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Alcohol Intoxication Impairs Memory and Increases Suggestibility for a Mock Crime: A Field Study

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Summary: Defendants and witnesses are often intoxicated by alcohol. We investigated whether memory and resistance to suggestive cues are undermined at blood alcohol concentrations (BACs) that were (close to) zero ($M_{BAC} = 0.01\%$), moderate ($M_{BAC} = 0.06\%$), or high ($M_{BAC} = 0.16\%$). Participants ($N = 67$) were approached in bars and instructed to commit a mock crime. Immediately after this, their memory and susceptibility to suggestive questions were tested, and these were re-tested during a sober follow-up 3–5 days later. Compared with sober participants, moderate and severe intoxication was associated with lower levels of correctly recalled crime details during both test sessions (i.e. intoxicated and sober). Also, during both sessions, severely intoxicated participants displayed a greater tendency to go along with suggestive cues compared with sober participants. Thus, intoxication impaired memory and increased suggestibility during an immediate interview, and both effects persisted when sober again.
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INTRODUCTION

Alcohol interferes with the transference of information from short- to long-term memory because it disturbs the encoding and consolidation of new information (Ray & Bates, 2006; Söderlund, Parker, Schwartz, & Tulving, 2005; Verster, Van Duin, Volkerts, Schrueder, & Verbaten, 2003; White, 2003). During intoxication, encoding is more superficial due to a lack of rehearsal and other mnemonic strategies (Saults, Cowan, Sher, & Moreno, 2007). Even a relatively modest but sudden rise in blood alcohol concentrations (BACs) may produce fragmentary blackouts or grayouts (Perry et al., 2006; Ray & Bates, 2006; Wetherill & Fromme, 2011; White, 2003). This means that parts of the event(s) that took place during intoxication are not consolidated and not remembered afterwards. Higher BACs may even lead to a complete (i.e. en bloc) blackout, that is, a total inability to recall events at a later point in time (Goodwin, Othmer, Halikas, & Freeman, 1970; Kalant, 1996; Mintzner & Griffiths, 2002; Van Oorsouw, Merckelbach, Ravelli, Nijman, & Mekking-Pompen, 2004). Number of drinks and also the rate at which they are consumed are important predictors of grayouts and blackouts. The faster the consumption rate, the more rapid intoxication levels rise (see also Goodwin, Crane, & Guze, 1969; White, 2003). In the study by Van Oorsouw et al. (2004), participants with blackouts reported having consumed about 15 drinks within 4 hours. This corresponds with BACs of up to 0.26%. To put this further into perspective, in the Netherlands, the maximum concentration of blood alcohol at which it is legally permitted to drive a motor vehicle is 0.02% (approximately 2 drinks within 1 hour); in the United States, this level is 0.08% (approximately 5.5 drinks within 1 hour).[1]

Suspects, victims, and witnesses of crimes are often under the influence of alcohol (Evans, Schreiber Compo, & Russano, 2009; Haggard-Grann, Hallqvist, Langstrom, & Moller, 2006). For example, 35% of the offenders who have been convicted for violent crimes claim alcohol-related amnesia for their offence (Cima, Nijman, Merckelbach, Kremer, & Hollnack, 2004; Kopelman, 1995). Although some of them may have been simulating their amnesia (e.g. van Oorsouw & Merckelbach, 2009), many of them are likely to have been intoxicated during the crime.

Given that alcohol may impair memory, one would expect police officers to refrain from interrogating an intoxicated suspect or witness. Nevertheless, Evans et al. (2009) noted in their survey conducted among police investigators that 22% of them said that they were willing to interrogate an intoxicated suspect. Only 7% of the police investigators said that they would allow the suspect to become sober before they would start the interrogation (Evans et al., 2009; see also Sigurdsson & Gudjonsson, 1994; Santtila, Ekholm, & Niemi, 1998). Likewise, an analysis of police files by Palmer, Flowe, Takarangi, and Humphries (2013) demonstrated that police investigators asked intoxicated witnesses to describe the culprit and to take an identification test just as often as they asked sober witnesses. For the subgroup of intoxicated suspects, it was not clear whether they were actually questioned about the crime while still being intoxicated. However, the majority of the arrested offenders were taken into custody while under the influence of alcohol, rendering it likely that they were still intoxicated when questioned.

A recent police survey in the Netherlands revealed that 50% of the professionals believe that perpetrators, including those who are intoxicated, are more likely to disclose crucial information in an immediate interrogation (Van Oorsouw, Merckelbach, & Willems, 2013). This assumption is not surprising because police investigators are familiar with the phenomenon that memory fades over time.

Given that police investigators often deal with intoxicated suspects and witnesses and question them in both intoxicated and sober states, it is important to study the dose–response effect of alcohol on memory. Previous studies in this domain have yielded mixed results. For example, regarding intoxicated eyewitnesses (BAC range: 0.06–0.12%), Hagsand, Roos af Hjelmsäter, Granhag, Fahlke, and Söderpalm-Gordh

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[1] For a male person weighing 80 kg.

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(2013a) demonstrated that at moderate dosages (mean BAC 0.06%), alcohol impaired the number of details that participants recalled of a crime video. However, intoxication level did not affect memory accuracy. Similar findings were reported by Hildebrand Karlén, Roos af Hjelmsäter, Fahlke, Granhag, and Söderpalm-Gordh (2014), but only for women (mean BAC 0.08%) and not for men (mean BAC 0.07%). On the other hand, Schreiber Compo et al. (2012) found that intoxicated individuals (with BACs ranging between 0.06% and 0.08%) who watched a staged theft did not differ from sober participants in either memory completeness or accuracy. In another study, Hagsand and colleagues investigated the effect of similar dosages on participants' identification accuracy (i.e. identifying a culprit) in a simultaneous target-absent or target-present lineup, after they had watched a crime video (Hagsand, Roos af Hjelmsäter, Granhag, Fahlke, & Söderpalm-Gordh, 2013b). Participants who had been intoxicated while watching the movie later performed at a similar level—which was indicative of overall poor lineup performance (i.e. 25% correct identifications)—as their sober counterparts. Similar findings were reported by Harvey, Kneller, and Campbell (2013) at slightly higher dosages. These researchers employed a slide sequence depicting a theft. Again, no effect of alcohol was found on subsequent identification accuracy in a simultaneous target-absent or target-present lineup. Importantly, in both studies, participants were sober when tested. Thus, it appears that recognition memory is relatively unaffected by alcohol intoxication.

An exception to this rule is the study by Dysart, Lindsay, MacDonald, and Wicke (2002). These authors did find a detrimental effect of alcohol on identification accuracy, but only in target-absent show-ups. However, their study differed in important respects from the studies cited earlier. First, participants were involved in a real-life interaction rather than passively watching a movie or slide sequence. Second, participants were still intoxicated (BACs ranging between 0.00% and 0.20%) when asked to identify the person they had interacted with. Third, the authors did not use a lineup but a single picture (i.e. a show-up). A meta-analysis by Steblay, Dysart, Fulero, and Lindsay (2003) demonstrated that lineups and show-ups do not generate different rates of false identifications. Still, the Dysart et al. finding of a heightened rate of false identifications in intoxicated witnesses might be the result of a subtle interaction between suggestive show-ups and intoxication.

In the older study of Yuille and Tollestrup (1990), sober and intoxicated individuals were exposed to a mock crime. Although free recall of the intoxicated participants (BACs ranging between 0.06% and 0.12%) was impaired, they did not differ from sober participants in the accuracy with which they identified the presence or absence of the culprit in a lineup 1 week later, when sober again. Taken together, these studies suggest that identification accuracy is only undermined when participants are intoxicated at the time of testing (Dysart et al., 2002), and not when sober again (Yuille & Tollestrup, 1990).

Only two studies have looked at intoxicated offenders' memories for crime details. Using a staged mock crime, Read, Yuille, and Tollestrup (1992) investigated intoxicated participants' memory for what they did (as perpetrators) and their memory for what they saw (as witnesses) in an immediate and/or delayed (1 week later) memory test. Alcohol intoxication (with BACs up to 0.10%) undermined perpetrators' memory for the mock crime, but not witnesses' identification accuracy. The memory-undermining effect of alcohol was not affected by the time of testing (immediate and/or delayed). Yet, repeated testing did improve memory, irrespective of intoxication level. In a field study, Van Oorsouw and Merckelbach (2012) tested memory for a staged robbery filmed from the perpetrator's perspective when participants were sober again. The authors noted that intoxication (with BACs up to 0.24%) during exposure to the film fragment impaired completeness and accuracy of delayed (3–5 days later) recall.

Most studies on alcohol and memory focussed on witnessed events rather than enacted events. This is an important limitation: Crimes mostly involve action rather than passive states, and memory for enacted events is better than memory for witnessed events (Engelkamp, 1995). The reason for this is that arousal is likely to be higher during an enacted event as compared with passively watching a crime video. Raised arousal levels might counteract the memory-undermining effect of alcohol (Engelkamp, 1995; Read et al., 1992).

With these considerations in mind, it is ecologically relevant to employ mock crimes when testing the effects of alcohol on crime-related memories. In doing so, it is informative to look not only at memory performance but also at suggestibility. Note that only a few studies have addressed the link between alcohol intoxication and suggestibility. Germane to this is the well-documented discrepancy-detection principle that dictates that people are more prone to misleading cues when their memory of the original event is poorer because it becomes more difficult for them to detect discrepancies between truly encoded details and merely suggested details (Peterson, Rothfleisch, Zelazo, & Pihl, 1990; Schooler & Loftus, 1986). Because alcohol undermines the encoding of detailed information, one expects intoxication to lead to problems in detecting discrepancies between stored information and information merely suggested during, for example, a police investigation. This, in turn, would lead to increased suggestibility by rendering the discrimination between falsely suggested and actual details exceedingly difficult. In line with this, Nash and Takarangi (2011) found in their survey among individuals with blackout experiences that they often tend to rely on less credible resources to fill in the gaps. Consequently, being exposed to inaccurate information (e.g. in a suggestive interview, or by co-witnesses or other external sources) could more easily make people with blackouts believe in and remember experiences that never occurred (Loftus, 2005; Mazzoni & Kirsch, 2002; Nash & Takarangi, 2011).

So far, only Santtila, Ekholm, and Niemi (1999) directly investigated the link between alcohol and suggestibility. These authors found that intoxicated individuals exhibited a *reduced* susceptibility to go along with leading questions, as measured with the Gudjonsson suggestibility scale (Gudjonsson, 1997). They concluded that intoxicated individuals may become *less* vulnerable to suggestive influences because of the anxiolytic properties of alcohol (Santtila et al., 1999). The rationale behind this idea is that anxiety—for

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example, fear of giving the wrong answer during an interview—is an important antecedent of suggestibility. However, Santtila et al. relied on an experimental procedure that deviated strongly from the order of events in real-life settings. Their participants first experienced an event; next, they were given alcohol, only to be questioned in a suggestive way about the target event in the final phase of the procedure. Thus, Santtila et al. did not address the short- and long-term suggestibility of offenders or witnesses who were intoxicated while undergoing the critical event. This is an important omission because, in reality, the perpetrator is often questioned about events that took place while he or she was intoxicated. In addition, when alcohol is consumed after encoding of an event, it may paradoxically enhance memory for the event through its inhibition of retrograde interference (i.e. the retrograde enhancement effect; Bruce & Pihl, 1997; Knowles & Duka, 2005). This effect could explain why Santilla et al. did not find an increase but rather a decrease in suggestibility after intoxication. Thus, the Santtila et al. study does not provide an optimal test of the idea that alcohol induced discrepancy-detection problems may contribute to increased suggestibility in former intoxicated offenders.

The aims of the present study were threefold. First, we tested whether alcohol would undermine memory for an event (i.e. mock crime) enacted in a perpetrator role. Second, we investigated whether intoxication would increase suggestibility in an interrogation situation. And third, we explored whether participants who were intoxicated during the critical event remember more correct details when interrogated immediately (while still intoxicated) or when sober again in a repeated interview about the event.

We hypothesized that compared with low and moderate levels of intoxication, higher levels (i.e. BACs above 0.11%) at the time of encoding (i.e. during the mock crime) would be detrimental to the accuracy and completeness of memory for crime details when participants are tested immediately following the mock crime. Based on the idea that intoxication interferes with encoding, this effect was expected to persist during a follow-up test when participants were sober again. With respect to suggestibility, we hypothesized that alcohol intoxication would increase suggestibility owing to difficulties in discrepancy detection that arise when people have memory deficits due to alcohol.

METHOD

Participants

Potential participants (mixed sample) were approached in three local bars in Maastricht, the Netherlands. These were regular bars with a mixed audience (e.g. students and working class people). Each participant was approached and tested individually. Participants were approached when it was evident that they were adults (>18 years), and when they made a healthy impression. When they appeared to be heavily intoxicated, they were not approached for participation. Participants were not further screened in any way. In total, 100 volunteers agreed to participate, and 67 of them (54 men) completed both the session in the bar and the follow-up session. Their mean age was 22.2 years (range, 18–36 years; $SD = 2.53$). The study was approved by the local standing Ethical Research Committee. Participants were asked not to talk to others about the experiment until after the second session.

Mock crime

The mock crime consisted of an introduction story and a criminal act that participants had to perform. The 2-minute introductory crime story was presented to them via headphones. This was carried out to eliminate distraction noise and to ensure that the story was read to each participant in the same pitch and volume. The introduction was as follows:

> You have been working at this bar for a while now. Usually you get paid on the last Friday of the month. However, your boss has not paid you for the last two months. Tonight you have a day off and you are in this bar with your friends. You know your boss keeps the daily cash turnover in a briefcase that is in his office, where the coats of the staff are also stored. You suspect that the key to the briefcase is inside his coat pocket. You decide to sneak into your boss' office and steal some of his money you know he keeps in a briefcase.[2]

Next, participants were asked to enter a room that was decorated as an office (e.g. a coat stand with coats, posters on the wall, a table with flowers, and a briefcase). They were instructed to search for a key that was in one of the coats and to use it to open the briefcase. They were then asked to steal the money from the briefcase. There were also other objects (e.g. an orange and a picture) in the briefcase. However, the instructions did not mention any details they were going to encounter (e.g. ringing of a phone and objects inside the briefcase). After the instruction had been given, participants were asked whether they understood the procedure. As a manipulation check, participants were asked to rate their emotional involvement and ability to empathize with the main character using two 100 mm (1 = *not emotionally involved/extremely difficult to empathize*, 100 = *very emotionally involved/very easy to empathize*) visual analogue scales.

Procedure

Participants were approached in bars between 20.00 h and 04.00 h and were invited to participate in a study on alcohol and cognition. They signed an informed consent form after which their BAC was measured, using the Lion Alcometer SD400. This breath analyser converts the breath alcohol ratio into blood alcohol ratio. Next, participants were asked several questions about their drinking habits and drug use (Van Oorsouw & Merckelbach, 2012). We also asked them to provide us with contact information so that we could send them a debriefing form and their BAC level afterwards. At that moment, nothing was mentioned about follow-up testing because we did not want to influence participants in any way. Next, participants were taken into a quiet room where they received the instructions for the mock crime. They were

[2] A detailed description can be obtained from the first author.

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asked to identify with the main character of the story that they were about to hear. The story was administered to them through headphones. Following this, they were given the instructions to commit the actual mock crime as described earlier. After having carried out the mock crime, participants were taken into a different, adjacent room where their memory and level of suggestibility were tested (i.e. immediate test). The interview was conducted by a different person than the one who approached participants and explained the procedure. Participants' responses were audiotaped using voice recorders. There was an interval of approximately 10 min between the invitation to participate in the study and the start of the interview. When all tests were completed, participants were thanked and informed that they would be contacted within the next 3–5 days for a follow-up test. Participants received a candy bar for their participation.

Three to five days later, participants were contacted by phone and asked to complete several tests about the mock crime. When they agreed, the free and cued recall instructions and suggestibility items employed during test 1 were once more administered. Thus, they were instructed to report as completely as possible about the mock crime and its introductory story. The response rate was 67%. Prior to the follow-up test, participants were asked whether they had been drinking alcohol. To reduce the chance of participants being intoxicated during the follow-up test, testing took place at weekdays between 9.00 h and 16.00 h. None of the participants said they had been drinking alcohol prior to the second test. Again, responses were audiorecorded. After completion of the follow-up test, participants were thanked and provided with information about their level of intoxication during the first test session. After the study was finished, all participants were fully debriefed by e-mail.

Memory testing and scoring

Participants' memory for the mock crime was tested both immediately after their return from the office space and at the follow-up session.[3] Memory testing consisted of a free recall test and a cued recall test. For the free recall test, participants were asked to give a detailed description of their motive, the surroundings, and the objects they had seen, as well as their own actions. Thus, they were instructed to recall everything they remembered of both the introductory story and the theft. The cued recall test consisted of 15 memory questions of the following type: 'When did you usually get paid?' and 'What objects were located in the briefcase?' The questions pertained to the details mentioned in the introductory story as well as details of the mock crime.

An *a priori* scoring protocol was employed to evaluate participants' free and cued recall (see for a similar method Van Oorsouw & Merckelbach, 2012). In total, 27 informational units were identified in the introductory story and 29 units in the mock crime. Thus, the maximum number of details was 56. Examples of informational units that were scored in the story are: 'my boss did not pay me' (1 point); 'for two months' (1 point). As for the mock crime, points were accredited when participants correctly described actions, for example, that they took the key out of the coat pocket (1 point) and that they opened the briefcase (1 point). Extra points were given when participants correctly specified the amount of stolen money (e.g. 50 euros), mentioned the colour of the wallet, and so on. One point was accredited to each unit that was accurately recalled. The number of correct units represented the total free recall score.

The 15 cued recall questions covered a total of 21 critical information units. For each correct answer to a question, participants received 1 point, except for the question about the objects in the briefcase. Here, participants could earn 7 points if they mentioned all objects correctly, adding to a total free recall score of 21. Most questions pertained to the enacted event and the objects involved [e.g. the briefcase (17 points)], and only four questions were about the introductory story and referred to the motive for stealing the money (4 points).

Apart from the numbers of correctly free- and cued-recalled details, we evaluated two types of errors. Commission errors were defined as the introduction of an entirely new and false piece of information (e.g. 'the briefcase contained a cell phone'). Distortion errors were defined as pieces of information that were essentially correct, but misrepresented during the cued recall test. An example of a distortion would be 'I took the key from the blue coat' when in fact the coat was grey.

Free and cued recall tests were scored by the first author and an independent second rater. Both were blind as to participants' intoxication levels. Pearson correlations between the two raters for the number of correctly recalled units during free (range: 0–56) and cued (range: 0 –21) recall were 0.98 and 0.91, respectively. For commission and distortion errors, these correlations were 0.85 and 0.76, respectively (all $ps < 0.01$).

Suggestibility measure

Suggestibility was assessed using 15 misleading questions that were intermixed with the 15 cued recall memory questions. The misleading questions pertained to details that had not been present in the story or during the mock crime. For instance, we asked participants 'Did the wallet contain 50 or 100 euros?' when in fact it contained 70 euros. We also gave participants questions containing two false alternatives such as 'Was there an apple or a banana in the briefcase?' when in fact the briefcase contained an orange. When participants yielded to a misleading question, this was scored with 1 point. In line with the procedure described by Gudjonsson (1997), participants received negative feedback after completion of the 30 cued recall and misleading questions. That is, they were told that they made quite a few mistakes and were asked to answer the questions for a second time. We were interested in whether negative feedback would lead to changes (shifting) in participants' answers to the second series of (misleading) questions. This way, we were able to calculate three suggestibility parameters: (i) the tendency to go along with misleading questions immediately (yield 1); (ii) the tendency to accept misleading cues after negative feedback (yield 2); and (iii) the tendency to change an answer after negative feedback (shift).

[3] Participants were first contacted after 3 days but were not always available to undergo the follow-up test. In those cases, the follow-up test was scheduled for the next day or 2 days later. The 3- to 5-day interval was also used in previous studies (e.g., Van Oorsouw & Merckelbach, 2012).

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Table 1. Number of correctly recalled details and errors for the three groups on the free and cued recall test, during session 1 (T1) and the follow-up test (T2)

	Sober ($n = 14$)		Moderately intoxicated ($n = 27$)		Severely intoxicated ($n = 26$)	
	T1	T2	T1	T2	T1	T2
Free recall story						
Correct total	14.15 (4.93)[a,b]	13.30 (4.31)[a,b]	11.18 (3.51)[c]	10.07 (3.51)[c]	6.23 (3.59)	5.90 (3.20)
Errors (com/dis)	1.76 (1.16)	1.92 (1.38)	1.88 (1.36)	1.70 (1.26)	2.04 (2.26)	1.23 (1.04)
Free recall actions						
Correct total	8.38 (5.31)[a,b]	12.93 (5.57)[a,b,*]	5.70 (3.97)	7.88 (4.21)*	5.04 (2.72)	7.42 (4.35)*
Errors (com/dis)	0.31 (0.48)	0.76 (0.83)	0.18 (0.48)	0.92 (1.46)	0.47 (0.81)	0.61 (0.92)
Cued recall story						
Correct total	2.71 (0.91)	2.50 (1.16)	2.44 (1.25)	2.29 (1.20)	2.03 (1.39)	1.80 (1.47)
Errors (com/dis)	1.14 (0.94)	1.35 (1.00)	1.18 (1.37)	1.14 (1.09)	1.69 (1.37)	1.65 (1.44)
Cued recall actions						
Correct total	11.71 (1.47)[b]	12.35 (1.90)[b]	10.59 (2.37)[c]	10.51 (1.98)	8.80 (2.36)	10.03 (3.05)*
Errors (com/dis)	0.42 (0.85)	0.21 (0.80)	0.62 (1.00)	0.05 (1.06)	1.23 (1.72)	1.11 (1.27)

Totals and errors (commission and distortion errors; com/dis) are displayed separately for the introductory story (recall story) and enacted event (recall actions).
[a] $p < 0.05$ between sober and moderately intoxicated groups.
[b] $p < 0.05$ between sober and severely intoxicated groups.
[c] $p < 0.05$ between moderately and severely intoxicated groups.
* $p < 0.05$ within this group between sessions.

RESULTS

Statistical analyses

To examine how different levels of intoxication affected memory and suggestibility, both recall data and suggestibility scores were subjected to 3 (groups: nearly sober vs. moderately intoxicated vs. severely intoxicated) × 2 (sessions: immediate vs. follow-up) analyses of variance (ANOVAs), with the last factor being a repeated measure. Follow-up pairwise comparisons between groups were carried out. Regression analyses were conducted to explore whether BAC and/or memory affected suggestibility.

Blood alcohol concentrations and memory performance

Blood alcohol concentrations ranged from 0.00% to 0.26%, with an average BAC of 0.09% ($SD = 0.07$).

Following the approach of Van Oorsouw and Merckelbach (2012), participants were subdivided in three groups: sober (BACs < 0.02%),[4] moderately intoxicated (BACs between 0.02% and 0.11%), and severely intoxicated (BACs > 0.11%). The sober group consisted of 14 participants ($M_{BAC} = 0.01\%$, $SD = 0.01$), the moderately intoxicated group had 27 participants ($M_{BAC} = 0.06\%$, $SD = 0.02$), and the severely intoxicated group had 26 participants ($M_{BAC} = 0.16\%$, $SD = 0.04$). As was to be expected, the groups differed in the number of alcoholic beverages participants reported to have drank on the night of testing [$F(2, 64) = 36.75$, $p < 0.01$, $\eta_p^2 = 0.53$]. Sober, moderately intoxicated, and severely intoxicated participants reported to have consumed respectively 4 ($SD = 2.7$), 9 ($SD = 3.7$), and 17 ($SD = 6.3$) alcoholic beverages.[5] Groups did not differ in self-reported number of drinking nights per week [$F(2, 64) = 1.00$, $p = 0.37$], or the number of drinks on a typical drinking occasion [$F(2, 64) = 1.28$, $p = 0.28$].

On the whole, participants reported they were able to identify with the main character of the mock crime ($M = 71.2$, $SD = 18.6$) and felt emotionally involved in the mock crime ($M = 66.6$, $SD = 20.3$). There were no group differences in the ability to empathize or in emotional involvement in role playing the thief [both Fs < 1.0].

Table 1 shows memory performance data (correct free recall, cued recall, and errors for the story and actions, respectively) of the three groups during the two test sessions for free recall and cued recall.

A repeated-measure ANOVA performed on *free recall of the introductory story*, with group (sober, moderately, and severely intoxicated) as a between-subject factor and session as a repeated measure, revealed no interaction between groups and session [$F(2, 64) < 1.0$, $\eta_p^2 = 0.04$], or an effect of session [$F(1, 64) = 2.43$, $p = 0.12$, $\eta_p^2 = 0.04$]. Yet, a significant main effect of group [$F(2, 64) = 24.00$, $p < 0.01$, $\eta_p^2 = 0.45$] did emerge. Bonferroni corrected *post hoc t*-tests revealed that during both sessions, the three groups differed significantly in the number of correctly recalled story details, with intoxication resulting in significant lower levels of correct recall (Table 1). No significant main effects or an interaction effect was found for number of errors made in recalling the introductory story (all Fs < 1.40, all ps > 0.05).

For *free recall of the enacted event*, no interaction [$F(2, 58) = 1.11$, $p = 0.33$, $\eta_p^2 = 0.03$][6] was found. But main effects emerged for session [$F(1, 58) = 20.93$, $p < 0.01$, $\eta_p^2 = 0.26$] and group [$F(2, 58) = 7.21$, $p < 0.01$, $\eta_p^2 = 0.20$]. Sober participants recalled significantly more correct details as compared with both intoxication groups during both sessions (both ts > 2.23, both ps < 0.05), and all groups recalled

[4] Although participants in this group had consumed alcohol, their BAC was below the Dutch legal driving limit (0.02%) according to which they would be legally perceived as sober. Therefore, this group will be referred to as the sober group.
[5] An alcoholic beverage refers to a standard glass of beer, wine, spirits, or a mixed drink.
[6] For six participants, data were partly missing on either the first or the second session.

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significantly more correct details of the enacted event during the second test session (all ts $> -2{,}22$, all ps < 0.05; Table 1). Regarding errors made in recalling the enacted event, only a significant effect of session was found [$F(2, 58) = 7.64$, $p < 0.01$, $\eta_p^2 = 0.12$]. Follow-up tests indicated that this effect was carried entirely by the moderately intoxicated participants, who made more errors in recalling the enacted event when they were sober as compared with when they were intoxicated [$t(26) = -2.92$, $p < 0.01$].

As for *cued recall of the introductory story*, only a significant main effect of session was found [$F(1, 64) = 5.04$, $p < 0.05$, $\eta_p^2 = 0.07$]. All groups recalled fewer correct details of the introductory story during the second (sober) test. An ANOVA on the number of errors that were made during cued recall of the introductory story yielded no effects (all Fs < 1.30).

Regarding *cued recall of the enacted event*, significant main effects for session [$F(1, 64) = 7.56$, $p < 0.01$, $\eta_p^2 = 0.11$] and group [$F(2, 64) = 6.74$, $p < 0.01$, $\eta_p^2 = 0.17$] and a significant interaction between group and session was found [$F(2, 64) = 5.04$, $p < 0.01$, $\eta_p^2 = 0.11$]. To break down this interaction, we carried out univariate follow-up ANOVAs for both sessions separately, with group as a between-subject factor. Significant between group differences were found in correct cued recall scores obtained during session 1 [$F(2, 64) = 9.10$, $p < 0.01$, $\eta_p^2 = 0.22$] and session 2 [$F(2, 64) = 4.23$, $p < 0.05$, $\eta_p^2 = 0.12$]. During the first test session, severely intoxicated participants recalled significantly fewer correct details of the enacted event relative to the other two groups [both ts > 2.96, both ps < 0.05]. This effect persisted during the second session [$t(64) = 2.85$, $p < 0.05$], but only so when severely intoxicated participants were compared with sober participants. Also, participants in the severe intoxication group recalled significantly more correct details during the second (sober) than during the first test [$t(25) = -3.12$, $p < 0.01$]. The group effect in the number of errors made in recalling the enacted event was close to reaching significance [$F(2, 64) = 2.98$, $p = 0.058$, $\eta_p^2 = 0.08$]. That is, compared with sober participants, participants in the severe intoxication group had a tendency to make more errors during both sessions.

Suggestibility

Yield and shift scores of the three groups are shown in Table 2. For yield scores, no interaction effect [$F(2, 64) < 1.0$], or an effect of session emerged [$F(1, 64) < 1.0$]. Yet, there was a significant main effect of group [$F(2, 64) = 4.49$, $p < 0.01$, $\eta_p^2 = 0.12$]. During both sessions, severely intoxicated participants displayed a stronger tendency to go along with misleading questions compared with sober participants [$t(39) = 2.94$, $p = 0.01$]. No other group differences in yield scores were apparent [ts < 1.78, ps > 0.24].

Shift scores revealed no interaction between intoxication level and session [$F(2, 64) < 1.0$]. Neither was there a significant group effect for the tendency to shift answers after negative feedback [$F(2, 64) < 1.0$]. However, a significant main effect was found for sessions [$F(1, 64) = 19.50$, $p < 0.01$, $\eta_p^2 = 0.24$]. Exploratory analyses showed that shift scores decreased significantly over sessions for both intoxication groups [both ts > 2.95, both ps < 0.01], but not for sober participants [$t = 1.53$, $p = 0.15$].

Regression analyses

For both free and cued recall tests, we calculated Pearson correlations between BACs, free and cued recall for the introductory story and enacted event, and suggestibility (yielding and shifting). The correlational patterns for both sessions are given in the Supporting information.

There was a negative correlation between BAC and memory performance ranging from $r = -0.32$, $p < 0.05$ to $r = -0.60$, $p < 0.01$ during both sessions. Similarly, significant negative correlations existed between suggestibility and several, but not all, memory output measures (Table 1 Supporting information). Yet, BAC only correlated negatively with yielding to suggestive questions ($r = 0.32$, $p < 0.01$ for sessions 1 and 2).

Using regression analyses, we investigated whether memory performance mediated the relationship between BAC level and yielding. Such pattern would be in line with the notion that failure to detect discrepancies between misleading information and the (poorly encoded) actual event underlies increased suggestibility in intoxicated individuals. A linear regression analysis was conducted with yield scores as dependent variable and BAC and proportions correct free recall and cued recall elements for story and actions as independent variables. Backwards elimination with a criterion of $p < 0.05$ resulted in a model in which free recall of story details was predictive of yield scores during the first test session. This model accounted for 22% of the variance. A similar analysis was carried out for the follow-up test session, now including BAC and all memory performance variables for the first *and* second test sessions. Yield scores during the second test were predicted by free recall of story and action details at session 1, accounting for 28% of the variance (Table 3).

Table 2. Yield and shift scores for the three groups during session 1 (T1) and the follow-up test (T2)

	Sober ($n = 14$)		Moderately intoxicated ($n = 27$)		Severely intoxicated ($n = 26$)	
	T1	T2	T1	T2	T1	T2
Yield	3.00 (3.01)[a]	2.80 (2.96)[a]	3.93 (2.67)	4.56 (2.72)	5.42 (2.85)	5.73 (3.31)
Shift	3.86 (4.52)	2.64 (3.00)	3.41 (2.81)	1.89 (2.19)*	4.54 (4.31)	2.29 (3.26)*

[a]$p < 0.05$ between sober and severely intoxicated groups.
*$p < 0.05$ within this group between sessions.

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Table 3. Summary of backwards linear regressions, with yield for sessions 1 and 2 as dependent variable and BAC, FRStory, FRAct, cued recall story, and cued recall actions for sessions 1 and 2 as independent variables

	B	*SE*	*β*	*t*	*p*
Yield 1					
FRStory1	−0.29	0.06	−0.48	−4.39	0.000
Yield 2					
FRStory1	−0.25	0.07	−0.39	−3.36	0.001
FRAct1	−0.22	0.09	−0.28	−2.46	0.017

BAC, blood alcohol concentration; FRStory, free recall story; FRAct, free recall actions.

DISCUSSION

A quick glance at the extant literature on alcohol intoxication and memory in the domain of legal psychology would lead one to believe that the memory-undermining effects of alcohol on, for example, identifications are limited (e.g. Harvey et al., 2013). We examined how alcohol affects free and cued recall at immediate and follow-up tests. Based on the well-established observation that alcohol intoxication impairs consolidation (Ray & Bates, 2006; Söderlund et al., 2005), we expected memory of the mock crime details to be impaired, even at the follow-up test when participants were sober again, and particularly so in participants who had previously been highly intoxicated. By and large, this was borne out by our data. To begin with, and in line with previous findings (e.g. Read et al., 1992; van Oorsouw & Merckelbach, 2012), alcohol intoxication was associated with lower levels of correct recall, although this effect was more straightforward for free than for cued recall. An exception to this pattern was the error rate for action details in the cued recall that was higher for intoxicated than for sober people.

Second, the memory-undermining effect increased with higher levels of intoxication. Thus, in accordance with previous research (e.g. Perry et al., 2006), we found a dose–response relationship. Third, the memory-undermining effect emerged when participants were tested immediately (i.e. when in the same state as while encoding) and persisted when sober again. Last, higher levels of intoxication were associated with a stronger tendency to go along with misleading questions (i.e. yielding) during both test sessions. This effect was largely mediated by less complete recall, a pattern that fits nicely with the idea of discrepancy detection (e.g. Peterson et al., 1990; Schooler & Loftus, 1986) and the work of Nash and Takarangi (2011).

As was the case in previous studies (e.g. Van Oorsouw & Merckelbach, 2012), intoxicated participants reported fewer correct details about the mock crime as compared with sober participants at both test sessions. Importantly, the undermining effect of intoxication was also evident when we looked specifically at memory for the enacted event (i.e. stealing the money). Apparently, and in contrast to the idea that memory traces for enacted events are more robust against intoxication because they are better consolidated (Engelkamp, 1995), alcohol impairs consolidation of memory traces regardless of whether or not the event is enacted. Furthermore, the lost material cannot be readily retrieved either when intoxicated or when sober again. We found free recall to be already impaired at moderate levels of intoxication, but the effects were more straightforward when intoxication exceeded a BAC of 0.10%. That intoxication impaired free recall more than cued recall is in line with previous studies that found recognition memory—for example, identification in line-ups—to be relative robust against at least moderate levels of intoxication (Hagsand et al., 2013b; Harvey et al., 2013).

One could argue that our findings are of little practical relevance because they relied on an artificial mock crime procedure. For example, one could question whether our participants performed to the best of their abilities. However, we found that participants were able to identify with the main character.[7] Furthermore, they had no motive to underperform, nor do we have reasons to assume that their memory performance was shaped by demand characteristics. After all, for a naïve participant, it is difficult to anticipate what a discrepancy-detection-like pattern of performance looks like. Thus, we believe that our findings bear relevance to the practical context of intoxicated defendants and witnesses. Is it better to interrogate such a defendant or witness immediately or wait until he or she is sober again? Police officers regularly interview a suspect or witness while he or she is still intoxicated, and also hold the belief that more critical information is disclosed during an immediate interrogation (Evans et al., 2009; van Oorsouw et al., 2013). The present findings demonstrate that during the second (sober) test, *all* participants were better at a free recall test of the *enacted* part of the mock crime as compared with the first test. In addition, only participants who had initially been severely intoxicated demonstrated an improvement in cued recall memory during the sober test. Given this significant increase in correct recall, police officers are well advised to have the suspect or witness sober up before questioning.

One explanation for the increase in recall of action details over sessions might be reminiscence. Reminiscence refers to the phenomenon that repeated testing elicits memory details that were inaccessible during a previous test (Kelley & Nairne, 2003; Odinot, Wolters, & Van Giezen, 2013; Otani, Von Glahn, Goenert, Migita, & Widner, 2009). One reason why we obtained a reminiscence pattern for free recall of action elements in all participants might be that during the second session, testing conditions were more favourable (i.e. quiet environment and testing during the day) as compared with the first session (noisy bar and testing late at night). However, the reminiscence pattern was only apparent for free recall and action elements. Most importantly, initially intoxicated groups recalled overall fewer items on both sessions compared with sober participants.

The present findings lend support to the idea that poor memory makes it difficult to detect discrepancies between misleading information and what really happened. This explains why high levels of intoxication (i.e. BAC above 0.11%) increased the tendency to go along with misleading information (i.e. yielding). In comparison with sober participants, severely intoxicated participants were more likely to

[7] Although one could argue, of course, that these self-reports were less credible owing to intoxication.

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opt for one of two false alternatives, or to endorse a suggested event. Severely intoxicated participants displayed this tendency both when questioned immediately as well as when sober again. According to the principle of discrepancy detection, poor memory for an event makes it difficult for individuals to detect discrepancies between what actually happened and what is only suggested (Peterson et al., 1990; Schooler & Loftus, 1986). We believe that this principle helps to understand the pattern found in the current study: Lacking specific and detailed memories of an event due to impaired encoding makes intoxicated participants more prone to go along with misleading questions. Because raised suggestibility levels were only evident for severe and not moderate intoxication, one could speculate that suggestibility increases merely when correct recall is compromised to a considerable extent.

We found that it was the tendency to go along with leading questions rather than the tendency to change answers after negative feedback ('shift') that was affected by higher levels of intoxication during encoding. This is in accordance with the Santtila et al. (1999) study, which also noted that intoxication was not related to an increased propensity to change answers after receiving negative feedback. Apparently, yielding and shifting are two distinct types of suggestibility that are not affected by intoxication in a similar way. We would argue that the memory-undermining effect of intoxication and its inference with discrepancy detection promotes yield suggestibility (i.e. acceptance of misinformation), while the anxiolytic properties of alcohol work against shift suggestibility (i.e. acceptance of misinformation under the pressure of negative feedback).

One limitation of our study was that the second test session was conducted over the telephone. This may have reduced participants' anxiety in comparison with the first session. The decrease in shift scores over sessions seems to support this interpretation. Unfortunately, we did not ask participants how anxious they felt. The links between intoxication, anxiety, and suggestibility clearly warrants further research. What can be said with some confidence on the basis of the current findings, however, is that poor memory mediates the increased tendency to go along with leading questions, especially when participants are immediately questioned in a misleading way.

Another limitation of our study is the repeated testing design that we employed. One could speculate that repetition of the same memory test within a timeframe of a few days in sober–sober versus intoxicated–sober participants contributed to artificial group differences (e.g. sober participants who feel familiar with the test vs. previously intoxicated participants who feel less familiar with it). As mentioned earlier, reminiscence in free recall of action details was demonstrated for all groups, indicating some beneficial effects of repeated testing in all participants. Yet, only previously severely intoxicated participants exhibited an increase over sessions in cued recall, perhaps reflecting a regression to the mean. Nevertheless, overall, previously intoxicated participants performed significantly worse than control participants. Our point is that these findings cannot be explained solely in terms of practice effects. More generally, some authors have argued that we should not exaggerate the effects of repeated testing (e.g. Greiffenstein, 2009). Still, a design including delayed-test only groups would, of course, be more ideal and future studies may want to include such groups in order to exclude practice effects.

Another limitation that is typical for this sort of field study is that it lacks control over potential confounders such as health factors and the amount of alcohol participants consume after the experimenters leave the scene. However, such confounders will introduce noise, and it is likely that they lead to an underestimation of intoxication-memory effects. Another factor that could have obscured the results is fatigue. That is, some participants were tested early in the evening and others in the middle of the night. But again, time of testing will have introduced error noise and therefore will have led to underestimation of effects.[8] The same is true for the relatively short interval between mock crime and first interview. Of course, a police interrogation is unlikely to be conducted some 10 minutes after the crime took place. But with a longer time interval—say 30–60 minutes—and keeping the slow breakdown of alcohol in mind (0.02% per hour), it is plausible that stronger memory-undermining effects of intoxication will occur.

Despite these limitations, our results indicate that it could be beneficial to wait with interrogating an intoxicated suspect or witness until he or she has sobered up. Evans and colleagues (2009) found that intoxicated suspects are more likely to waive their Miranda rights and incriminate themselves. These are alarming observations considering that we found intoxication to be associated with poorer memory and heightened suggestibility.

Criminal courts frequently face complications when defendants or witnesses have been intoxicated. In such cases, expert witnesses are often appointed to examine, for example, claims of amnesia. Given the limited number of studies in this domain, we need more research on the links between alcohol, memory, and suggestibility so as to be better able to inform triers of fact in intoxication cases. The present study is one step in that direction. It clearly shows that intoxication interferes with memory completeness in a dose-dependent manner.

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[8] There was no interaction between time of testing (before or after midnight) and group, or a main effect of time of testing on any of the dependent variables (all Fs < 3.4, all ps > 0.05).

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