RUNNING HEAD: IMPLICIT WANTING AND LIKING

Heavy social drinkers score higher on implicit wanting and liking for alcohol than alcohol-dependent patients and light social drinkers

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Abstract

Background and Objectives: Automatic hedonic ("liking") and incentive ("wanting") processes are assumed to play an important role in addiction. Whereas some neurobiological theories suggest that these processes become dissociated when drug use develops into an addiction (i.e., "liking" becomes weaker, whereas "wanting" becomes exaggerated; e.g., Robinson & Berridge, 1993), other theories suggest that there is a linear relationship between these two processes (i.e., both "liking" and "wanting" increase equally; e.g., Koob & Le Moal, 1997). Our aim was to examine “wanting” and “liking” in three groups of participants: alcohol-dependent patients, heavy social drinkers, and light social drinkers. **Methods:** Participants performed two different single target implicit association tests (ST-IATs; e.g., Bluemke & Friese, 2007) and explicit ratings that were designed to measure "liking" and "wanting" for alcohol. **Results:** Our results are in sharp contrast with the theories of both Robinson and Berridge and Koob and LeMoal: heavy drinkers had higher scores than light drinkers and alcohol-dependent patients on both the wanting ST-IAT and the liking ST-IAT. There were no differences between alcohol-dependent patients and light drinkers. Explicit ratings mirrored these results. **Limitations:** These findings suggest that our ST-IATs are not valid measures of “wanting” and “liking”. Instead, they might assess more complex knowledge regarding participants’ experiences and goals. **Conclusions:** These findings suggest that the relationship between drug consumption and appetitive drug associations is not linear, highlighting the importance of testing both sub-clinical and clinical samples in future research.

Keywords: Alcoholism; Implicit measures; Wanting; Liking; Incentive Sensitization; Addiction

1. Introduction

Like many other psychopathologies, drug addiction has a paradoxical character. On the one hand, addicts have sufficient declarative knowledge about the relationship between alcohol misuse and the negative consequences it has regarding their health, their relationships, and their professional activities. On the other hand, they continue to pursue and use drugs in spite of these negative consequences. Where does this irrational motivation to behave in such a destructive manner originate from?

Several theories postulate that automatic (i.e., uncontrolled, unintentional, independent of goals, stimulus driven, unconscious, efficient, and fast; e.g., Moors & De Houwer, 2006) processes play a role in the development and maintenance of addiction. For instance, Incentive Sensitization Theory (IST; e.g., Robinson & Berridge, 2003; 2008) makes specific predictions about different types of automatic processes in addiction. ISTs main hypothesis is that the driving force in substance abuse is "wanting" and not "liking". Whereas "liking" (i.e., the automatic, unconscious hedonic impact of consuming a drug) diminishes after repeated drug use, "wanting" (i.e., the automatic, unconscious attribution of incentive salience to drug cues) becomes exaggerated due to exaggerated activation (sensitization) in specific dopamine systems. On the basis of this theory, we can make several predictions regarding "wanting" and "liking" in drug users. First, we expect that infrequent drug users experience both "wanting" and "liking", whereas full-blown addiction is characterized by a complete dissociation between "wanting" and "liking": drugs are no longer "liked", but highly "wanted". Frequent drug users who do not (yet) suffer from addiction would already experience a less pronounced dissociation between "wanting" and "liking". In contrast, Koob and Le Moal (e.g., 1997; 2001) postulated different roles for motivation and hedonism. Rather than hypothesizing a dissociation, they suggested that hedonic impact and reward go hand in hand: "liking" and "wanting" are weak in infrequent substance users, and both processes

become stronger in frequent substance users. In addicts, both processes are at their highest intensity. Surprisingly, empirical studies that examine these hypotheses are lacking. The main aim of our study was therefore to examine automatic hedonic and incentive processes in three groups of drinkers: light and heavy social drinkers, and alcohol-dependent patients. We assumed that this comparison could yield important insights into the differential role of automatic processes in substance use and substance *dependence*.

But how does one measure hedonic and motivational processes in addiction? Because of the automatic nature of these processes, researchers have turned to using so-called implicit measures. An implicit measure can be defined as the outcome of a measurement procedure that is caused by the to-be-measured-attribute automatically (De Houwer, Teige-Mocigemba, Spruyt, & Moors, 2009). The most well-known and widely-used measurement procedure in the context of research on implicit attitudes is the Implicit Association Test (IAT; Greenwald, McGhee, & Schwarz, 1998), a task that is assumed to capture associations between target (e.g., "alcohol" versus "soda") and attribute concepts (e.g., "good" versus "bad"). In a seminal study, Wiers, Van Woerden, Smulders, and De Jong (2002) used two different IATs: a valence IAT (in which the association between the two targets "alcohol" or "soda" and the two attributes "positive" and "negative" were examined); and an arousal IAT (in which the targets were the same, but the attributes were "active" and "passive") to measure hedonic and incentive processes respectively. Wiers and colleagues found that heavy drinkers had positive alcohol arousal associations (i.e., positive "wanting") but negative alcohol valence associations (i.e., negative "liking") whereas light drinkers had negative scores on both tasks. The authors interpreted this as evidence for Incentive Sensitization Theory. De Houwer, Crombez, Koster, and De Beul (2004) corroborated these findings and showed that, just like heavy social drinkers, alcohol dependent patients showed negative alcohol associations and positive alcohol arousal associations. However, contrasting findings have been reported as

well (e.g., Wiers, Houben, & De Kraker, 2007; Van den Wildenberg, Beckers, Van Lambaart, Conrod & Wiers, 2006).

The mixed nature of the available evidence could be related to methodological issues. First, the IATs discussed above are relative measures, in the sense that commonly, attitudes toward alcohol in comparison to sodas are measured. Theoretical predictions, however, are non-relative (i.e., "wanting" and "liking" of alcohol as such). Furthermore, research has shown that the type of contrast category (e.g., "alcohol" versus "soft drink" or "alcohol" versus "animals") can affect the data pattern (e.g., Houben & Wiers, 2006). Luckily, non-relative implicit measures exist. For instance, the single-target IAT (ST-IAT) is a variant of the IAT in which only one target category is used (e.g., Bluemke & Friese, 2007; Karpinski & Steinman, 2006). Second, negative associations could possibly reflect internalized societal views regarding alcohol use ("other people view drinking as something bad") instead of a lack of pleasurable alcohol effects (e.g., Houben & Wiers, 2007). To remove the influence of these extrapersonal associations researchers started using IAT tasks with personalized attributes such as "I like" and "I do not like" (e.g., Olsen, & Fazio, 2004) instead of "positive" and "negative". Third, even though "wanted" stimuli are usually arousing, research has shown that arousal and incentive salience cannot be equated (e.g., Berridge, Venier, & Robinson, 1989)IST does not assign a major role for arousal to the development and maintenance of addiction (e.g., Robinson & Berridge, 1993). This sheds some doubt on the validity of the arousal IAT as a measure of "wanting". Perhaps, a more straightforward way to capture incentive salience attribution would be to use the attributes "I want" and "I do not want" (Tibboel et al., 2011). To further improve this measure of incentive salience, one can select attribute items that better reflect the concept "wanting". As Govan and Williams (2004) have shown, the nature of the attribute items influences the way in which the attribute labels are conceptualized. Whereas in previous studies generic positive and negative words as attribute

stimuli in wanting IATs (e.g., Tibboel et al., 2011), we therefore opted to use words that are more closely related to reward, because this is a central concept in the definition of wanting (e.g., Berridge, Robinson, & Aldridge, 2009).

On the basis of these considerations, we examined implicit "wanting" and "liking" of alcohol in alcoholic patients, heavy drinkers, and light drinkers using personalized ST-IATs with labels and attribute stimuli that actually reflect "wanting" and "liking". On the basis of IST, one would predict higher "wanting" but less "liking" in alcoholic patients than in light drinkers, with heavy drinkers being in between patients and light drinkers on both measures. Koob and Le Moal (e.g., 1997; 2001), on the other hand, would predict more "wanting" and "liking" in alcoholic patients than in the other two groups, again with heavy drinkers revealing intermediate scores.

2. Method

2.1. Participants.

Participants were a convenience sample of 52 alcohol-dependent patients, 25 heavy social drinkers, and 30 light social drinkers (see Table 1 for a summary of demographic data and information regarding substance use for each group). Alcohol-dependent patients were recruited at the Psychiatric Institute of the Brugmann University Hospital in Brussels, Belgium, where they received treatment at their own volition. Participants from the control group were recruited by word of mouth and by means of advertisement posters displayed at public places in the near surroundings of the Brugmann University Hospital. All participants were tested at the addictology department of the Psychiatric Institute of the Brugmann Hospital and gave their informed consent before testing started. The study was approved by the Ethics Committee of the Brugmann University Hospital.

2.2. Materials and procedure.

Cognitive functioning. We administered the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975), which is a measure to screen global cognitive

functioning. The UPPS Impulsive Behavior Scale (UPPS; Whiteside & Lynam, 2001) was also administered. This questionnaire was designed to measure impulsivity and has four sub-scales to assess (lack of) premeditation, urgency, sensation seeking, and (lack of) perseverance. We also asked participants to fill in the Attentional Control Scale (ACS; Derryberry, 2002), a survey that assesses the extent to which individuals are able to focus and switch their attention.

Alcohol use and problems. Participants completed the Alcohol Use Disorder Identification Test (AUDIT; Babor, Higgins-Biddle, Saunders, & Monteiro, 2006), on which scores higher than eight indicate problematic drinking behavior. Participants also completed the Alcohol Expectancy Questionnaire (AEQ), a questionnaire regarding participants' expectancies regarding the effects of alcohol. This questionnaire contains six subscales that assess expectancies regarding positive global changes, sexual enhancement, social and physical pleasure, assertiveness, relaxation/tension reduction, and arousal/personal power (Goldman, Darkes, & Del Boca, 1999).

Mood and affect. Participants filled in the Positive and Negative Affect Schedule (PANAS; (Crawford & Henry, 2004, Watson, Clark, & Tellegen, 1988;) which is commonly used to separately assess positive and negative affect; and the Beck Depression Inventory-II (Beck, Steer, & Brown, 1998), a 21-item survey regarding depressive symptoms, on which scores below 9 indicate minimal depression, scores between 10 and 18 indicate mild depression, scores between 19 and 29 indicate moderate depression, and higher scores indicate severe depression.

ST-IATs. Participants performed a liking ST-IAT and a wanting ST-IAT. Both ST-IATs were implemented using Inquisit software (Millisecond Software, 2001) on a laptop with a 15 inch color screen. In both ST-IATs, the stimulus set consisted of six alcohol-related pictures (e.g., a glass of beer) that were approximately 310 pixels wide and 225 pixels high

and twelve French words. In the liking ST-IAT, these words were six generic positive (e.g., rainbow, love) and negative words (e.g., death, sadness) and in the wanting ST-IAT, these words were six positive motivational (e.g., gain, praise) and negative motivational words (e.g., deprivation, punishment). Words needed to be classified as referring to "I like" (J'aime) or "I do not like" (Je n'aime pas) in the liking ST-IAT and "I want" (Je veux) or "I do not want" (Je ne veux pas) in the wanting ST-IAT. When an alcohol picture occurred, participants responded by pressing a specific key. In both tasks, participants responded by pressing the left ("a") or right ("p") key on a standard AZERTY keyboard. The ST-IATs consisted of four blocks. In all blocks, both words and pictures were presented in the center of the screen. The first and third block consisted of 24 practice trials and the second and fourth block each consisted of 72 trials. For half of the participants, the alcohol pictures were assigned to the same key as the "I like" ("I want") words in the first two blocks, whereas the "I do not like" ("I do not want") words were assigned to the other key. In the third and the fourth block, alcohol pictures were assigned to the same key as the "I do not like" ("I do not want") words, whereas the "I like" ("I want") words were assigned to the other key. For the other half of the participants, the order of the blocks was reversed. All blocks had an equal number of positive, negative, and alcohol trials. If an incorrect response was given, a red X appeared for 400 ms. The intertrial interval (ITI) was 380 ms. All stimuli were presented randomly, with an equal amount of repetitions (twice in the first and third block, six times in the second and fourth block).

Ratings. Participants were asked to rate the alcohol pictures that were presented in the ST-IAT. In a first block, participants viewed each picture as long as they wanted[1], until they pressed the space-bar. Then, a nine-point Likert scale appeared on the screen and participants were asked to indicate how much they *liked* the item in the picture. A score of 1 meant that

[1] We analyzed the viewing time, but this revealed no differences between the three groups.

they did not like it at all, and 9 indicated that they liked it very much. After an answer was given, another 9-point Likert scale appeared and participants were asked to indicate to what extent they *wanted* the item in the picture. A score of 1 meant that they did not want it at all, and 9 indicated that they wanted it very much. After these ratings, each picture appeared again, and participants were asked how they thought another average person would rate these pictures, again on 9-point Likert scales assessing wanting and liking. We assumed these ratings would show participants' ideas about societal views on alcohol-use.

3. Results

For each ST-IAT, we calculated effects using the D600 scoring algorithm (Greenwald, Nosek, & Banaji, 2003). An ANOVA with group (patient, heavy drinker, light drinker) and type of ST-IAT (liking, wanting) as between-subjects factors did not yield a significant interaction, $F < 1$. The main effect for ST-IAT, on the other hand, approached significance, $F(1, 103) = 3.15$, $p = .08$, as did the main effect for group, $F(2, 103) = 3.01$, $p = .05$. As can be seen in Table 2, patients had significantly lower scores than heavy social drinkers on the liking ST-IAT, $t(74) = 2{,}49$, $p < .05$, and marginally lower scores than heavy social drinkers on the wanting ST-IAT, $t(74) = 1.77$, $p = .08$, while there were no such differences between patients and light drinkers, ts < .51. When we compared heavy and light social drinkers, we found that heavy drinkers had higher liking ST-IAT scores than light drinkers, $t(52) = 2.05$, $p < .05$, but there was no difference on the wanting ST-IAT, $t < 1.57$.

Due to a problem during data collection, ratings for twelve participants (patients) were lost. Thus, for these analyses we had data for 40 patients. An ANOVA with group (patient, heavy drinker, light drinker) and type of rating (liking, wanting) as between-subjects factors yielded a significant interaction between group and rating, $F(2, 91) = 4.07$, $p < .05$, a main effect for rating $F(1, 91) = 22.63$, $p < .001$, and a main effect for group, $F(2, 91) = 11.71$, $p < .001$. Again, patients had lower scores compared to heavy social drinkers on both their liking

and wanting ratings, $t(62) = 5.08$, $p < .001$, and $t(62) = 3.25$, $p < .005$, while there were no differences between patients and light drinkers, ts < .86. Finally, light drinkers had lower scores than heavy drinkers on both the liking and the wanting ST-IAT, $t(52) = 5.15$, $p < .001$, and $t(52) = 3.53$, $p < .001$. The interaction shows that the differences are more extreme for the wanting ratings. A similar ANOVA using the ratings concerning societal views yielded only a significant effect for group, $F(2, 91) = 5.46$, $p < .01$, showing that patients gave more negative scores on both wanting, $t(62) = 2.14$, $p < .05$, and liking, $t(62) = 3.70$, $p < .001$, compared to heavy drinkers. Patients also had more negative scores compared to light drinkers on liking, $t(62) = 3.05$, $p < .005$, but not on wanting, $t < 1.52$. There were no differences between light and heavy drinkers, ts < .88.

Finally, we calculated correlations between ST-IAT scores, AUDIT scores, explicit personal ratings and explicit ratings concerning societal views. We found a significant positive correlation between the two ST-IATs, $r(106) = .65$, $p < .001$. There were also positive correlations between the wanting ST-IAT and wanting ratings, $r(94) = .29$, $p < .01$, and between the wanting ST-IAT and liking ratings, $r(94) = .23$, $p < .05$. Furthermore, there were positive correlations between the liking ST-IAT and wanting ratings, $r(94) = .34$, $p < .005$, and between the liking ST-IAT and liking ratings, $r(94) = .29$, $p < .01$. Correlations between the ST-IATs and the AUDIT and ratings concerning societal views failed to reach significance, $-.12 < r\text{s} < .19$.[2]

4. Discussion

Most importantly, our results show striking group differences that are not in line with the hypotheses of Robinson and Berridge (i.e., an increasing dissociation between "wanting"

[2] For a part of our patient sample ($N = 42$), we managed to obtain data showing whether they had relapsed three months after they were discharged from the hospital. Binary logistic regression analyses including AUDIT scores, ST-IAT scores, and explicit self/societal ratings showed that none of these factors could predict relapse. However, because our sample is too small to perform these analyses (e.g., Wilson Van Voorhis & Morgan, 2007), firm conclusions regarding this null-effect cannot be drawn. The fact that even the AUDIT scores could not predict relapse, suggests that we did not have sufficient power to perform these analyses.

and "liking" as substance (ab)use intensifies; e.g., 1993) nor with the hypotheses of Koob and Le Moal (i.e., a positive linear relationship between both "wanting" and "liking" with substance (ab)use severity; 1997). Instead, we found that (a) heavy drinkers have higher scores than light drinkers and alcohol-dependent patients on both the wanting ST-IAT and the liking ST-IAT; and (b) there were no differences between alcohol-dependent patients and light drinkers. Furthermore, explicit ratings mirrored these results.

Our study illustrates the danger of drawing conclusions about addiction on the basis of sub-clinical samples. If we would have tested only heavy and light social drinkers, our results could be interpreted as evidence for the idea that increased substance use goes hand in hand with less negative implicit attitudes toward alcohol consumption.[3] However, the inclusion of a group of alcohol-dependent patients drastically changed this interpretation. Our results suggest that the relationship between automatically activated attitudes and alcohol (ab)use is not linear.

One explanation for these findings is that both ST-IATs used in the present study tap into different processes than we initially hypothesized. First, our liking ST-IAT might not capture "liking" in the sense of an unconscious, hedonic experience but instead might capture personal alcohol-associations that are very likely to be quite negative in alcohol-dependent patients (who experienced many negative consequences of their substance-abuse, including being hospitalized for the purpose of the detoxification) and light social drinkers (who might lack positive experiences with alcohol), but not in heavy social drinkers (for whom the positive effects of alcohol might still outweigh the negative effects of alcohol). Second, our wanting ST-IAT might not capture "wanting" in the sense of unconscious incentive salience but instead might capture a more cognitive form of wanting that involves higher-order goals (e.g., the long-term goal to be healthy and productive). Alcohol may have very basic, low-

[3] Apart from the significant differences between heavy and light social drinkers, we also found significant positive correlations between the IATs and the AUDIT when we analyzed the data for only these two groups.

level, short-term rewarding effects, but if one considers the rewarding value of alcohol in the context of the goal to remain sober, drinking can be considered as a punishment more than an incentive. In sum, positive scores on both ST-IATs might be due to a positive "balance" in the sense that the number of positive experiences (still) outweigh the negative experiences (i.e., in the case of heavy social drinkers), whereas negative scores might reflect a lack of positive experiences (i.e., in the case of light social drinkers) or a surplus of negative experiences (i.e., in the case of alcohol-dependent patients). In heavy drinkers, this balance is probably more positive than in either patients or light drinkers.

Furthermore, the context in which participants were tested may have affected ST-IAT scores as well. The experiment took place at the addiction clinic of the Brugmann hospital, and participants were explained they would perform tasks in which they would be asked to categorize alcohol stimuli and to rate alcohol stimuli, and to fill in questionnaires concerning their alcohol use. Under these circumstances, it is not unlikely that the negative experiences or aversive aspects of alcohol use come to mind more quickly than positive experiences or appetitive aspects, thereby decreasing scores on both the wanting and the liking ST-IAT. For instance, participants may not want alcohol in the sense that drinking alcohol would hinder their long-term goals to be healthy and sober. On the other hand, in a different context they might still want to drink alcohol because they remember how it would help them feel more relaxed. Similarly, cue expose might even lead to the more low-level "wanting" that is central to IST (e.g., Robinson & Berridge, 2003). Possibly, an individual can experience different types of wanting and not-wanting in different contexts. An important implication of this is that wanting and liking IAT effects could differ across contexts as well. IAT effects have indeed been shown to be malleable (e.g., see Blair, 2002, for a review on the malleability of the IAT in the context of prejudice). Interestingly, Marhe, Waters, Van de Wetering, and

Franken (2013) found that IAT scores could in fact predict relapse in patients, but only when the IAT was performed in a condition of increased temptation.

Another argument against the validity of our ST-IATs as "wanting" and "liking" measures is that the correlation between the "wanting" and "liking" ST-IAT scores were significant, suggesting that both measures might, to some extent, tap into similar processes. Again, this is in line with our explanation the ST-IAT scores are based more on one's experiences and one's goals. Because these are commonly heavily intertwined, a significant correlation between the two measures is not surprising.

If this is true, the theoretical question remains to what extent alcohol cues continue to have hedonic (i.e. "liking") and/or appetitive (i.e., "wanting") characteristics to alcohol-dependent patients. A second, more practical question is how we should measure these characteristics. Regarding the first question, our results show that alcohol-dependent patients' automatic reactions to alcohol can be negative or aversive, but this does not exclude the possibility that there is room for appetitive or positive automatic reactions as well. Whereas scores on some implicit measures are positive, others seem to reflect aversive processes (e.g., Van den Wildenberg, Beckers, Van Lambaart, Conrod, & Wiers, 2006; Wiers, Houben, & De Kraker, 2007). Furthermore, different implicit measures can be uncorrelated (e.g., Van den Wildenberg, Beckers, Van Lambaart, Conrod, & Wiers, 2006), or even correlate negatively (e.g., Wiers et al., 2002). And importantly, they are, in some cases, not related to actual drug use at all (e.g., Cohn et al., 2012; Houben & Wiers, 2007; Van den Wildenberg et al., 2006). Viewed in this light, our data are not so deviant: they merely suggest that in alcohol dependent patients, at least some implicit processes reflect aversion toward drug cues, but the possibility remains that other processes (that we were unable to capture) reflect appetitive tendencies toward drug cues. Future research should focus on examining to what extent these different automatic processes play a *causal* role in addiction. Regarding the second question,

in spite of our efforts to optimize the design, we can indeed doubt that our ST-IAT measures are capable of assessing hedonic or incentive processes. But how can we further improve our chances to capture these processes? And how can we objectively judge whether a "wanting" or "liking" measure is valid? Whereas IST's predictions regarding the effects of incentive sensitization on human overt behavior are not clear (e.g., Robinson & Berridge, 2000), the theory does make very clear predictions regarding the neural effects. Neuroscience might thus provide us with a way to examine and improve the validity of our implicit measures. In fact, a recent development in the study of automatic processes in addiction is the use of neuropsychological paradigms in association with brain imagery. For instance, in a recent fMRI study, Cousijn and colleagues (2012) failed to find differences between heavy cannabis users and controls on their task that was designed to measure automatic approach bias. However, they did find that approach bias activation on different brain areas (higher dorsolateral prefrontal cortex and anterior cingulate cortex) was associated with cannabis use and could predict future cannabis problem severity. Similarly, Korucuoglu, Gladwin, and Wiers (2014) examined the influence of a priming dose of alcohol on event-related desynchronization in the beta band (an index of advanced response preparation) and performance on an implicit approach-avoidance task. Their behavioral data did not show a clear effect of the priming dose on automatic approach behavior. However, the EEG data suggested that there was more response preparation during trials on which alcohol was paired with an approach-response when participants had received a priming dose of alcohol compared to when they had received a placebo. In other words, both studies show that where implicit behavioral tasks alone fall short, the combination between behavioral paradigms and brain imagery can shed light on the situation

Finally, there are several alternative explanations that need to be addressed. One might argue that the effects that we found are not actually automatic in the sense that they were

uncontrollable. Instead, one could claim that alcohol-dependent patients tried to respond in a socially acceptable way (i.e., trying to give the impression that they do not enjoy drinking) on both our implicit and explicit measures. Even though tasks like the IAT are assumed to be implicit in the sense that participants have little control over the outcome, recent research has shown that IAT effects can be "faked". More specifically, it has been demonstrated that participants are able to complete the task in a way that conforms to the researchers' expectations (e.g., De Houwer, Beckers, & Moors, 2007). However, in this scenario this seems an unlikely explanation, because patients' scores on the AEQ differed significantly from light drinkers on all subscales, and from heavy drinkers on most subscales. If patients had the goal to paint a more positive picture regarding their alcohol-related attitudes, they would have responded on this questionnaire about their alcohol expectancies in a more socially desirable manner as well. Furthermore, commonly it is only possible to fake implicit attitudes on the IAT when one has some experience in performing this task (De Houwer et al., 2007), which was not the case for the participants in our study. Finally, we would expect significant correlations between our ST-IAT scores and ratings concerning societal views on alcohol, which we failed to find. **4.1. Limitations**

The ST-IAT has some disadvantages that should not be overlooked. First, the ST-IAT is unbalanced in the sense that all categories (positive words, negative words, alcohol-related pictures) are presented equally often, which means that in each block, one response key is used twice as often compared to the other response key (e.g., when alcohol and positive words require a left key press, and negative words require a right key press, the left key will be used more often than the right key), which might skew reaction times. However, it must be noted that in total, each response key was used an equal number of times (i.e., in one block the left key would be used more often, but in the other block the right key would be used more often).

Furthermore, and most importantly, it is unlikely that the data pattern we report here was influenced by this, because we counterbalanced the order of the blocks across participants.

Second, because there was only one category for which pictures were used (i.e., the alcohol category), participants technically could ignore the content of these pictures. However, on average, responses to pictures were slow (M = 916.55, SD = 296.18 milliseconds in the wanting ST-IAT and M = 885.39, SD = 270.06 in the liking IAT), suggesting that participants in fact did thoroughly process these stimuli. It is also important to note that highly similar ST-IATs have already been successfully used (e.g., Bongers, Jansen, Houben, & Roefs, 2013; Huijding & De Jong, 2006). Finally, problems with the ST-IAT cannot explain differences between the groups, as all participants performed the same task.Considering these limitations, future research might focus on using other types of IATs. For instance, Houben and Wiers (2006) employed unipolar IATs, in which the attribute labels do not consist of two opposites (e.g., "positive" and "negative") but instead compare one valenced attribute (e.g., "positive") with a non-valenced attribute (e.g., "neutral"). These IATs revealed that social drinkers have both positive as well as negative associations with alcohol.

A final consideration is that by the time of the experiment, patients no longer drank alcohol and in general reported that they had no desire to do so (craving intensity is generally low during treatment). However, if this is the case, we might expect that heavy drinkers, who were tested in the same context, would have relatively negative scores on both ST-IATs as well. Even though they had less negative experiences with alcohol, a hospital context should be able to trigger knowledge regarding unfavorable consequences of alcohol use. Nevertheless, it would be interesting to examine in future research whether our results hold when patients are tested outside of the clinic or at other times during their stay in the clinic.

5. Conclusion

We want to highlight the importance of making a distinction between infrequent substance users, frequent substance users, and dependent substance users in addiction research. Our study strongly suggests that the common implicit assumption that the same processes that underlie heavy social drinking should also underlie alcohol dependence, but to a greater extent (i.e., "if alcohol is an incentive for heavy social drinkers, it must be an even stronger incentive to alcohol-dependent patients") is not tenable. Even though it is clear that heavy drinkers run a higher risk to become alcohol dependent, it is important that this does not necessarily imply a linear relationship between alcohol consumption or alcohol-related problems on the one hand and stronger automatic hedonic and incentive processes on the other. *Unlike* heavy drinking, alcohol dependence is characterized not only by alcohol consumption, but also by serious behavioral (e.g., social, legal, medical) problems and dependence (tolerance, withdrawal, impaired control) and that it has a chronic, compulsive nature that is absent in (heavy) social drinking (e.g., Edwards & Gross, 1978; Kranzler, & Li, 2008). Thus patients differ from (heavy) social drinkers on more than one dimension. This should be taken into account also when examining the role of automatic processes in addiction. Of course, our study is limited in the sense that we only used one type of implicit measure that is assumed to reflect effects of automatic alcohol-associations. It is important to compare the role of other implicit processes such as automatic approach tendencies and automatic attentional bias within alcohol use and alcohol *abuse* as well in order to draw general conclusions. For instance, it is possible that alcohol-dependent patients' automatic associations with alcohol are negative, whereas alcohol cues still have the power to activate automatic approach tendencies. It may be noted, however, that earlier research suggests (different versions of) the IAT are in fact related to automatic approach reactions (e.g., Wiers et al., 2011).

To sum up, our experiment has important practical and theoretical implications. First, it lays bare an important weakness in the current study on the role of automatic processes in addiction: a lack of a focus on the comparison of clinical and sub-clinical groups. Second, in addition to the failure to support the validity of the theories of Koob and LeMoal (e.g., 1997; 2001) and Robinson and Berridge (e.g., 2003; 2008), our study also offers valuable insights in the validity of our implicit measures: our findings suggest that instead of low-level processes like “wanting” and “liking” we possibly measured effects of the automatic activation of a more complex knowledge structure regarding one’s experiences or expectations regarding alcohol (ab)use. This means that the relationship between alcohol (ab)use and automatically activated attitudes and cognitions is more complex than hypothesized by current models of addiction.

Declaration of Interest

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Table 1

Group characteristics: Summary statistics

	Patients		*Heavy dinkers*		*Light dinkers*		*Difference*		
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Patients-heavy*	*Patients-light*	*Heavy-light*
Proportion men	59.61	-	48.00	-	46.67	-	11.61	12.94	1.33
Age	44.88	10.47	38.36	12.87	49.77	8.89	6.52*	-4.89*	-11.41**
Years of education	2.54	.95	3.28	.98	2.83	.87	-.74**	-.29	.45
Years of alcohol abuse	14.20	10.77	-	-	-	-	-	-	-
Number of earlier withdrawal attempts	3.75	3.25	-	-	-	-	-	-	-
Age loss of control	35.56	10.49	-	-	-	-	-	-	-
AUDIT	30.25	6.58	9.36	1.89	3.33	1.86	20.89***	26.92***	6.03***
MMSE	28.08	1.97	28.88	1.79	29.17	.95	-.80	-1.09**	-.29
BDI-II	12.12	8.22	2.48	2.66	.97	1.35	9.64***	11.15***	1.51**
PANAS positive	30.33	7.97	34.16	6.56	32.27	5.56	-3.83*	-1.94	1.89
PANAS negative	23.12	8.59	14.04	5.44	16.37	5.71	9.08***	6.75***	-2.33
UPPS Global	107.19	14.58	99.08	13.39	89.93	12.89	8.11*	17.26***	9.15**
UPPS Premeditation	32.63	8.15	29.60	7.91	25.47	4.37	3.03	7.16***	4.13**
UPPS Urgency	22.67	5.41	21.48	6.14	19.57	3.88	1.19	3.10**	1.91
UPPS Sensation Seeking	22.42	4.84	18.80	4.60	17.40	3.62	3.62**	5.02***	1.4
UPPS Perseverance	29.52	7.85	29.24	6.25	27.83	7.26	.28	1.69	1.41
AEQ Global	6.36	2.56	2.40	1.80	1.20	1.65	3.96***	5.16***	1.2*
AEQ Sexual	2.12	2.09	1.28	1.46	.80	1.24	.84	1.32**	.48
AEQ Social/physical	6.28	2.00	5.20	1.68	2.87	1.85	1.08	3.41***	2.33***
AEQ Social security	6.12	3.22	4.34	3.27	2.03	2.19	1.78*	4.09***	2.31*
AEQ Relaxation	5.84	2.11	3.60	2.06	2.40	2.04	2.24***	3.44***	1.2
AEQ Excitement	5.66	2.04	3.84	2.06	2.60	1.89	1.82**	3.06***	1.24*

ACS	50.06	12.98	56.08	10.13	51.33	8.45	-6.02*	-1.27	4.75*

***$p < .001$
**$p < .01$
*$p < .05$

Table 2

Implicit and explicit lliking and wanting scores per group

	Patients		*Heavy dinkers*		*Light dinkers*		*Difference*		
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Patients-heavy*	*Patients-light*	*Heavy-light*
Wanting IAT	-.15	.43	.03	.42	-.15	.44	-.18*	.00	.18*
Liking IAT	-.27	.47	.01	.40	-.22	.41	-.28+	-.05	.23
Explicit wanting self	2.53	2.43	4.33	1.57	2.86	1.47	-1.80**	-.33	1.47**
Explicit liking self	2.83	2.29	5.50	1.51	3.25	1.66	-2.67***	-.42	2.25***
Explicit wanting other	4.62	2.23	5.52	1.20	5.27	1.33	-.90+	-.65	.25
Explicit liking other	4.44	2.01	5.85	1.04	5.59	1.12	-1.41**	-1.15**	.26

***$p < .001$
**$p < .01$
*$p < .05$
+$p < .05$