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Creativity on tap? Effects of alcohol intoxication on creative cognition

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ABSTRACT

Anecdotal reports link alcohol intoxication to creativity, while cognitive research highlights the crucial role of cognitive control for creative thought. This study examined the effects of mild alcohol intoxication on creative cognition in a placebo-controlled design. Participants completed executive and creative cognition tasks before and after consuming either alcoholic beer (BAC of 0.03) or non-alcoholic beer (placebo). Alcohol impaired executive control, but improved performance in the Remote Associates Test, and did not affect divergent thinking ability. The findings indicate that certain aspects of creative cognition benefit from mild attenuations of cognitive control, and contribute to the growing evidence that higher cognitive control is not always associated with better cognitive performance.

1. Introduction

Can alcohol consumption support creative thought by inducing disinhibition, or will it just impair cognitive control and similarly affect creative cognition? The idea about a positive relationship between alcohol and creativity has been popularized by reports associating eminent creativity with excessive alcohol consumption (Knafo, 2008). But empirical evidence is sparse, and the association between alcohol and creativity seems at odds with the relevance of cognitive control for creative thought (e.g., Benedek, Jauk, Sommer, Arendasy, & Neubauer, 2014). Therefore, this study examined the effect of alcohol on executive control and on standard measures of creative cognition.

Creative cognition is assumed to rely on both controlled, goal-directed and spontaneous, undirected cognitive processes (Beaty, Silvia, Nusbaum, Jauk, & Benedek, 2014; Benedek & Jauk, in press; Sowden, Pringle, & Gabora, 2015). Pertinent research mostly focused on divergent thinking (viz. creative idea generation) and creative problem solving (i.e., problems that can be solved either analytically or insightfully, which typically implies a restructuring of the problem representation). The relevance of cognitive control for divergent thinking is evidenced by consistent correlations with intelligence (Kim, 2005; Silvia, 2015), particularly with fluid intelligence (Jauk, Benedek, Dunst, & Neubauer, 2013; Nusbaum & Silvia, 2011) and broad retrieval ability (Avitia & Kaufman, 2014; Benedek, Franz, Heene, & Neubauer, 2012; Silvia, Beaty, & Nusbaum, 2013). At the level of executive abilities, divergent thinking has been associated with working memory capacity and cognitive inhibition (Benedek et al., 2012, 2014; De Dreu, Nijstad, Bass, Wolsink, & Roskes, 2012; Zabelina, Robinson, Council, & Bresin, 2012). Divergent thinking requires overcoming prepotent, uncreative response tendencies and involves cognitive strategies (Gilhooly, Fioratou, Anthony, & Wynn, 2007), which was shown to be facilitated by intelligence (Beaty & Silvia, 2012; Nusbaum & Silvia, 2011; Nusbaum, Silvia, & Beaty, 2014). While much of the empirical evidence on creative cognition and cognitive control is based on divergent thinking, similar evidence also exists for creative problem solving. Creative problem solving tasks like Duncker's candle problem or the Remote Associates Test can be achieved in a

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strategic way (Fleck & Weisberg, 2004; Smith, Huber, & Vul, 2013), and higher performance again has been related to intelligence and executive control (Gilhooly & Fioratou, 2009; Lee, Huggins, & Therriault, 2014).

Creativity has also been associated with disinhibition and spontaneous insight (Eysenck, 1995; Kounios & Beeman, 2014). Empirical evidence for the relevance of spontaneous, undirected cognitive processes in creative thought mostly comes from research on incubation processes. Creative problem solving sometimes leads to an impasse of thought, also known as *mental fixation*, were goal-directed solving attempts are no longer fruitful. Incubation research has demonstrated that breaks from deliberate problem solving can benefit creativity by refreshing inadequate mindsets while leaving room for unconscious work (Hélie & Sun, 2010; Sio & Ormerod, 2009). Similarly, while expertise typically supports problem solving by guiding search through problem space, it can also be detrimental when misdirecting search efforts to salient but inadequate concepts (Wiley, 1998). Together, these findings suggest that cognitive control generally supports creative cognition by facilitating the effective implementation of goal-directed processes, but focused attention may sometimes be ineffective and potentially even harm creative problem solving (Wiley & Jarosz, 2012).

The role of cognitive control in creative cognition has also been addressed by experimental studies examining the effects of low to moderate doses of alcohol (i.e., usually inducing a blood alcohol concentration < 0.08) on different measures of creative ability. One study reported that the fluency of idea generation was reduced in both an alcohol group and a placebo group compared to the control group (Gustafson, 1991). Another investigation found that intoxicated writers and non-writers showed reduced idea flexibility but an increased number of non-obvious, original ideas (Norlander & Gustafson, 1998). Yet another study observed no notable effects of alcohol on divergent thinking performance, but participants evaluated their performance as more creative when they thought that they had received alcohol (Lang, Verret, & Watt, 1984). A more recent study demonstrated that moderate alcohol intoxication impaired working memory performance, but the intoxicated group showed higher performance in the Remote Associates Test (RAT) compared to a control group not receiving any drinks (Jarosz, Colflesh, & Wiley, 2012).

Together, the available research provides partial support for a positive effect of alcohol on creative cognition, but evidence is still sparse and inconsistent. Part of the inconsistency might be attributed to missing placebo control groups, and the focus on single measures of creative potential. People tend to overestimate their creative performance and even become more creative when they think they have consumed alcohol, which points to the importance to include placebo control groups in order to dissociate pharmacological effects from expectation effects (Lang et al., 1984; Lapp, Collins, & Izzo, 1994). Moreover, findings may be specific to certain aspects of creative cognition such as insight problem solving and divergent thinking, and even the scoring of divergent thinking tasks can be an issue when focusing on summative uniqueness, which is known to be severely confounded with response fluency (Silvia et al., 2008). The present study thus tested the effects of mild alcohol intoxication in a placebo-controlled design using alcoholic and non-alcoholic beer. We examined the effects of alcohol on objective and subjective levels of intoxication, executive control, and two standard tasks of creative potential: creative problem solving in the Remote Associates Task and divergent thinking ability, scored for rated creativity, fluency, flexibility and novelty. Reduced cognitive control via mild alcohol intoxication could be expected to attenuate fixation effects (Smith & Blankenship, 1991) and thus support cognitive flexibility in the Remote Associates Test (Jarosz et al., 2012). The available research allows no clear prediction regarding the effect of alcohol on divergent thinking ability (Gustafson, 1991; Norlander & Gustafson, 1998). On the one hand, divergent thinking is known to involve executive processes similar to intelligence tasks (Benedek et al., 2014; Silvia, 2015). On the other hand, lower cognitive control might increase disinhibition and unusualness of thought (e.g., Babor, Berglas, Mendelson, Ellingboe, & Miller, 1982; Eysenck, 1995; Field, Wiers, Christiansen, Fillmore, & Verster, 2010), and thereby support the exploration of new and unusual parts of the idea space in the given problem (as measured by fluency, flexibility and novelty). Together, these mechanisms might facilitate the generation of unusual and potentially even creative ideas.

2. Material and methods

2.1. Participants

132 people participated in an online screening, which aimed to identify those eligible for participation in the main study. The online screening asked about age, potential pregnancy, heart or liver diseases, psychiatric disorders, and included the Alcohol use disorders identification test (AUDIT; Saunders, Aasland, Babor, De la Fuente, & Grant, 1993). 89 people from the screening met all criteria for participation, as they were at least 18 years old (the local age limit for legal consumptions of any type of alcoholic drinks), reported no pregnancy or relevant disease, and were casual drinkers of alcohol but with an AUDIT level < 8 reflecting no risk for alcohol-related problems. A total of 70 young adults (54 % female), aged between 19 and 32 years (M = 23.3; SD = 2.8), finally participated and completed all measures.

2.2. Experimental design and procedure

This study investigated the effect of alcohol on cognition in a randomized placebo-controlled pretest-posttest design. We used beer as experimental intervention, because it is available in alcoholic and non-alcoholic form and represents a highly popular drink among male and female University students. Participants of the alcohol group received *Gösser Zwickl®* (5.2% alcohol by volume) and participants of the non-alcoholic group received *Gösser Naturgold®* (< 0.5% alcohol by volume). These two beers were selected because they are very similar in taste and visual appearance (i.e., golden, naturally cloudy). The amount of beer was individually adjusted for weight, age and gender (Watson, Watson, & Batt, 1980; Widmark, 1932) targeting at a blood alcohol concentration (BAC) of 0.03 (in case of alcoholic beer). For a male with 22 years, 75 kg and 182 cm this results in about 500 ml of beer, whereas a female with 22 years, 65 kg and 165 cm received about 350 ml beer. Drinks were cooled and prepared in a separate room and served in neutral drinking glasses.

Participants were asked not to consume alcohol or other drugs 24 h before the experiment and not to eat and drink caffeinated drink 2 h before the experiment. They were tested in groups of two people, who were randomly assigned to the experimental groups (1 alcohol and 1 placebo). The participants were blind to the experimental condition, and the employed group setting was intended to avoid any experimenter effects. After a general instruction, participants signed informed consent. A first measurement of alcohol concentration with the alcohol tester *ACE Neo* (ACE Handels- & Entwicklungs GmbH; Freilassing, Germany) confirmed that all participants were sober at the start of the experiment. In the pretest, participants completed an executive function test (2-back task), two measures of creative potential (Remote Associates Test and divergent thinking test), and a test of creativity evaluation skills. Then participants were given their drinks and they watched a documentary about South Africa for half an hour to allow the BAC level to reach its maximum. In the posttest, participants worked on different versions of the same tests as in the pretest. The BAC was measured right after the executive function test, with the result being concealed from the participants. Additionally, all participants were asked indicate their subjective level of alcohol intoxication on a four-point rating scale (0 = not at all, 1 = a little, 2 = quite a bit, 3 = very much). After the experiment, the participants were informed about the existence of the placebo-control group and what group they had been assigned to. The total experiment took about two hours. The procedure had been approved by the ethics committee of the local university.

2.3. Measures

2.3.1. Self-reported alcohol use

The alcohol use disorders identification test (AUDIT; Saunders et al., 1993) is a 10-item screening of individual drinking behavior. It asks for the frequency of alcohol consumption, and for indicators of alcohol dependence and harmful alcohol use. Total scores of 8 or more are recommended as indicators of potentially hazardous and harmful alcohol use (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001).

2.3.2. Executive control

Executive control was measured with a verbal 2-back task (Baddeley, 2003). The computer-based task presented a sequence of single white letters (K, M, R, or T) on black background with an inter-trial-interval of 1.5 s (inter-stimulus-interval = 0.2 s). Participants had to decide whether the current letter is identical with the one presented two stimuli ago by pressing a button for each target. Participants completed 20 practice trials, followed by the actual test with 100 trials (25% targets). The final score reflected the total number of correct responses to targets and non-targets.

2.3.3. Creativity measures

Creative thinking was assessed with the Remote Associates Test (RAT; Mednick, 1962) and divergent thinking tasks (Guilford, 1967), two common measures of creative potential (Kaufman, Plucker, & Baer, 2008). The RAT presents three unrelated words (e.g., cottage, blue, cake) and ask for a solution word that provides an unexpected connection between them (cheese: cottage cheese, blue cheese, cheesecake). Pretest and posttest used different sets of 10 items with increasing difficulty, but matched for item difficulty across tests (Landmann et al., 2014). The items were presented on a computer and participants entered the solution via a keyboard (timeout: 30 s).

Divergent thinking (DT) was assessed with a computer-based version of the alternate uses task, which asks to find creative uses for common objects within 2.5 min (pretest: umbrella, shoe; posttest: car tire, fork). Task performance was scored for rated creativity as well as for fluency, flexibility, and novelty. All responses were evaluated for creativity (a holistic rating reflecting the novelty and usefulness of ideas) by six independent judges on a 4-point Likert-like scale ranging from (0 = uncreative, to 3 very creative). Inter-rater-reliability ranged from 0.75 to 0.81. DT creativity was defined as the average creativity evaluation of the three most creative ideas per task according to judge's ratings. This *top-3 creativity* score was shown to avoid confounds with the fluency of responses (Benedek, Mühlmann, Jauk, & Neubauer, 2013). DT fluency reflected the number of ideas per task. DT flexibility was defined as the number of categories into which ideas fall. To this end, two judges classified all responses for the 28 categories provided by the manual of the Torrance Test of Creative Thinking (Torrance, 1974). The inter-rater-reliability of the flexibility assessments ranged from 0.86 to 0.95. Finally, DT novelty was defined as the average statistical infrequency across ideas. We computed the novelty of each idea as the inverse of its frequency within our sample (e.g., ideas generated by five people get a score of 0.2, whereas unique ideas get a score of 1). For all DT scorings, pretest and posttest scores represented the average performance in the two respective DT tasks.

Creativity evaluation skills were assessed with a short-version of the creativity evaluation test (CET; Benedek et al., 2016). The CET presents different ideas that have to be judged as either common, inappropriate, or creative. Short versions for pretest and posttest were defined by selecting 8-item task blocks from the original CET. CET performance was scored by the informedness of judgements, a standard index from signal detection theory that equally accounts for sensitivity and specificity of judgements (Powers, 2011).

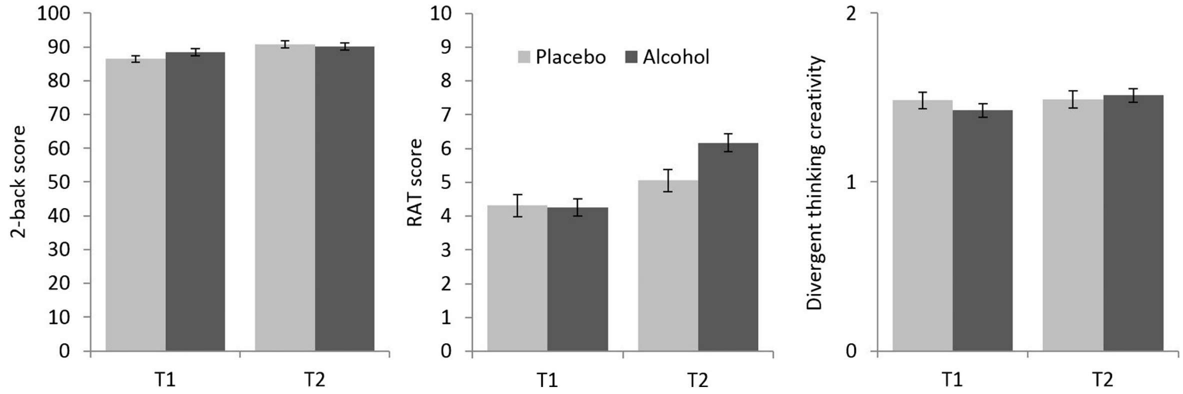

Fig. 1. Performance in the 2-back task (left panel), the Remote Associates Test (RAT; middle panel) and divergent thinking tasks for groups receiving alcohol (alcoholic beer) versus placebo (non-alcoholic beer) before (T1) and after intervention (T2).

3. Results

3.1. Manipulation check and control analyses

The alcohol and the placebo groups each consisted of 35 participants, with a similar ratio of females (49% and 60%, respectively; $\chi[1] = 0.92$, $p = 0.47$). Participants who had consumed alcoholic beer had an average BAC of 0.026 ($SD = 0.08$), which is close to the targeted BAC level of 0.03. As expected, participants who had consumed non-alcoholic beer had a BAC of 0 ($SD = 0.00$; $t[66] = -19.5$, $p < 0.001$). Importantly, however, the two experimental groups did not differ in the level of subjectively perceived intoxication ($U = 711.5$, $p = 0.13$); drinkers of alcoholic and non-alcoholic beer all predominantly indicated to feel a little bit intoxicated (both groups: *mode* = 1, *median* = 1).

We observed no significant differences between gender groups: In the alcohol group, the BAC was largely similar between females (0.028; $SD = 0.08$) and males (0.025, $SD = 0.08$; $t[33] = 1.64$; $p = 0.11$). Moreover, gender groups did not differ in the subjective level of intoxication, neither in total ($U = 565$, $p = 0.51$), nor within experimental groups (alcohol group: $U = 121.5$, $p = 0.30$; placebo group: $U = 149.5$, $p = 0.93$; all *modes* and *medians* = 1).

3.2. Effects of alcohol intoxication on cognition

We analyzed effects of *time* (from pretest to posttest, i.e., T1 to T2) and experimental *group* (alcohol versus placebo) on cognitive performance with two-way mixed ANOVAs. In the 2-back task, participants showed practice effects (*time*: $F[1,68] = 20.81$, $p < 0.001$, partial-η^2=0.23), but this effect tended to be moderated by the experimental group (interaction: *time* * *group*: $F[1,68] = 3.95$, $p = 0.05$, partial-$\eta^2 = 0.06$): only the placebo group significantly increased their performance from T1 to T2 ($t[34] = -4.40$, $p < 0.001$), whereas the intoxicated group showed only a trend towards improvements ($t[34] = -1.93$, $p = 0.06$; see Fig. 1); yet, the groups did not differ significantly at T1 ($t[68] = -1.37$, $p = 0.18$) or T2 ($t[68] = -0.43$, $p = 0.57$).

In the Remote Associates test (RAT), participants also showed increased performance at T2 (*time*: $F[1,68] = 24.47$, $p < 0.001$, partial-$\eta^2 = 0.27$), and this effect was again moderated by experimental group (*time* * *group*: $F[1,68] = 4.76$, $p = 0.03$, partial-$\eta^2 = 0.07$): groups did not differ in performance at T1 ($t[68] = 0.14$, $p = 0.89$), but following the intervention, intoxicated participants showed higher RAT solution rates than those from the placebo control group ($t[61.82] = -2.50$, $p = 0.02$, $d = 0.59$; see Fig. 1).

Regarding divergent thinking (DT) performance, we observed no time effects and, importantly, no significant moderation by experimental group for all DT scores, including DT creativity (*time*: $F[1,68] = 2.13$, $p = 0.15$; *time* * *group*: $F[1,68] = 1.73$, $p = 0.19$; see Fig. 1), DT fluency (*time*: $F[1,68] = 3.77$, $p = 0.06$; *time* * *group*: $F[1,68] = 1.50$, $p = 0.22$), DT flexibility (*time*: $F[1,68] = 1.01$, $p = 0.32$; *time* * *group*: $F[1,68] = 0.23$, $p = 0.63$), or DT novelty (*time*: $F[1,68] = 0.89$, $p = 0.35$; *time* * *group*: $F[1,68] = 0.55$, $p = 0.46$).

Finally, creativity evaluation performance showed a significant time effect (*time*: $F[1,68] = 5.78$, $p = 0.02$, partial-$\eta^2 = 0.08$; T1: $M = 0.53$, $SD = 0.49$; T2: $M = 0.69$, $SD = 0.29$), but no significant interaction with experimental group (*time* * *group* : $F[1,68] = 2.17$, $p = 0.24$).

4. Discussion

This study investigated the effect of low alcohol intoxication on creative cognition in a placebo-controlled design. Consumption of a low dose of alcohol tended to impair executive control, but facilitated creative problem solving (viz. insight problem solving), and did not affect divergent thinking ability. These findings replicate and extend recent research in this field. For example, Jarosz et al. (2012) also reported reduced working memory capacity and increased performance in the Remote Associates Test after moderate alcohol consumption. As a difference, Jarosz and colleagues did not include a placebo control group, because this may not be credible for moderate to high doses of alcohol (Martin & Sayette, 1993). However, assuming to have consumed alcohol can lead to higher evaluations of one's creative output, and potentially even to more original performance (Lapp et al., 1994). Therefore, this study used a lower dosage (target BAC of 0.03, versus 0.07 in Jarosz et al., 2012), which effectively induced similar levels of subjectively experienced intoxication in alcohol and placebo groups. We found that intoxicated participants actually improved their performance in the RAT beyond the level of the placebo group, which rules out the possibility that performance gains were caused by expectancy effects alone. This study thus replicated effects of alcohol on creative problem solving for a lower BAC level, while more clearly attributing them to the (additional) pharmacological effect of alcohol.

Alcohol intoxication neither improved nor harmed divergent thinking (DT) performance. This is consistent with some previous findings (Lang et al., 1984), while other studies found reduced idea fluency, flexibility, and increased originality at higher levels of intoxication (Gustafson, 1991; Norlander & Gustafson, 1998). Given the important role of executive control for divergent thinking ability (e.g., Benedek et al., 2014), it seems possible that negative effects on controlled processes are compensated by positive effects on spontaneous processes at low levels of alcohol, but one might expect reduced DT creativity for higher alcohol levels. We also observed no effect of alcohol intoxication on creativity evaluation skills, which is in line with the idea that intoxicated people do not differ in their creativity evaluation from people who assume to have consumed alcohol (Lang et al., 1984).

Finally, it is interesting to mention that the employed N-back task proved to be a sensitive indicator of mild intoxication effects on cognitive control. Previous studies have often used complex span tasks (Colflesh & Wiley, 2013; Jarosz et al., 2012), but findings do not always align between these tasks (Redick & Lindsey, 2013). Therefore, it is useful to note N-back and complex span tasks both appear to reliably capture effects of mild to moderate alcohol intoxication on cognitive control.

Considering the findings together, a moderate attenuation of cognitive control seems to benefit creative problem solving but not divergent thinking. Creative cognition is generally assumed to rely on the interaction of controlled and spontaneous processes, but the optimal balance may differ between tasks (Benedek & Jauk, in press). While most cognitive activities usually benefit from high cognitive control, some may actually suffer from too much focus (Chrysikou, Weber, & Thompson-Schill, 2014; Radel, Davranche, Fournier, & Dietrich, 2015; Wiley & Jarosz, 2012). Our findings suggest that high cognitive control is relatively more important to divergent thinking than to creative problem solving. This interpretation is consistent with the observation that creative problem solving tasks are often solved by spontaneous insight and accompanied by "Aha"-experiences (Kounios & Beeman, 2014). While attentional control typically supports the cued search of memory (Unsworth & Engle, 2007), looking for *remote* associations may benefit from by a slightly reduced attentional focus and more flexible integration of semantic concepts (Rowe, Hirsh, & Anderson, 2007; Wiley, 1998).

Alcohol may particularly play a role in mitigating fixation effects. In creative problem solving, problems can often only be solved after a restructuring of the problem representation. When initial solution attempts get on the wrong track, this can cause blocks to immediate problem solving, which is known as *mental fixation* (Smith & Blankenship, 1991). These fixations typically fade with time, which is considered a central mechanism behind incubation effects (Storm & Koppel, 2012; Vul & Pashler, 2007). In a similar way, alcohol may reduce fixation effects by loosening the focus of attention and hence impeding the building and maintenance of dominant but inappropriate mental representations. Thereby, alcohol may facilitate a broader associative search and the effective solving of creative tasks that are prone to fixation effects.

4.1. Conclusions

Our study corroborates the notion that small attenuations of cognitive control may facilitate certain aspects of creative cognition while not affecting others. It contributes to our understanding of the interplay between controlled and spontaneous processes in creative thought and of their relative importance in different types of creative cognition. The findings, however, should not be overgeneralized by assuming that creativity is generally supported by alcohol. Beneficial effects are likely restricted to very modest amounts of alcohol, whereas excessive alcohol consumption typically impairs creative productivity (Kerr, Sheffer, Chambers, & Hallowell, 1991). Moreover, positive effects appear limited to specific phases in the creative process that are not fully tractable by goal-directed thought, while other phases such evaluation and implementation of ideas usually suffer from reduced cognitive control (Norlander, 1999). Our findings thus add to the increasing evidence suggesting that higher cognitive control is not always equivalent to better cognitive performance (Amer, Campbell, & Hasher, 2016; Beilock, Carr, MacMahon, & Starkes, 2002; Chrysikou, et al., 2014; Wiley & Jarosz, 2012).

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