uniquely predicts prospective alcohol use in high risk adolescents next to previous alcohol use, explicit cognitions and impulsive sensation seeking (Stacy, Ames, Sussman, & Dent et al., 1996). Furthermore, Wiers et al. (2002) found using the Implicit Association Task (Greenwald et al., 1998) that heavy drinking college freshmen associated alcohol more strongly with arousal than sedation, whereas light drinkers did not. Therefore, Wiers et al. (2002) have been arguing that the implicit arousal associations could represent a human equivalent of ‘incentive sensitization’ that develops with repeated alcohol and drug use (Robinson & Berridge, 1993). Consistently, alcohol expectancy research has shown that older and heavier drinking adolescents showed stronger arousal alcohol expectancies, whereas lighter drinking children showed stronger sedation alcohol expectancies (Dunn & Goldman, 1998, 2000). However, contrary to what was found in alcohol expectancy research (Dunn & Goldman, 1998, 2000), both light and heavy drinkers more strongly associated alcohol with negative than with positive outcomes. The finding that heavy drinkers hold both negative and arousal associations has been replicated (De Houwer, Crombez, Koster, & De Beul, 2004; Wiers, van de Luitgaarden, van den Wildenberg, & Smulders, 2005). Yet, the interpretation of this finding is still not entirely clear: it has been proposed that this implicit negative association with alcohol could represent negative experiences with alcohol (cf. Jones & MacMahon, 1996), cultural evaluations or salience asymmetries (Houben & Wiers, 2006; cf. Rothermund & Wentura, 2004) or a relative preference for soft drinks (De Houwer et al., 2004). Although Houben and Wiers (2006) recently showed that salience asymmetries cannot fully account for negative association with alcohol, the questions remains what these implicit negative associations with alcohol actually represent.

Given the remaining questions regarding the development of explicit cognitions and implicit alcohol-related cognitions in the early stages of alcohol consumption, it is important to measure explicit and implicit alcohol-related cognitions in the early development of alcohol consumption. Therefore, this study focused on two main questions. The first main question was what the differences would be in implicit and explicit alcohol-related cognitions between adolescents who initiated drinking (drinkers) and those who did not initiate drinking (abstainers). It was expected that drinkers and abstainers would differ in both their explicit and implicit alcohol-related cognitions. More specifically, it was hypothesized that drinkers would show stronger positive and arousal alcohol expectancies and weaker negative and sedation alcohol expectancies than abstainers (cf. Cameron et al., 2003; Dunn & Goldman 1996, 1998, 2000; Wiers et al., 1997). When one assumes that implicit associations with alcohol partly represent cultural evaluations (Houben & Wiers, 2006), one would expect that abstainers primarily hold negative associations towards alcohol given the fact that they do not have any direct experience either positive or negative with alcohol yet. Additionally, when one assumes that these implicit associations with alcohol represent experiences with alcohol (Wiers, Houben, Smulders, Conrod, & Jones, 2006; cf. Jones & MacMahon, 1996), one would expect that heavily drinking adolescents with problematic alcohol use would hold stronger negative implicit associations towards alcohol than lighter drinker adolescents. Thus, it seems as though implicit negative associations might develop according to an inverted U-shaped curve, whereas implicit positive associations with alcohol seem to develop in a positive linear relationship. It should be noted that this proposed relationship between the development of drinking and implicit associations is at this point merely theoretical. Since this study was designed to compare abstaining adolescents with (relative light) drinking adolescents, we expected that drinking adolescents would hold weaker negative associations with alcohol and stronger positive associations with alcohol than abstainers. In addition, it was hypothesized that drinkers would show stronger implicit arousal associations and weaker implicit sedation associations with alcohol than abstainers (Wiers et al., 2002). The second main question was which variables would predict prospective drinking after one year. It was hypothesized that besides grade and gender, both explicit and implicit cognitions would predict a unique part of the variance in prospective drinking. Furthermore, it was expected that implicit arousal and implicit negative associations with alcohol would positively predict prospective drinking (cf. Stacy, 1997; Wiers et al., 2002).

Given the fact that Cameron et al. (2003) showed that children can be positive and negative towards alcohol at the same time, we decided to use unipolar measures to assess alcohol-related cognitions in this study. A new measure, the unipolar Single Target Implicit Association Test (ST-IAT), was used as the implicit measure of alcohol-related cognitions. The ST-IAT is an adapted version of the IAT and has the advantage that no contrast category is used (Wigboldus, 2001, in De Houwer, 2002; Wigboldus, Holland, & van Knippenberg, submitted for publication; cf. Huijding & De Jong, 2006; Karpinski & Steinman, 2006). This measure was chosen in order to obtain single associations with alcohol instead of the relative comparison between alcohol and a contrast category (e.g. soda) which is measured with the original IAT. Moreover, this unipolar measure was used in order to measure the association between alcohol and a single attribute (e.g. positive) instead of the association with alcohol on a bipolar scale (e.g. positive vs. negative). A unipolar explicit expectancy questionnaire was used as the explicit measure of alcohol-related cognitions to be able to compare implicit and explicit alcohol-related cognitions. After one year, participants were followed up regarding their alcohol use.

## 2. Method

### 2.1. Participants

One hundred Dutch high school students (49 males) participated. Fifty-one participants were twelve years old (mean age 12.29; SD=0.46) and 49 were fifteen years old (mean age 15.53; SD=0.58). Participants were recruited from Dutch grades one and four of secondary education. These two grades were chosen based on a national health survey among high school adolescents which showed a large increase between these grades in the number of adolescent who started drinking alcohol. Participants were regarded as abstainers if they indicated that they did not drink any alcoholic beverages. Participants were regarded as drinkers if they indicated that they normally drank at least one alcoholic consumption per week (see Table 1). Drinkers drank an average of 8.36 Dutch standard alcoholic drinks per week (SD=8.97) (a standard alcohol serving in the Netherlands contains somewhat less alcohol than a standard English or American standard glass: 10 vs. 14 g). Out of the 57 drinkers, 33 (57.9%) indicated having one or more binge drinking episodes (five or more Dutch standard drinks on one occasion) in the past two weeks.

### 2.2. Material

#### 2.2.1. Alcohol use

Alcohol use was measured with a shortened version of a self-report Dutch alcohol use questionnaire (Wiers et al., 1997), based on the timeline follow-back method (Sobell & Sobell, 1990). Self-report questionnaires have been proven to be reliable and valid if the soberness of the participant and confidentiality of data is assured (Sobell & Sobell, 1990). Both requirements were fulfilled in this study. Participants indicated how many Dutch standard glasses of alcohol they normally consumed for each day of the week. Additionally, they indicated on a 6 point Likert scale on how many occasions they drank five Dutch standard glasses of alcohol or more in the past two weeks (ranging from ‘I do not drink’ to ‘seven times or more’). From these alcohol consumption measures, a quantity-frequency index was calculated (number of drinks per week) and a binge drinking index was calculated (frequency of binges per two week).

Table 1
Means and standard deviations of the explicit and implicit dependent variables and alcohol use

| | Grade 1 | | | | Grade 4 | | | |
|---|---|---|---|---|---|---|---|---|
| | Boys | | Girls | | Boys | | Girls | |
| | Abstainers | Drinkers | Abstainers | Drinkers | Abstainers | Drinkers | Abstainers | Drinkers |
| | ($N$=19) | ($N$=10) | ($N$=15) | ($N$=7) | ($N$=5) | ($N$=15) | ($N$=4) | ($N$=25) |
| Expl. pos. expec. | 3.46 | 5.01 | 4.02 | 5.47 | 4.56 | 7.17 | 4.53 | 6.92 |
| | (2.33) | (2.05) | (1.71) | (1.03) | (2.75) | (1.88) | (3.14) | (1.96) |
| Expl. neg. expec. | 4.11 | 3.88 | 4.57 | 2.61 | 2.07 | 2.14 | 4.52 | 2.22 |
| | (2.71) | (3.00) | (2.24) | (1.70) | (2.02) | (1.33) | (2.37) | (1.60) |
| Expl. aro. expec. | 5.08 | 4.81 | 5.27 | 4.49 | 3.97 | 6.29 | 6.04 | 6.50 |
| | (2.75) | (1.48) | (1.90) | (1.17) | (0.97) | (2.17) | (1.72) | (1.92) |
| Expl. sed. expec. | 3.22 | 4.36 | 2.62 | 3.21 | 4.07 | 4.45 | 3.56 | 2.56 |
| | (2.40) | (1.78) | (1.26) | (1.18) | (1.65) | (1.43) | (1.65) | (1.69) |
| Impl. pos. assoc. | −34.70 | −21.08 | −53.05 | −51.68 | −22.47 | 38.04 | −84.97 | −14.81 |
| | (136.81) | (73.56) | (118.53) | (170.47) | (122.30) | (152.29) | (100.79) | (118.91) |
| Impl. neg. assoc. | −13.55 | 47.58 | 36.88 | 43.52 | 134.85 | −11.70 | 70.94 | −12.70 |
| | (151.04) | (185.37) | (130.12) | (110.28) | (201.31) | (94.99) | (114.21) | (105.18) |
| Impl. aro. assoc. | −70.39 | 30.73 | −9.78 | −83.86 | 123.04 | 94.59 | −21.70 | 13.81 |
| | (156.21) | (166.29) | (95.14) | (98.41) | (96.42) | (126.89) | (90.71) | (102.90) |
| Impl. sed. assoc. | −16.86 | −26.05 | −72.35 | −46.42 | 67.83 | −28.62 | −71.967 | −9.40 |
| | (91.78) | (108.29) | (130.04) | (62.83) | (196.36) | (81.96) | (120.14) | (97.84) |
| Alc. use | 0 | 3.05 | 0 | 2.21 | 0 | 16.33 | 0 | 7.42 |
| | (0) | (1.64) | (0) | (1.82) | (0) | (12.14) | (0) | (6.04) |

Note. All explicit expectancy scores were average scores on an unmarked 110 mm Visual Analogue Scales; all implicit association scores were reaction time difference scores in millisecond between the incompatible and compatible block on the Single Target Implicit Association Test; Expl. pos. expec. = explicit positive expectancies; Expl. neg. expec. = explicit negative expectancies; Expl. aro. expec. = explicit arousal expectancies; Expl. sed. expec. = explicit sedation expectancies; Impl. pos. assoc. = implicit positive associations; Impl. neg. assoc. = implicit negative associations; Impl. aro. assoc. = implicit arousal associations; Impl. sed. assoc. = implicit sedation associations; Alc. use = number of standard drinks per week at T0.

### 2.2.2. Implicit measure

A new measure, the unipolar Single Target Implicit Association Test (ST-IAT) was used as the implicit measure of alcohol-related cognitions. The single target IAT (ST-IAT) is a new variant of the IAT (Greenwald et al., 1998) that does not require the use of target contrast category (in case of alcohol often soft-drinks).

In the ST-IAT, participants categorized words as quickly as possible without making too many mistakes into different categories by pressing a left or right response-button. The test consisted of four blocks: the attribute discrimination block, the combination block, the reversed attribute discrimination block and the reversed combination block (see Fig. 1). During the attribute discrimination block and the reversed attribute discrimination block, participant categorize stimulus words into one attribute category (e.g. positive) or the other (e.g. neutral). During the combination and reversed combination block, the target category (e.g. alcohol) is paired with one of the attributes (i.e. positive or neutral). For someone who has a very strong association between the target (e.g. alcohol) and one of the attribute categories (e.g. positive), the compatible combination block (alcohol and positive on the same side) will be significantly easier than the incompatible reversed combination block (alcohol and positive on different sides). The difference score between the reaction times of these two combined blocks is the so-called IAT-effect and gives an indication of strength of the association

| | Block 1 AD | Block 2 C | Block 3 RAD | Block 4 RC |
|---|---|---|---|---|
| Positive ST-IAT | Positive – Neutral | Positive – Neutral<br>Alcohol | Neutral – Positive | Neutral – Positive<br>Alcohol |
| Negative ST- IAT | Negative – Neutral | Negative – Neutral<br>Alcohol | Neutral – Negative | Neutral – Negative<br>Alcohol |
| Arousal ST- IAT | Arousal – Neutral | Arousal – Neutral<br>Alcohol | Neutral – Arousal | Neutral – Arousal<br>Alcohol |
| Sedation ST- IAT | Sedation – Neutral | Sedation – Neutral<br>Alcohol | Neutral – Sedation | Neutral – Sedation<br>Alcohol |

Fig. 1. Schematic overview of the block sequence in the four Single Target–Implicit Association Tests. AD = attribute discrimination, C = combination, RAD = reversed attribute discrimination, RC = reversed combination.

between target (e.g. alcohol) and the attribute (e.g. positive) (Greenwald et al., 1998). Thus, a larger IAT-effect indicates a stronger association between the target (e.g. alcohol) and the attribute (e.g. positive).

In this study four ST-IATs (alcohol-positive, alcohol-negative, alcohol-arousal, alcohol-sedation) were used in balanced order. The ST-IATs were programmed in ERTS 3.18 (Beringer, 1996). Words were presented in black small font (14-point) in the middle of the screen. Feedback appeared in red mid font letters (16-point) 1 inch below the stimuli words. The category words were always presented at the top of the screen, appropriately positioned on the left or the right side of the screen, depending on the required response. The words used (see Appendix) were matched on number of letters, syllables, familiarity, and on valence and arousal values. In total, these four ST-IATs consisted of 16 blocks; each consisted of two attribute discrimination blocks and two combined blocks. Each attribute discrimination block consisted of 24 trials and each combined block consisted of 48 trials. The interstimulus interval was 250 ms. Words were selected randomly for each participant. The internal consistency of each of these four ST-IATs was acceptable (see Table 2).

The D-2SD penalty score for practice and test was chosen as the main reaction time measure, because Greenwald, Nosek and Banaji (2003) recently recommended using a new "D-algorithm" that includes all trials (including the practice phases), gives an error-penalty to the reaction times on erroneous responses, and divides the outcome with a personalized SD of the combination phases. This particular D-measure was chosen, because in the calculation of the recommended new algorithm score a standard deviation of 300 ms is assumed (Greenwald et al., 2003) and at this point there is no information available to determine whether this is a plausible assumption when testing adolescents. Following the recommendation of Greenwald et al. (2003), the effects are calculated with the D-measure, but in Table 1 the IAT effects are given in ms. Main outcomes were also calculated with the original scoring algorithm and the pattern of results was the same.

*2.2.3. Explicit measure*

The explicit measure of alcohol-related cognitions was a 24 unipolar item questionnaire representing an explicit version of the exact same words as used in the implicit tests (cf. Wiers et al. 2002, 2005). Each

Table 2
Pearson correlation and Cronbach alphas for implicit and explicit cognition and alcohol use

| | No. of items | α | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Expl. pos. expec. | 6 | .87 | – | | | | | | | | | |
| 2. Expl neg. expec. | 6 | .59 | .43** | – | | | | | | | | |
| 3. Expl. aro. expec. | 4 | .81 | .34** | .15 | – | | | | | | | |
| 4. Expl. sed. expec. | 4 | .55 | −.04 | .16 | −.22* | – | | | | | | |
| 5. Impl. pos. assoc. | 2 | .51 | .11 | −.10 | .04 | −.05 | – | | | | | |
| 6. Impl. neg. assoc. | 2 | .52 | −.08 | −.02 | −.09 | .09 | −.09 | – | | | | |
| 7. Impl aro. assoc. | 2 | .46 | .16 | .03 | .13 | .04 | .16 | −.03 | – | | | |
| 8. Impl sed. assoc. | 2 | .43 | −.02 | −.01 | −.06 | .20 | .15 | .10 | .07 | – | | |
| 9. Alcohol use T0 | 7 | .63 | .53** | −.33** | .22* | .04 | .25* | −.08 | .26* | .06 | – | |
| 10. Alcohol use T1 | 7 | .55 | .46** | −.27* | .18 | .07 | .22 | −.07 | .30** | .16 | .79** | – |

Note. All explicit expectancy scores were average scores on an unmarked 110 mm Visual Analogue Scales; all implicit association scores were D-2SD reaction time scores on the Single Target Implicit Association Test; Expl. pos. expec. = explicit positive expectancies; Expl. neg. expec. = explicit negative expectancies; Expl. aro. expec. = explicit arousal expectancies; Expl. sed. expec. = explicit sedation expectancies; Impl. pos. assoc. = implicit positive associations; Impl. neg. assoc. = implicit negative associations; Impl. aro. assoc. = implicit arousal associations; Impl. sed. assoc. = implicit sedation associations; Alcohol use T0 = combined number of standard drinks for each day of the week at T0; Alcohol use T1 = combined number of standard drinks for each day of the week after one year T1.
*$p<.05$, two-tailed. **$p<.01$, two-tailed.

item consisted of a statement on drinking alcohol (for example: 'drinking alcohol makes me feel energetic'). Participants indicated the extent to which they (dis)agreed with each item on a 110 mm unmarked Visual Analog Scale (VAS). The questionnaire consisted of four scales: a positive, a negative, an arousal and a sedation scale. The internal consistency of the positive and negative scale was acceptable (see Table 2). After removing two deviating items from the arousal and sedation scale, the internal consistency of these scales was moderate (see Table 2).

## 2.3. Procedure

After this study was approved by the ethical committee of the research institute, participants were recruited. After active consent from participants and parents, participants were tested individually at school in a separate test room during school time. After a short introduction, the ST-IATs were administered on a laptop with a separate response device. The four ST-IATs consisted of a total of 16 blocks with a short break after the 8th block. The instructions were given on the computer screen preceding each task. Throughout the trails, participants received feedback on their screen in red letters (incorrect response: "ERROR", <300 ms: TOO SLOW', >3000 ms: 'TOO FAST'). After each block, the participants received feedback on their performance in the form of average reaction times and errors. The total task required approximately 15 min. The implicit measure was administered before the explicit measure, because of possible carry-over effects which are stronger when the explicit test is administered first (Bosson, Swann, & Pennebaker, 2000). Subsequently, the participants filled out the explicit measure of alcohol related-cognitions. The alcohol use questionnaire was administered last, in order to avoid any interference between having to report ones alcohol use and the measures of implicit and explicit alcohol-related cognitions. The total experiment took approximately 25 min for each participant, after which the participant received their monetary incentive (€2.50). Approximately one year later, the participants received a letter on their home address with the question to fill out the enclosed alcohol use questionnaire. The confidentiality of the data was guaranteed. Participants were requested to return the filled out questionnaire with an enclosed prepaid envelop within one week to receive an additional reward (€5voucher). Eighty one of the 100 participants returned a filled out follow up alcohol use questionnaire. The 19 non-responders scored somewhat higher on the binge-drinking index than the 81 responders at baseline, $t\ (22.52) = -1.88$, $p = .07$.

## 3. Results

This study focused on two main questions. The first question concerned the difference in explicit and implicit alcohol-related cognitions between abstainers and drinkers (cross-sectional). The second question concerned which factors in drinkers predicted their prospective drinking behavior after one year. The initial alpha level was set at .05 for all analyses. This decision was made to ensure an optimal trade-off between completeness (not leaving out possibly interesting effects) and the correctness (restricting Type-II error) given the exploratory nature of the data. However, it should be noted that especially borderline significant effects need to be interpreted with caution given the fact that multiple testing leads to a larger chance at a Type II error.

### *3.1. Difference in alcohol-related cognitions between abstainers and drinkers (cross-sectional)*

#### *3.1.1. Explicit measures*

*Positive expectancies*. A 2 (Drinker) × 2 (Gender) × 2 (Grade) ANOVA for positive alcohol expectancies revealed a significant effect for Grade ($F(3, 96) = 9.28$, $p < .001$) and Drinker ($F(3, 96) = 15.87$, $p < .001$). Fifteen year olds generally had stronger positive alcohol expectancies than twelve year olds ($t(98) = -5.44$, $p < .001$) and drinkers generally had stronger positive alcohol expectancies than abstainers ($t(98) = -6.10$, $p < .001$) (see Table 1).

*Negative expectancies*. A 2 (Drinker) × 2 (Gender) × 2 (Grade) ANOVA for negative alcohol expectancies revealed a significant Gender × Drinker interaction effect ($F(6, 93) = 4.04$, $p < .05$). Only among girls, drinkers and abstainers significantly differed from each other ($t(29.38) = 3.89$, $p < .001$). Female abstainers had stronger negative alcohol expectancies than female drinkers (see Table 1).

*Arousal expectancies*. A 2 (Drinker) × 2 (Gender) × 2 (Grade) ANOVA for arousal alcohol expectancies revealed a significant Grade × Drinker interaction effect ($F(6, 93) = 4.13$, $p < .05$). Only among fifteen year olds, drinkers and abstainers significantly differed ($F(1, 47) = 4.58$, $p < .05$). Fifteen year old drinkers had stronger arousal alcohol expectancies than fifteen year old abstainers (see Table 1).

*Sedation expectancies.* A 2 (Drinker) × 2 (Gender) × 2 (Grade) ANOVA for sedating alcohol expectancies revealed a significant Gender effect ($F(3, 96) = 12.06$, $p < .01$). Boys generally had stronger sedating alcohol expectancies than girls ($t(89.59) = 3.33$, $p < .01$) (see Table 1).

#### *3.1.2. Implicit measures*

The average overall percentage of errors made on the ST-IAT was 17. 69% (SD = 8.51). This number is relatively high, but could be explained by the fact that this task still is relatively difficult for young adolescents. To determine if every participant should be included for further analysis, we used 3 different criteria: the average overall percentage of errors, the percentage of responses under 300 ms and the percentage of responses over 10,000 ms (Greenwald et al., 2003). In total 3 participants were excluded from further analysis because they exceeded at least one of these criteria with more than 2 SDs.

*Implicit positive associations.* A 2 (Drinker) × 2 (Gender) × 2 (Grade) ANOVA for implicit positive associations with alcohol revealed a significant Grade × Drinker interaction effect ($F(3, 96) = 4.85$, $p < .05$). Only among fifteen year olds, drinkers and abstainers significantly differed in their implicit positive cognitions towards alcohol ($F(1, 46) = 5.19$, $p < .05$). Fifteen year old drinkers had stronger implicit positive associations with alcohol than fifteen year old abstainers (see Table 1). Fifteen year old drinkers showed a significant ST-IAT effect associating alcohol more strongly with positive than neutral attributes ($t(14) = 2.16$, $p < .05$).

*Implicit negative associations.* A 2 (Drinker) × 2 (Gender) × 2 (Grade) ANOVA for implicit negative associations revealed a significant Grade × Drinker interaction effect ($F(6, 90) = 4.19$, $p < .05$). Only among fifteen year olds, drinkers and abstainers significantly differed in their implicit negative cognitions towards alcohol ($F(1, 46) = 7.98$, $p < .01$). Fifteen year old abstainers had stronger implicit negative associations with alcohol than fifteen year old drinkers (see Table 1). Fifteen year old abstainers showed a borderline significant ST-IAT effect associating alcohol more strongly with negative than neutral attributes ($t(8) = 2.15$, $p = .06$).

*Implicit arousal associations.* A 2 (Drinker) × 2 (Gender) × 2 (Grade) ANOVA for implicit arousal associations with alcohol revealed a borderline significant Grade × Gender × Drinker interaction effect ($F(7, 89) = 3.89$, $p = .05$). A 2 (Drinker) × 2 (Gender) ANOVA only revealed a significant Gender × Drinker interaction effect for implicit arousal associations among twelve year olds ($F(3, 45) = 7.30$, $p < .05$). Only among the twelve year olds, boys and girls differed significantly in their alcohol-arousal associations.

Table 3
Summary of multivariate regression analysis for variables predicting binge drinking after one year ($N = 77$)

| | Cumulative | | Simultaneous | | |
|---|---|---|---|---|---|
| Variable | $R^2$ | $\Delta R^2$ | $B$ | SE B | $\beta$ |
| Grade | | | 0.38 | 0.16 | .25* |
| Gender | .25 | | −0.40 | 0.41 | −.25 |
| Expl. pos. expec. | | | 0.04 | 0.04 | .11 |
| Expl. neg. expec. | | | −0.10 | 0.04 | −.28** |
| Expl. aro. expec. | | | −0.02 | 0.05 | −.05 |
| Expl. sed. expec. | .32 | .07 | 0.06 | 0.04 | .14 |
| Impl. pos. assoc. | | | 0.60 | 0.18 | .43** |
| Impl. neg. assoc. | | | 0.04 | 0.23 | .02 |
| Impl. aro. assoc. | | | 0.86 | 0.30 | .53** |
| Impl. sed. assoc. | .42 | .10* | −0.17 | 0.14 | −.10 |
| Grade × Impl. neg. assoc. | | | −1.80 | 0.42 | −.67** |
| Gender × Impl. pos. assoc. | | | −0.50 | 0.25 | −.26 |
| Gender × Impl. neg. assoc. | | | 0.03 | 0.31 | .02 |
| Gender × Impl. aro. assoc. | | | −0.46 | 0.34 | −.24 |
| Gender × Expl. aro. expec. | | | 0.11 | 0.07 | .46 |
| Grade × Gender × Impl. neg. assoc. | .63 | .21** | 2.22 | 0.55 | .66** |

Note. $R^2$ and $\Delta R^2$ are from hierarchical models in which preceding effects were entered first; the B, SE B and $\beta$ are from a simultaneous model. Expl. pos. expec. = explicit positive expectancies; Expl. neg. expec. = explicit negative expectancies; Expl. aro. expec. = explicit arousal expectancies; Expl. sed. expec. = explicit sedation expectancies; Impl. pos. assoc. = implicit positive associations; Impl. neg. assoc. = implicit negative associations; Impl. aro. assoc. = implicit arousal associations; Impl. sed. assoc. = implicit sedation associations.
*$p < .05$ **$p < .01$.

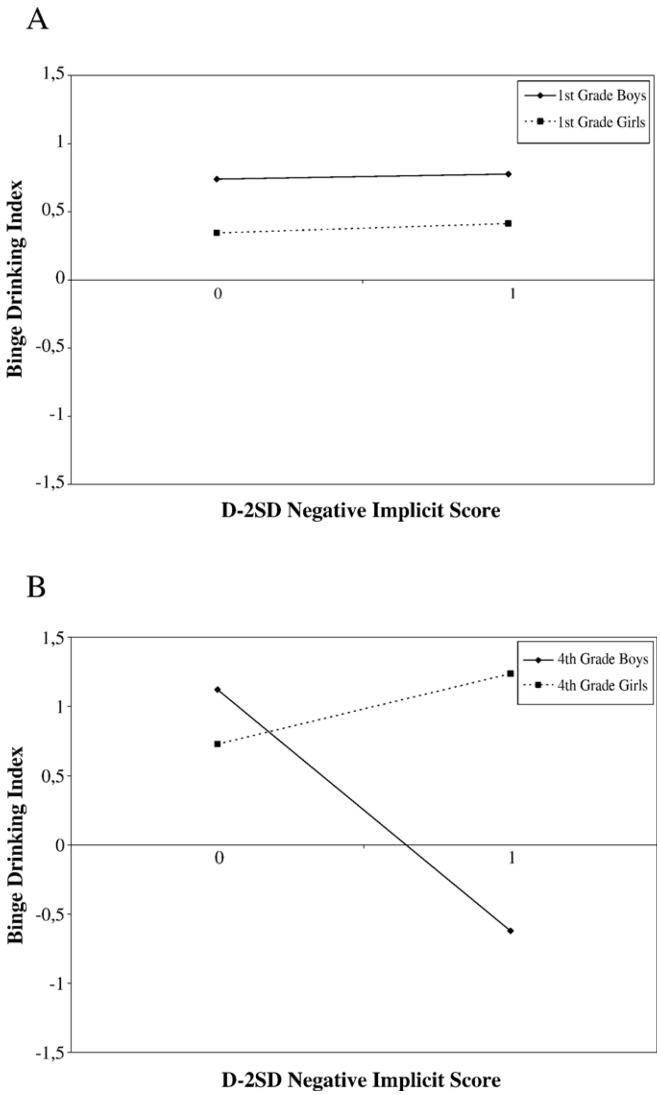


Fig. 2. Implicit negative associations predict prospective binge drinking in interaction with grade and gender. The binge drinking index represents on how many occasions five glasses of alcohol or more were consumed in the past two weeks (ranging from 0 = 'I do not drink' to 6 = 'seven times or more'). The D-2SD implicit negative score represents a standardized difference score between the reaction times in the combination and the reversed combination block. A D-2SD implicit negative score of 0 indicates an absent negative association with alcohol as compared with neutral, whereas a D-2SD implicit negative score of one indicates a strong negative association with alcohol compared with neutral. Fig. 2A indicates that in the first grade implicit negative alcohol associations are not related to prospective binge drinking. To the contrary, Fig. 2B indicates that in the fourth grade stronger negative alcohol associations negatively predict prospective binge drinking in boys but not in girls.

Among twelve year old boys, drinkers significantly differed from abstainers ($F(1, 26) = 4.345$, $p < .05$). Twelve year old drinking boys did associate alcohol more strongly with arousal than twelve year old abstaining boys (see Table 1). However, among twelve year old girls, drinkers differed from abstainers at borderline significance ($F(1, 21)=3.08$, $p=.10$). Contrary to twelve year old boys, twelve year old female drinkers had a tendency to have weaker arousal associations with alcohol than twelve year old female abstainers (see Table 1).

*Implicit sedation associations.* A 2 (Drinker)×2 (Gender)×2 (Grade) ANOVA for implicit sedation associations with alcohol revealed a significant Gender×Drinker interaction effect ($F(3, 96)=3.36$, $p=.07$). Only among girls, drinkers differed from abstainers at borderline significance ($F(1, 48)=3.38$, $p=.07$). Female drinkers had stronger implicit sedation associations with alcohol than female abstainers (see Table 1). Female drinkers did not show a significant ST-IAT effect for implicit sedation association with alcohol.

### *3.2. Factors predicting prospective drinking behavior after one year*

The same three participants were excluded from the analysis because they exceeded at least one of the set criteria with more than 2 SDs. In addition, one other participant was excluded from the regression analysis (Cook's distance>1). We chose to use prospective binge drinking after one year as dependent variable, given the fact that adolescent binge drinking causes severe damage and long term consequences in the adolescent brain (e.g., Crews, Braun, Hoplight, Switzer, & Knapp, 2000; White, Ghia, Levin, & Swartzwelder, 2000) and that binge drinking had a more normal distribution than other drinking variables. We decided not to conduct a logistic regression predicting binge drinking after one year, because of the loss of relevant information regarding the amount of binging and the relative small number of participants included in the analysis. Instead, a stepwise hierarchical procedure was used for the multiple regression analysis. In Step 1, gender and grade were entered as background variables into the regression equation. In Step 2, the four explicit measures were added to the regression model. In Step 3, the four implicit

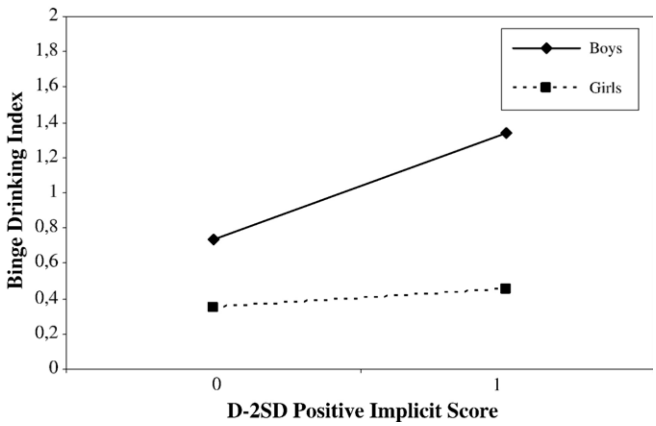


Fig. 3. Implicit positive associations predict prospective binge drinking in interaction with gender. The binge drinking index represents on how many occasions five glasses of alcohol or more were consumed in the past two weeks (ranging from 0='I do not drink' to 6='seven times or more'). The D-2SD implicit positive score represents a standardized difference score between the reaction times in the combination and the reversed combination block. A D-2SD implicit positive score of zero indicates an absent positive association with alcohol as compared with neutral, whereas a D-2SD implicit positive score of one indicates a strong negative association with alcohol compared with neutral. As is shown, stronger implicit positive alcohol associations positively predict prospective binge drinking in boys but not in girls.

measures were added to the regression. In Step 4 all two-way and three-way interaction were added. To obtain the final model, all three-way interactions with a $p$ value above .30 were removed from the regression equation. Subsequently, all the two-way interactions with a $p$ value above the .30 were excluded from further analysis. By using this procedure an optimal trade-off between power (including all interactions reduces power) and the completeness (not leaving out important interactions) was ensured. The final model is represented in Table 3.

The hierarchical regression model revealed that the implicit measures (as a group) significantly added to the prospective prediction of binge drinking ($\Delta R^2=.10$, $p=.04$), whereas the explicit measures (as a group) did not ($\Delta R^2=.07$, $p=.14$) (see Table 3). Furthermore, the final model revealed that grade, explicit negative alcohol expectancies, implicit positive associations and implicit arousal association significantly predicted binge drinking after one year (see Table 3). Additionally, the three-way interaction between grade, gender and implicit negative alcohol associations predicted binge drinking after one year significantly (see Table 3). Follow-up analyses indicated that with increasingly stronger negative implicit alcohol associations fourth grade boys engaged in less binge drinking, whereas fourth grade girls did not. No such interaction effect was found in the first grade (see Fig. 2). Finally, it must be noted that the interaction between gender and positive alcohol associations was borderline significant ($t(60)=-2.00$, $p=.05$). With increasingly strong positive implicit associations with alcohol, boys displayed a stronger increase in binge drinking compared to girls (see Fig. 3).

Table 4
Summary of multivariate regression analysis for variables predicting binge drinking after one year ($N=77$)

| | Cumulative | | Simultaneous | | |
|---|---|---|---|---|---|
| Variable | $R^2$ | $\Delta R^2$ | $B$ | SE B | $\beta$ |
| Baseline binge drinking | | | 0.16 | 0.09 | .18 |
| Grade | | | 0.34 | 0.16 | .22* |
| Gender | .40** | | −0.41 | 0.40 | −.26 |
| Expl. pos. expec. | | | 0.02 | 0.04 | .05 |
| Expl. neg. expec. | | | −0.09 | 0.04 | −.25* |
| Expl. aro. expec. | | | −0.02 | 0.49 | −.05 |
| Expl. sed. expec. | .42 | .02 | 0.06 | 0.04 | .13 |
| Impl. pos. assoc. | | | 0.51 | 0.18 | .36** |
| Impl. neg. assoc. | | | 0.01 | 0.22 | .01 |
| Impl. aro. assoc. | | | 0.75 | 0.30 | .46* |
| Impl. sed. assoc. | .47 | .06 | −0.17 | 0.14 | −.11 |
| Grade × Impl. neg. assoc. | | | −1.60 | 0.43 | −.60** |
| Gender × Impl. pos. assoc. | | | −0.39 | 0.25 | −.20 |
| Gender × Impl. neg. assoc. | | | 0.12 | 0.31 | .06 |
| Gender × Impl. aro. assoc. | | | −0.37 | 0.33 | −.20 |
| Gender × Expl. aro. expec. | | | 0.11 | 0.07 | .48 |
| Grade × Gender × Impl. neg. assoc. | .64 | .16** | 1.96 | 0.57 | .57** |

Note. $R^2$ and $\Delta R^2$ are from hierarchical models in which preceding effects were entered first; the $B$, SE B and $\beta$ are from a simultaneous model. Expl. pos. expec. = explicit positive expectancies; Expl. neg. expec. = explicit negative expectancies; Expl. aro. expec. = explicit arousal expectancies; Expl. sed. expec. = explicit sedation expectancies; Impl. pos. assoc. = implicit positive associations; Impl. neg. assoc. = implicit negative associations; Impl. aro. assoc. = implicit arousal associations; Impl. sed. assoc. = implicit sedation associations.
$*p<.05$ $**p<.01$.

Additionally, the longitudinal analysis was repeated controlling for baseline binge drinking. Generally the pattern of results remained the same, although the implicit measures did not significantly add to the prediction of prospective binge drinking (see Table 4), which is not surprising, given the limited power of this analysis. Note that it is a different question whether the change in binge drinking can be predicted by implicit and explicit alcohol-related cognitions or binge drinking itself can be predicted by implicit and explicit alcohol-related cognitions. The question that we primarily tried to answer in this study was which cognitive processes might underlie prospective binge drinking. Therefore it seemed most relevant to focus on cognitive factors predicted prospective binge drinking.

## 4. Discussion

This study focused on two main questions. The first question concerned the (cross-sectional) difference in explicit and implicit alcohol-related cognitions between abstainers and drinkers. It was found that higher grade and heavier drinking were associated with stronger implicit and explicit positive alcohol-related cognitions, weaker implicit negative alcohol-related cognitions and stronger explicit arousal alcohol-related cognitions. For other alcohol-related cognitions, interactions were found between gender and drinking-status (explicit negative alcohol-related cognitions, implicit arousal alcohol-related cognitions and implicit and explicit sedation alcohol-related cognitions). The second question concerned which factors predicted binge drinking after one year. The hierarchical regression analyses revealed that overall the implicit measures significantly added to the prediction of binge drinking after one year, whereas the explicit measures (as a group) did not. However, the final regression model revealed that explicit negative alcohol expectancies next to grade and implicit arousal associations predicted binge drinking after one year. Additionally, a three-way interaction between grade, gender and negative implicit associations significantly predicted binge drinking after one year. Noteworthy, a two-way interaction between gender and implicit positive associations predicted prospective binge drinking at borderline significance.

Concerning the first question, the results on the explicit measures are generally in line with what was found in previous research (Cameron et al., 2003; Dunn & Goldman, 1996, 1998, 2000). Subsequently, although it appears that the implicit measures follow the pattern of the explicit measure, there is an important difference. Only in implicit arousal associations a difference between young drinking boys and young abstaining boys was found. Since this was the only difference found in the young age group, this might indicate that young drinking boys consume alcohol because of associated arousal effects. Furthermore, these young male drinkers might be guided implicitly by these arousal associations with alcohol in their future drinking behavior. Indeed, the results showed that implicit arousal associations significantly predicted prospective binge drinking, but this was not specific for boys.

Concerning the second question, the role of explicit alcohol expectancies in predicting binge drinking after one year may be different and smaller than previously was assumed. First, the role of explicit alcohol expectancies may be smaller, because the hierarchical regression model revealed that overall the explicit measures as a group did not add significantly to the prediction of binge drinking after one year. Additionally, the role of explicit alcohol expectancies may be different, because rather than positive or arousal alcohol expectancies (Dunn & Goldman, 1996, 1998, 2000), negative alcohol expectancies significantly predicted binge drinking after one year in the final regression model. This is in line with the notion that negative expectancies play a vital role in the preventive approach of affecting current and future drinking (Jones et al., 2001). Moreover, the results show that implicit alcohol associations are important in the early development of drinking. The hierarchical regression model revealed that the implicit measures significantly added to the prediction of binge drinking after one year when controlling for gender, grade and explicit expectancies. This is consistent with previous research on the influence of implicit and explicit alcohol cognitions in older adolescents (Stacy et al., 1996).

In addition, one conclusion is that the influence of implicit alcohol-related valence associations on subsequent drinking behavior seems to be dependent of factors like gender and grade; a three-way interaction between grade, gender and negative implicit associations (and a two-way interaction between gender and implicit positive associations at borderline significance) predicted binge drinking after one year. To the contrary, implicit alcohol arousal associations and explicit negative alcohol expectancies seem to influence drinking behavior more generally across ages and gender as the final regression model showed. Although the general nature of the predictive value of implicit arousal associations and explicit negative alcohol expectancies are similar to previous research with adults (Jones et al., 2001; Wiers et al., 2002), it is noteworthy that these effects are already so apparent in adolescent drinkers who do not have a long history of alcohol (ab)use and alcohol-related problems. These findings seem to be in line with neurobiological models of addiction (e.g. Di Chiara, 2000; Robinson & Berridge, 1993), which suggest that the effect of incentive motivation processes might already be important in the early development of addictive behaviors. Furthermore, the fact that both implicit negative and implicit positive associations seem to have an influence on prospective drinking behavior may be different from results previously found with bipolar measures (Wiers et al., 2002, 2005), and could indicate that measuring alcohol-related cognitions in a unipolar fashion is a good idea (cf. Houben & Wiers, 2006).

However, given a number of limitations, these results should be interpreted with some caution. First, it is complicated to come to any firm conclusions about the relative role of grade (or age) and drinking status, given that these variables are naturally confounded. A second limitation in this study might be that a new measure was used which was based on the IAT. Currently, some authors question the validity of the IAT (e.g. De Houwer, 2001; Rothermund & Wentura, 2004). It has been proposed that participants performing the IAT may recode the stimuli based on other features than the associations the IAT intends to measure. Participants may sometimes select one 'yes'- or 'figure'-category and one 'no'- or '(back-)ground'-category based on salience. This is referred to as the so-called figure ground asymmetry (Rothermund & Wentura, 2004). The figure ground asymmetry could play a role in tasks such as the unipolar ST-IAT. However, research indicated that this figure ground asymmetry cannot fully explain all results that were found with unipolar alcohol-IATs similar to the ones used here (Houben & Wiers, 2006). Third, some of the measures that were used showed a somewhat lower reliability than expected. The internal consistencies of the explicit arousal and sedation expectancy scales were somewhat lower than the positive and negative expectancy scales. This could be due to the relative difficulty in finding alcohol expectancy words that are high on arousal or sedation, but are neutral on the valence dimension. Consequently, on average the arousal and sedation expectancy scale were high on arousal or sedation and neutral on the valence dimension, but contained arousal and sedation items that were slightly more positive or negative than neutral. Recently, it has been suggested that alcohol cognition research should consider mapping alcohol-related cognitions along the lines of the combined categories of positive arousal and positive sedation because pure arousal or sedation items which are neutral on valence seem hard to find (cf. Lang, 1995). Additionally, the internal consistency of the unipolar ST-IAT seems to be lower than the previously reported reliability of the bipolar alcohol-IAT (Wiers et al., 2002, 2005). However, the reported internal consistency of unipolar measures seem to be comparable or better than most other implicit measures (see Houben & Wiers, 2006).

Although these limitations must be taken into consideration when interpreting the results, this study does provide additional information for the role of alcohol-related cognitions in the early development of drinking alcohol. For several reasons these insights are useful for developing new prevention and intervention methods. First, assessing implicit next to explicit alcohol-related cognitions is important because existing interventions may differentially influence implicit and explicit cognitions (Wiers et al., 2005; cf. Teachman & Woody, 2003). Second, besides focusing on explicit alcohol-related cognition new interventions could target implicit alcohol-related as well. For instance, alcohol intervention and prevention could focus more on minimizing the influence of hazardous implicit alcohol associations (such as arousal associations). It has been proposed that minimizing the influence of implicit associations that enhance drinking could be obtained by alteration of these fast implicit automatic reactions and/or strengthening of more explicit controlled reactions (Wiers, De Jong, Havermans, & Jelicic, 2004).

Summarizing, both explicit and implicit alcohol-related cognitions seem to influence drinking behavior in young adolescents. The role of implicit alcohol-related cognitions even may be more important than previously assumed. Moreover, interventions may have a differential influence on implicit and explicit cognitions. Therefore, it seems essential that implicit alcohol-related cognitions are taken into account when prevention and intervention methods are being developed. This can be achieved by either the alteration of these fast implicit automatic reactions or strengthening the more explicit controlled reactions. Future research has to indicate if these methods can be included as proven effective components in prevention and intervention programs.

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## Appendix A

ST-IAT stimuli (translated from Dutch)

| |
|---|
| *Alcohol Stimuli:* wine, bacardi, whisky, heineken, hoegaarden, amstel |
| *Positive Stimuli:* positive (label), happy, sociable, nice, pleasant, likeable, cosy |
| *Neutral Stimuli:* neutral (label), daily, steep, related, wide, usual, flat |
| *Negative Stimuli:* negative (label), unhappy, lonely, moody, sad, rude, gloomy |
| *Neutral Stimuli:* neutral (label), massive, normal, totally, recent, extensive, square |
| *Arousal Stimuli:* active (label), talkative, jovial, restless, alert, unrestrained, rambunctious |
| *Neutral Stimuli:* neutral (label), constant, historical, oval, central, blue, digital |
| *Sedation Stimuli:* passive (label), silent, listless, sleepy, quiet, relaxed, calm |
| *Neutral Stimuli:* neutral (label), direct, common, different, compact, attached, brown |

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