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A meta-analysis of the effects of acute alcohol intoxication on witness recall

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Summary

There is widespread belief in the legal system that alcohol impairs witness testimony. Nevertheless, most laboratory studies examining the effects of alcohol on witness testimony suggest that alcohol may affect the number of correct but not incorrect details recalled. However, it is difficult to draw conclusions because sample sizes, testing paradigms, and recall measures vary between individual studies. We conducted a meta-analysis to address this issue. We found alcohol intoxication had a significant and moderate sized effect on the number of correct details recalled (g = 0.40). The effect of alcohol on the number of incorrect details recalled was not significant. Further, the effect of alcohol on the recall of correct details was significantly moderated by multiple factors like intoxication level, the retention interval length between encoding and recall, and the types of questions asked (i.e., free recall vs. cued recall). We discuss the applied implications of the results.

KEYWORDS

alcohol, eyewitness, investigative interviews, memory, recall, witness

1 | INTRODUCTION

On the night of 24 October 2015, Matthew McKay and Matthew Miles drunkenly left a party, hosted by the son of a police officer, after allegedly stealing a handgun from a police van. They later encountered two teenage girls, one of whom was Calli Vanderaa. After a brief disagreement, a bullet was fired through a car window, hitting Vanderaa in the chest. Both boys were arrested later that day, and on January 2018, the case was taken to court. While Miles was charged with theft and sentenced to 42 months in prison, McKay was acquitted of attempted murder because all of the people who witnessed the crime were alcohol intoxicated. The witnesses were aware that a gun was present, but they did not unanimously identify who fired it. Due to the witnesses' intoxicated states, the judge cast doubt upon their testimony, and this led to McKay's freedom (Malone, 2018). The case is a prime example of the impact that eyewitness alcohol intoxication can have on criminal cases.

The view that alcohol impairs memory is widespread in the legal system. Both police officers (Evans, Schreiber Compo, & Russano, 2009) and lay people (Benton, Ross, Bradshaw, Thomas, & Bradshaw, 2006; Evans & Schreiber Compo, 2010; Houston, Hope, Memon, & Read, 2013; Lynch, Wasarhaley, Golding, & Simcic, 2013) tend to view testimony as less accurate if it is given by someone who was intoxicated during the crime. In a survey of psychology and law experts, 90% agreed that alcohol impairs eyewitness performance, with 65% stating that they would be willing to proffer testimony about alcohol's negative effects (Kassin, Tubb, Hosch, & Memon, 2001). Basic memory research suggests that these views may be warranted. Even at low levels of intoxication, alcohol can have a negative effect on an individual's ability to pay attention and process visual and auditory stimuli (Calhoun et al., 2004; Dougherty, Marsh, Moeller, Chokshi, & Rosen, 2000). Research investigating the effects of alcohol on the accuracy of episodic memory is especially relevant for investigating the effects of alcohol on witness memory. Alcohol intoxication during encoding has been found to impair the recollection of specific episodic memory details (Bisby, Leitz, Morgan, & Curran, 2010; Mintzer & Griffiths, 2001). Thus, on the basis of these findings, we may expect that witnesses who were acutely alcohol

intoxicated compared with sober during a crime will remember the details about the crime less accurately.

The effect of acute alcohol intoxication on attention allocation may be one mechanism by which alcohol impairs witnesses' ability to remember a crime. According to alcohol myopia theory (AMT), alcohol's pharmacological effects cause an intoxicated person's attention to be allocated to the most central, or immediate and salient, cues in the environment (Steele & Josephs, 1990; Crossland, Kneller, & Wilcock, 2016). The AMT framework leads to the prediction that people who are alcohol intoxicated compared with sober during encoding will later remember details that are more peripheral less accurately, whereas memory for central details will be less affected by alcohol intoxication. In accordance with AMT, there is evidence that alcohol impairs memory for peripheral but not central details (Schreiber Compo et al., 2011). Findings are mixed, however, because other studies investigating differential effects of alcohol on memory for central versus peripheral details have found that both types of details were remembered more poorly by intoxicated compared with sober individuals (e.g., Van Oorsouw & Merckelbach, 2012).

Several studies assessing the impact of alcohol on testimony have found that participants who consumed alcoholic beverages prior to encoding recall fewer correct details when interviewed immediately afterwards while participants are still intoxicated (Altman, Schreiber Compo, McQuiston, Hagsand, & Cervera, 2018; Hildebrand Karlén, Roos Af Hjelmsäter, Fahlke, Granhag, & Söderpalm Gordh, 2017; Yuille & Tollestrup, 1990). However, several other studies have found no effect of alcohol on the number of correct details recalled (LaRooy, Nicol, & Terry, 2013; Schreiber Compo et al., 2011; Schreiber Compo et al., 2012; Schreiber Compo et al., 2016). Moreover, multiple studies assessing immediate recall have found no significant effect of alcohol intoxication during encoding on the number of incorrect details recalled (Altman et al., 2018; Hildebrand Karlén et al., 2017; LaRooy et al., 2013; Schreiber Compo et al., 2012; Schreiber Compo et al., 2016). This suggests that alcohol intoxication reduces the *completeness* of testimony. In other words, while people who have consumed alcohol prior to encoding may recall fewer correct details, they may not be more likely to recall incorrect details than do sober individuals.

The effects of alcohol on recall also seem to depend on the retention interval between encoding and test. A number of studies have investigated the impact of delayed testing on the accuracy of testimony provided by sober and intoxicated participants. Multiple studies have found that, for both sober and intoxicated participants, as the retention interval between the crime and recall increases, the number of correct details recalled decreases (Hagsand, Roos-af-Hjelmsäter, Granhag, Fahlke, & Söderpalm Gordh, 2013; Hagsand, Roos af Hjelmsäter, Granhag, Fahlke, & Söderpalm Gordh, 2017; Hildebrand Karlén et al., 2017; Schreiber Compo et al., 2016; Van Oorsouw & Merckelbach, 2012; Yuille & Tollestrup, 1990) and the number of incorrect details recalled increases (LaRooy et al., 2013; Van Oorsouw & Merckelbach, 2012; Yuille & Tollestrup, 1990). Thus, delayed recall can negatively affect the *accuracy* of testimony for both those who are sober and those who are intoxicated: People recalling an event after a delay may recall fewer correct details and more incorrect details, regardless of whether they were intoxicated during encoding.

Across studies, alcohol intoxication has had mixed effects on the accuracy of recall with regard to free- and cued-recall question types. To clarify, in free-recall questioning, the interviewer allows the witness to report all that they remember about an event without interruption or further instruction. In cued-recall questioning, the interviewer uses specific questions or prompts to acquire certain pieces of information. Previous research with sober individuals suggests that free-recall techniques can help to elicit larger amounts of correct information than can other question formats (Fisher, 1995; Memon, Meissner, & Fraser, 2010). Moreover, some studies suggest that cued questioning may lead to more incorrect details being reported than will free recall, as cued questioning can prompt individuals to respond even when they are unsure (Altman et al., 2018). It seems that cued-recall questions can reduce the quantity and quality of information (Schreiber Compo et al., 2012) and increase suggestibility (Altman et al., 2018) regardless of intoxication state. This is relevant as police have been found to use cued, closed, and also suggestive questions when interviewing witnesses (Fisher, Milne, & Bull, 2011). Because researchers in the alcohol eyewitness literature as well as police forces use free- and cued-recall techniques during witness interviews, it is important to examine how both types of questioning may affect the completeness and accuracy of recall in relation to alcohol intoxication during encoding.

The body of literature on alcohol and witness recall has grown rapidly in recent years, and a meta-analysis of these studies may help to clarify the mixed picture with regard to alcohol's effects on recall. From an applied perspective, a greater understanding of the effects of alcohol intoxication on witness recall is important because witness alcohol intoxication can carry significant weight in judicial proceedings. With these issues in mind, we conducted a meta-analysis of eyewitness memory studies in which alcohol intoxication was manipulated prior to participants' encoding an event and their ability to recall the event was measured. We tested whether alcohol intoxication during encoding affected the number of correct and incorrect details participants recalled.

In order to maintain generalisability to criminal cases, we included studies in which there was a crime as the to-be-remembered event. Some have argued that it may be unwise to assume alcohol effects found in studies employing basic memory tasks (e.g., memorising word lists or text passages, and recognition testing) generalise to real-life crimes, which are arguably more complex (Yuille & Tollestrup, 1990). Further, because crime often occurs in and around drinking establishments (e.g., Block & Block, 1995), we also included witness studies that involved participants in an interactive social event in a bar lab setting as the to-be-remembered event.

To accomplish our aims, we meta-analytically compared the number of correct and incorrect details reported as a function of acute alcohol consumption, and we examined possible moderators, including intoxication level during encoding and the retention interval between encoding and recall. In view of the legal system's assumption that alcohol decreases eyewitness memory accuracy, we tested whether

participants who had consumed alcohol prior to encoding would recall fewer correct details and more incorrect details than would their sober counterparts. We also tested whether alcohol's effects on recall would be larger for peripheral compared with central details, cued- compared with free-recall tests, and when participants were tested immediately while still intoxicated as opposed to later (after a delay period of days to a week) when sober.

2 | METHOD

2.1 | Sample

We searched online sources such as Google Scholar, PsycINFO, and PsycARTICLES, and JSTOR using various combinations of search terms, including alcohol, memory, eyewitness, eyewitness memory, crime, and recall. Of the 13 papers that we found, three were excluded because they tested participant memory using recognition questions, not free or cued recall. The total number of subjects across all 10 studies was 1,189. The mean age of participants ranged from 21.00 to 27.76 years, and the total sample consisted mostly of college undergraduates, or employees and volunteers from local bars. Two of these papers did not report the number of incorrect details reported by participants; the authors of those two papers were contacted, but they did not have any records of the desired data.

2.2 | Coding

Two of us (T. J. and H. S.) independently recorded information from the studies using the coding definitions described below. Results were compared, and discrepancies were reconciled, resulting in 100% agreement across coders. Typical methodological features, including the mean age, gender composition, sample, and group sizes, were recorded for each study. Alcohol groups were coded on the basis of the type of beverage (alcohol, non-alcohol) that participants consumed. The alcohol dose(s) employed in each study was also recorded. The mean breath alcohol concentration (BAC) for intoxicated participants ranged from 0.03 to 0.16. On the basis of the natural cut points in BAC levels across the studies, we formed two intoxication groups, with the moderate alcohol intoxication group composed of participants with BAC levels ranging from 0.03 to 0.09% and the high alcohol intoxication group composed of participants with BAC levels above 0.09%. Research suggests that BAC levels from these ranges are sufficient enough to induce episodic memory difficulties without causing adverse health consequences (Tracy & Bates, 1999). Control and placebo group participants drank no alcohol or a very small amount of alcohol; the BAC levels of participants in these groups were coded as zero.

We further coded information about the retrieval conditions of the studies, such as the procedures that were used to test the participants' memory (i.e., cued recall, free recall, and both cued and free recall); the retention interval between encoding and recall; the number of times that participants recalled the critical event; and the participants' recall state (i.e., whether participants recalled while intoxicated or when sober). The dependent variables were the number of correct and incorrect details recalled. For each study, we recorded the mean number of correct and incorrect details reported in each condition, the standard deviations for those means, and the number of participants in each condition of the study. In the studies that measured recall centrality (i.e., reported the number of central details and the number of peripheral details recalled), we also recorded the mean number of correct and the mean number of incorrect details recalled for central and peripheral details. Studies typically defined central details as information that pertained to the appearance and actions of the key individual (e.g., the culprit) and peripheral details as information regarding the participant's or key individual's surroundings (e.g., furniture and room size; Schreiber Compo et al., 2011; Van Oorsouw & Merckelbach, 2012).

2.3 | Meta-analytic approach

Using the computer program Jamovi (https://www.jamovi.org), one of us (T. J.) calculated mean weighted effect sizes for each study. For a given study, the standardised mean difference was computed to yield an effect size (*g*). A total of 48 effect sizes were calculated for correct details, and 24 effect sizes were calculated for incorrect details; eight papers reported the number of incorrect details recalled by participants. Past research suggests that aggregating results may increase statistical power and allow for more robust identification of moderating variables (Fawcett, Russell, Peace, & Christie, 2013). Therefore, we began our analysis by examining whether alcohol consumption influenced the number of correct details recalled and the number of incorrect details recalled, not taking into account any moderating influences, with a random effects model fit to the data. We also performed fail-safe *n* analysis and examined forest plots of the data. Significant effects were followed up with moderator analysis, which included retention interval (immediate or delayed), detail type (peripheral or central), non-alcohol group type (placebo or control), intoxication level (moderate or high intoxication), and question type (free or cued recall).

3 | RESULTS

3.1 | Methodological overview

From Table 1, it is clear that most studies were lab based and employed control groups in which participants did not consume alcohol and did not believe that they had consumed alcohol. Moreover, in most studies, mean BAC ranged from 0.3 to 0.9. From Table 1, we can see that most researchers used mock-crime videos as stimuli, and burglaries and thefts were the most common types of crime presented. Researchers also used verbal interviews most often, and only two studies used written interviews. Interviews involved free- and cued-recall questions most often. Moreover, the researchers used

TABLE 1 Summary of the methodological characteristics of each study

Study	Year	*N*	Participants	Mean age (*SD*)	Experiment	Non-alcohol group	Intoxication levels
Altman et al	2018	138	Bar patrons	27.67 (7.91)	Field	Control	Moderate and high
Hagsand et al.	2017	99	Staff/ students	24.76 (4.19)	Lab	Control	Moderate
Hildebrand Karlén et al.	2017	136	Students	24.76 (4.19)	Lab	Control	Moderate and high
Schreiber Compo et al.	2016	249	Students	24.36 (4.53)	Lab	Placebo and control	Moderate
Hagsand et al.	2013	126	Staff/ students	26.00 (3.26)	Lab	Control	Moderate
LaRooy, Nicol, & Terry	2013	58	Students	21.50 (2.20)	Lab	Placebo	Moderate and high
Schreiber Compo et al.	2012	93	Students	24.00 (4.60)	Lab	Control	Moderate
Van Oorsouw & Merckelbach	2012	76	Bar patrons	21.00 (2.25)	Field	Control	Moderate and high
Schreiber Compo et al.	2011	94	Students	24.00 (N/A)	Lab	Placebo and control	High
Yuille & Tollestrup	1990	120	Students	21.20 (N/A)	Lab	Control	Moderate

Study	Stimulus type	Event details	Interview	Question type	Immediate	Delayed	Immediate + Delay	Incorrect details analysis presented?
Altman et al.	Mock-crime video	Armed robbery	Verbal	Free and cued recall	Yes	N/A	N/A	Yes
Hagsand et al.	Mock-crime video	Kidnapping	Verbal	Free and cued recall	15 min	1 week	Yes	Yes
Hildebrand Karlén et al.	Mock-crime video	Argument	Verbal	Free recall	10 min	1 week	Yes	No
Schreiber Compo et al.	Mock-crime video	Theft	Written	Written Free and cued recall	10 min	1 week	N/A	Yes
Hagsand et al.	Mock-crime video	Kidnapping	Verbal	Free recall	N/A	1 week	N/A	Yes
LaRooy, Nicol, & Terry	Mock-crime video	Armed robbery	Written	Written free recall	30 min	1 day	N/A	Yes
Schreiber Compo et al.	Live staged event	Theft	Verbal	Free, cued or mixed recall	20 min	N/A	N/A	Yes
Van Oorsouw & Merckelbach	Mock-crime video	House robbery	Verbal	Free and cued recall	N/A	3–5 days	N/A	Yes
Schreiber Compo et al.	Interaction	Bar		interaction	Written	Free recall	1–2 min	N/A
N/A	Yes							
Yuille & Tollestrup	Live staged event	Theft	Verbal	Free and cued recall	30 min	1 week	Yes	No

Note. Moderate intoxication includes the breath alcohol concentration (BAC) range 0.03–0.09. High intoxication includes the BACs of 0.10 and above.

various combinations of immediate and delayed interviews, with some studies interviewing participants at multiple instances. A total of three papers indicated that researchers interviewed participants immediately after encoding while the alcohol group participants were still intoxicated, and one paper indicated that researchers interviewed participants after a delay period when all participants were sober. Furthermore, five papers indicated that researchers interviewed participants in separate immediate and delayed recall groups, and in three of those five, researchers also interviewed one group of participants immediately and after a delay period (from a few days up to a week later).

3.2 | Aggregate analysis

3.2.1 | Correct details

Figure 1 shows a forest plot including all 48 group comparisons regardless of methodologies employed in the studies (e.g., recall state and intoxication level). The polygon at the bottom of the plot reflects the main effect size, and each individual box plot reflects the mean difference between groups along with the 95% confidence intervals. The correct details meta-analysis yielded an aggregate effect size of $g = 0.40$, 95% CI [0.21, 0.59], $p < 0.001$, indicating a significant and moderate

effect of alcohol on the number of correct details recalled, with participants who had consumed alcohol recalling fewer correct details. A fail-safe *n* analysis was conducted as a measure of the number of studies with effect sizes of zero needed to render the effect of alcohol nonsignificant; the analysis suggested 1,556 additional analyses would need to be conducted to render the findings null. Heterogeneity statistics indicated that the results of the correct details meta-analysis were significantly heterogeneous (I^2 = 82.57% p < 0.001). Thus, subset analyses were performed, and the results are presented in Section 3.3.

3.2.2 | Incorrect details

The incorrect details meta-analysis yielded an aggregate effect size of g = −0.08, 95% CI [−0.21, 0.05], indicating that alcohol had a nonsignificant effect (p = 0.226) on the number of incorrect details reported. Figure 2 shows the forest plot for this analysis with 24 comparisons. No further analyses were needed to render the effect null because it was already null. This result was also not significantly heterogeneous (I^2 = 0.03%, p = 0.086), indicating that additional subset analyses were not necessary.

3.3 | Subset analyses for the number of correct details recalled

Given the heterogeneity of the correct details meta-analysis results, subset analyses were performed to examine the effect of alcohol on the number of correct details recalled as a function of intoxication level during testing (moderate or high), the type of detail reported (peripheral or central), retention interval (immediate or delayed), non-alcohol group type (control or placebo), and question type (free or cued); see Table 2 for a summary of effect sizes and p values for each of these analyses. Each analysis below represents a separate random effects model (e.g., Fawcett et al., 2013).

3.3.1 | Intoxication level analysis

For this analysis, we compared the number of correct details recalled by sober (placebo and control group) participants with the number of correct details recalled by moderately intoxicated participants (i.e., 0.03–0.09 BAC). We then compared the number of correct details

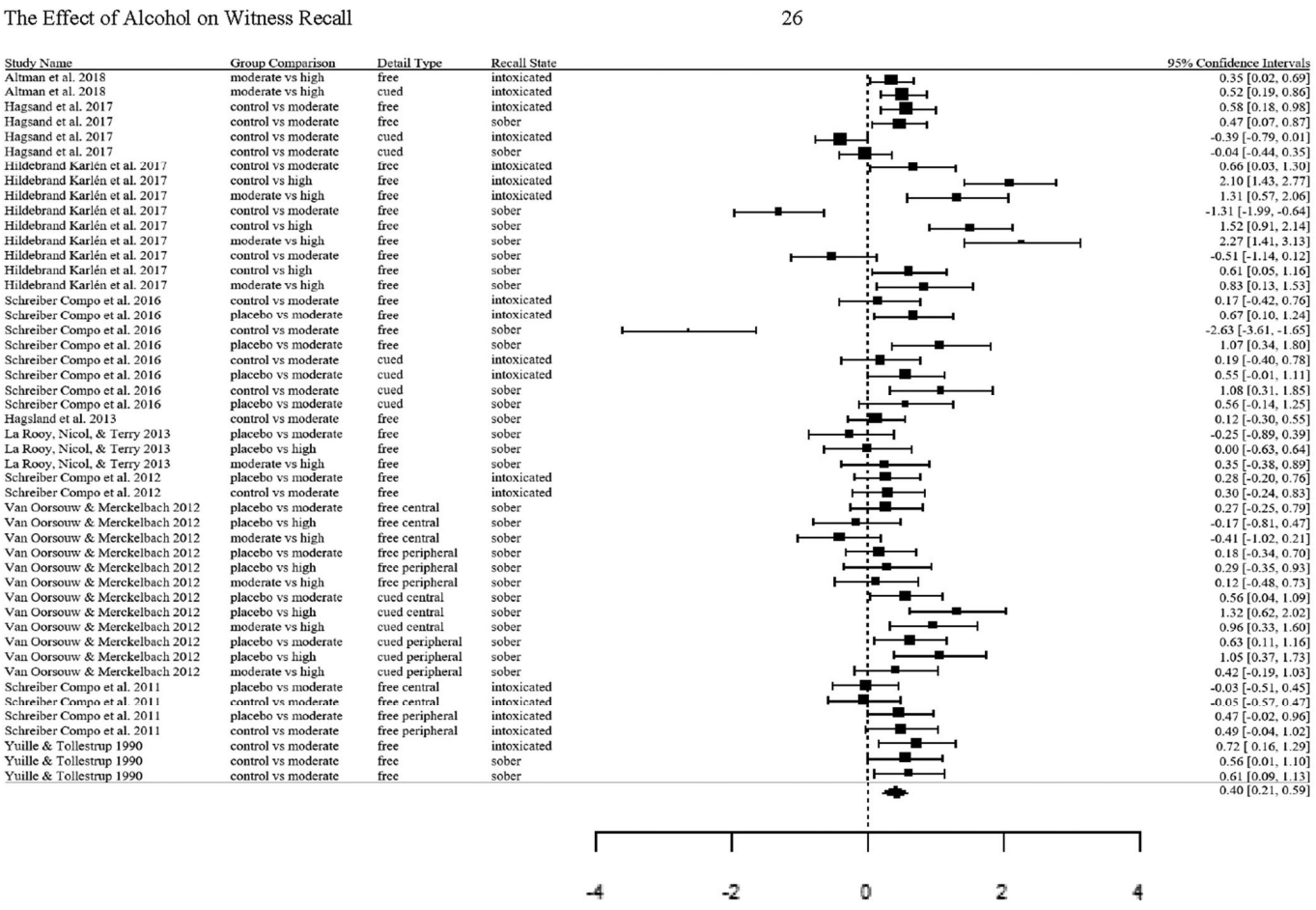

FIGURE 1 A forest plot displaying the individual effect sizes for each comparison between participant groups (e.g., control vs. moderate intoxication group) for the number of correct details recalled (organised by study). The detail type heading represents the type of detail reported by participants, and the recall state heading details the participants' physiological state at interview. Each box plot represents an effect size with confidence intervals on either side, which determine the length of the scale at the bottom. The polygon at the bottom reflects the aggregate effect size calculated by a random effects model

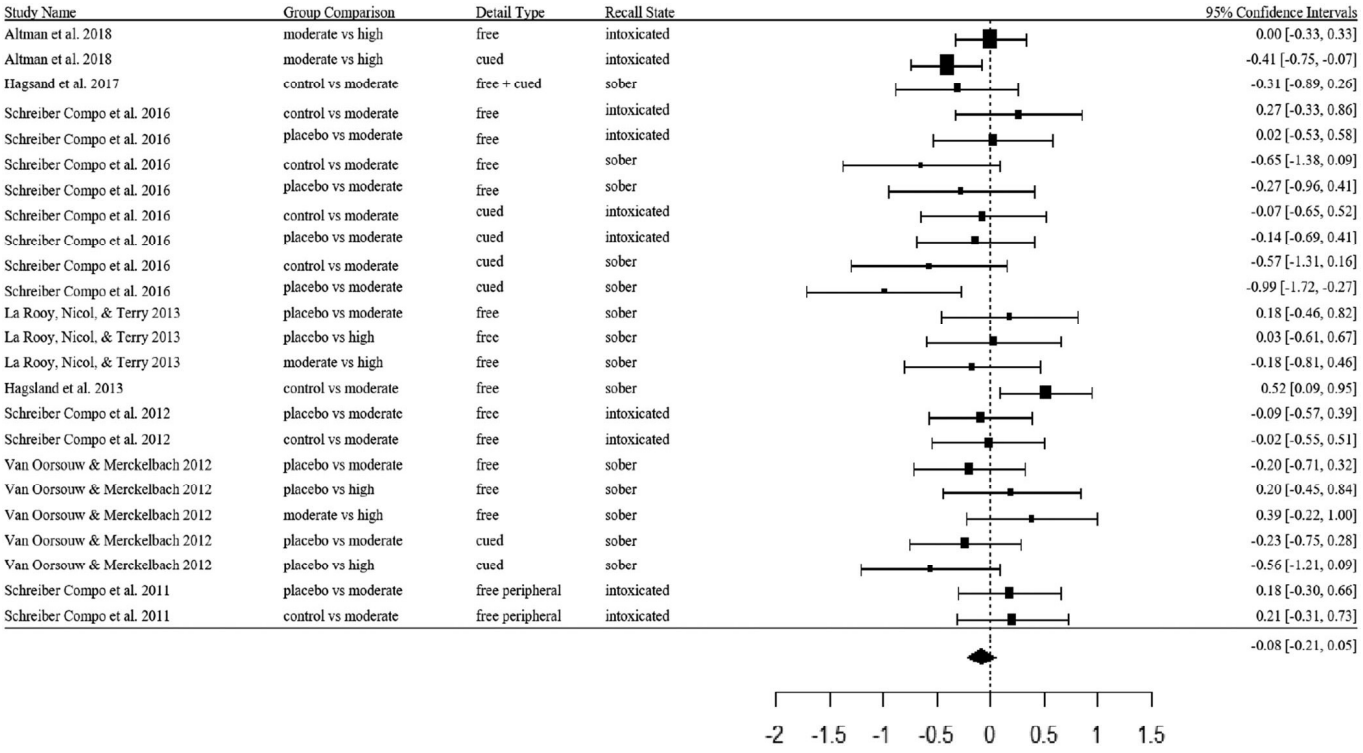

FIGURE 2 A forest plot with the individual effect sizes for each comparison between participant groups for the number of incorrect details recalled (arranged by experiment); each box plot represents an effect size with confidence intervals on either side, which determine the length of the scale below. The range of confidence intervals was lower in this analysis, which is why the scale is smaller. The polygon at the bottom reflects the aggregate effect size calculated by a random effects model

recalled by sober participants with the number of correct details recalled by highly intoxicated participants (i.e., 0.10 BAC and above). Across all the studies, the mean BAC levels for alcohol groups classified by the researchers as moderately intoxicated ranged from 0.03 to 0.09, and the mean BAC levels for alcohol groups classified as highly intoxicated were equal to or above 0.10. On the basis of these natural cut-off points, we formed two alcohol groups, moderate intoxication and high intoxication. The moderate intoxication analysis involved nine studies and 30 comparisons, and the high intoxication analysis involved four studies and 18 comparisons. Moderate alcohol intoxication had a small but statistically significant effect (g = 0.22, p = 0.03), and high alcohol intoxication had a large and statistically significant effect (g = 0.72, p < 0.001) on the number of correct details recalled. This indicates that moderate levels of intoxication reduced the number of correct details reported, but higher levels of intoxication reduced the number of correct details reported to a greater extent.

3.3.2 | Detail type analysis

This analysis compared the number of correct central and peripheral details recalled by sober and intoxicated participants. Each analysis involved two studies and eight comparisons. Alcohol intoxication had no significant effect on the number of correct central details reported (g = 0.02, p = 0.935) but did have a small albeit significant effect, leading to a reduction in the number of correct peripheral details reported, g = 0.27, p < 0.001.

TABLE 2 Summary of subset analyses on number of correct details remembered with effect sizes (g), standard error (SE), Z scores, p values, and 95% confidence intervals

Subset		g	SE	Z	p	95% CI
Detail type	Peripheral	0.44	0.10	4.35	<0.001	[0.24, 0.64]
	Central	0.02	0.30	0.08	0.935	[−0.56, 0.61]
Retention interval	Immediate	0.35	0.15	2.44	0.015	[0.07, 0.64]
	Delayed	0.46	0.12	3.94	<0.001	[0.23, 0.69]
Non-alcohol group	Control	0.27	0.19	1.40	0.161	[−0.11, 0.64]
	Placebo	0.41	0.09	4.38	<0.001	[0.23, 0.60]
Intoxication level	Moderate	0.23	0.11	2.14	0.032	[0.02, 0.44]
	High	0.72	0.17	4.26	<0.001	[0.39, 1.05]
Question type	Free	0.35	0.13	2.72	0.006	[0.10, 0.60]
	Cued	0.52	0.14	3.84	<0.001	[0.26, 0.79]

3.3.3 | Retention interval analysis

In this analysis, we compared the number of correct details recalled by sober participants who were interviewed immediately after encoding with the number of correct details recalled by intoxicated participants who were interviewed immediately after encoding. We also compared the number of correct details recalled by participants who were sober during encoding and were interviewed after a delay period with the number of correct details recalled by participants who were intoxicated during encoding and were also interviewed after a delay period when sober.

The immediate recall analysis involved seven studies and 30 comparisons, and the delayed recall analysis involved seven studies and 16 comparisons. Alcohol intoxication had a moderate and significant effect, leading to a reduction in the number of correct details reported during immediate recall when participants in the alcohol group were still intoxicated, $g = 0.46$, $p < 0.001$. Alcohol intoxication also significantly reduced the number of correct details recalled after a delay period when all participants were tested sober, with the size of the effect being moderate, $g = 0.35$, $p = 0.015$.

3.3.4 | Non-alcohol group analysis

This analysis compared the number of correct details recalled by placebo group participants, who believed they had consumed alcohol when they had not, with the number of correct details recalled by intoxicated (both moderately and highly intoxicated) participants. We also compared the number of correct details recalled by control group participants, who did not consume alcohol, with the number of correct details recalled by intoxicated participants. The placebo group analysis involved five studies and 17 comparisons, and the control group analysis involved seven studies and 21 comparisons.

When placebo groups were used as the non-alcohol comparison group, alcohol intoxication reduced the number of correct details recalled, with the effect being moderate in size, $g = 0.41$, $p < 0.001$. When control groups were used as the non-alcohol comparison group, alcohol intoxication had a nonsignificant effect on the number of correct details recalled, $g = 0.27$, $p = 0.161$. This indicates intoxication had no effect on the number of correct details recalled when control group participants (who knowingly did not consume alcohol) were compared against intoxicated groups, but alcohol had a large effect on the number of correct details recalled when placebo groups were compared against intoxicated groups.

3.3.5 | Question type analysis

For this analysis, we compared the number of correct details reported by sober participants during free recall—where participants reported as much information as they could remember without leading questions or prompts—with the number of correct details reported by intoxicated participants during free recall. Next, we compared the number of correct details reported by sober participants during cued recall—where participants were asked to provide information in response to direct questions from the interviewer—with the number of correct details reported by intoxicated participants during cued recall.

The free-recall analysis involved all 10 studies and 35 comparisons, and the cued recall analysis involved four studies and 13 comparisons. Alcohol intoxication reduced the number of correct details reported during free recall, with the size of the effect being small ($g = 0.35$, $p < 0.001$) and reduced the number of correct details reported during cued recall, with the size of the effect being moderate ($g = 0.52$, $p < 0.001$). This suggests that alcohol intoxication reduced the amount of correct information recalled in response to both free-recall and cued-recall questions and had a larger sized effect on the number of correct details reported during cued recall.

4 | DISCUSSION

We meta-analytically investigated whether the number of correct and incorrect details recalled in eyewitness studies was significantly impaired by alcohol intoxication during encoding. Although findings across individual studies are mixed, our meta-analytic results that aggregated data across studies indicated that acute alcohol intoxication significantly decreased the number of correct details recalled but did not increase number of incorrect details recalled to a statistically significant degree. This suggests that alcohol intoxication during encoding reduces the *completeness* of recall: Generally speaking, people who have consumed alcohol prior to encoding may recall fewer correct details but do not seem to be more likely to recall incorrect details. Moreover, we found that the detrimental effect of alcohol on the number of correct details reported was moderate in terms of effect size. The size of this alcohol effect was, however, moderated by several variables.

One variable that moderated the size of the effect of alcohol on the number of correct details recalled was the level of intoxication. Compared with no intoxication, high levels of intoxication had a large, detrimental effect on the number of correct details recalled; however, moderate levels of intoxication had a smaller (but still statistically significant) detrimental effect on the number of correct details recalled. These results suggest that highly intoxicated witnesses may provide less complete testimonies. Our highly intoxicated group included participants with BAC of 0.10 and above. Many real-world witnesses are considerably intoxicated (Hagemann et al., 2013; BAC levels above 0.18) and more intoxicated than are participants consuming alcohol in laboratory studies. As such, future research should sample self-intoxicating participants in real-world drinking establishments so that the effects of larger doses of alcohol on memory performance can be investigated (e.g., Altman et al., 2018). However, the causal effects of alcohol on memory might be difficult to determine using self-intoxicating participants given that alcohol dose will likely covary with other individual differences associated with memory performance.

Another important moderating variable was the type of non-alcohol control group employed. Considering the number of correct details recalled, we found no significant difference between control

group participants and intoxicated participants, but we found a large and statistically significant difference between placebo group participants and intoxicated participants. This suggests that the recall of placebo group participants, who believed that they had consumed alcohol when they had not, was more complete than that of intoxicated participants, while the number of correct details recalled by control group participants and intoxicated participants was more similar. Placebo participants may have been influenced by expectancy effects, and thus, became hypervigilant with respect to their performance during encoding and/or retrieval. Previous research suggests that placebo participants can employ compensatory behaviour in expectation of impaired performance (Fillmore & Blackburn, 2002; Flowe, Takarangi, Humphries, & Wright, 2016; Schreiber Compo et al., 2016; Testa & Parks, 1996). This raises an interesting question of whether future alcohol eyewitness memory studies should use placebo or a no-alcohol-consumption control group for comparison. Research suggests that both types are important for disentangling the psychological and pharmacological effects of intoxication on eyewitness recall (Schreiber Compo et al., 2011; Schreiber Compo et al., 2016). Using only one comparison group may lead to overestimation or underestimation of the effects of alcohol intoxication on recall.

Retention interval also moderated the size of the effect of alcohol on the number of correct details recalled. The retention interval analyses revealed that alcohol intoxication decreased the number of correct details recalled by intoxicated participants both when interviews were conducted immediately (when participants who were alcohol intoxicated during encoding were still intoxicated) and when interviews were conducted after a delay period (when all participants were sober). This suggests that intoxication at encoding decreased the amount of correct details recalled immediately after encoding, and over time (i.e., days–weeks after encoding). Many individual studies have found that alcohol intoxication had no significant effect on the recall of correct details immediately after encoding (Hildebrand Karlén et al., 2017; Schreiber Compo et al., 2016). We may have found a significant effect because data were aggregated across studies and because our analysis included highly intoxicated participants from field studies whose immediate recall was far worse due to their extreme intoxication (e.g., Altman et al., 2018). It should also be noted that six of the seven studies using a delay period did not control for the change in intoxication state between study and test (Hagsand et al., 2013; Hagsand et al., 2017; Hildebrand Karlén et al., 2017; LaRooy et al., 2013; Van Oorsouw & Merckelbach, 2012; Yuille & Tollestrup, 1990). It is possible that the change in intoxication state between encoding and test, and not the delay itself, could account for the poorer performance in the alcohol-intoxicated groups (Crow & Ball, 1975; Weingartner, Adefris, Eich, & Murphy, 1976; Weingartner & Faillace, 1971; see Schreiber Compo et al., 2016, for a discussion on the issue). Future eyewitness memory studies should investigate same-state and different-state recall over delay periods to further understand the underlying mechanisms.

Finally, we found that the type of detail recalled moderated the size of the alcohol effect. Specifically, our analyses indicated that alcohol had a significant and detrimental effect on the number of peripheral but not central correct details recalled. This suggests that central correct details were remembered equally well across sober and intoxicated groups, while correct peripheral details were not. This finding is consistent with previous research (e.g., Bisby et al., 2010; Mintzer & Griffiths, 2001) and is in line with the AMT (Steele & Josephs, 1990) framework as applied to eyewitness memory (e.g., Schreiber Compo et al., 2011), which proposes that memory for central but not peripheral details is affected by intoxication. It is important to note, however, that only two studies reported recall results for central versus peripheral information and only 16 comparisons between sober and intoxicated groups were conducted with respect to peripheral and central detail analyses. As such, this is a relatively tentative conclusion.

The findings of this meta-analysis have several applied implications. First, the effect of alcohol on the number of correct details recalled was of moderate size. This suggests that intoxicated witnesses might provide fewer correct details when questioned using free and cued recall. Second, alcohol impairment was worse in conditions of high intoxication compared with relatively moderate intoxication levels. Also, alcohol reduced the number of correct peripheral details recalled, but not the number of correct central details recalled. Together, these factors could be taken into account when evaluating the completeness of a witness's statement. Generally speaking, it suggests that witnesses who were only moderately intoxicated during encoding would be likely to recall complete information about the salient or central details of an event.

Third, regarding the retention interval between encoding and recall, we found a larger difference between the alcohol and non-alcohol groups when participants were interviewed immediately (and participants in the alcohol group were still intoxicated) than when participants were interviewed after a delay (and all participants were sober). Nevertheless, if police delay an interview until an individual is sober again, they may risk losing valuable information due to natural forgetting (Hildebrand Karlén et al., 2017). Research indicates that interviewing intoxicated witnesses immediately after the crime may have a beneficial effect on memory consolidation (Baddeley, Allen, & Hitch, 2011; Hildebrand Karlén et al., 2017); thus, repeated interviews at multiple time points with witnesses who were intoxicated at encoding seem to result in the most complete recall, provided that the interviews are conducted according to the appropriate guidelines and are nonsuggestive. Therefore, more research is required to fully understand the effects of retention intervals between encoding and interview especially with regard to the effects of immediate, delayed, and repeated interviewing on correct recall.

Fourth, the completeness of recall in response to free and cued questioning was significantly affected by intoxication. Specifically, intoxication had a moderate effect on the number of correct details recalled during cued recall and a smaller effect on number of correct details recalled during free recall. Very few studies investigated the effect of intoxication and question type on recall, and only four out of the six studies reported completeness information with regard to cued questioning. Even so, some previous research has also found similar results suggesting that cued questioning negatively affects

recall when participants are intoxicated at encoding (Schreiber Compo et al., 2012; Van Oorsouw & Merckelbach, 2012); however, other research has found no effect of intoxication on recall accuracy across question types (Hagsand et al., 2017). Thus, it is integral that future research be conducted to gain a greater understanding of the effect of question type on the recall of intoxicated witnesses so that the police can use procedures that may benefit the quality of eyewitness testimony in the field.

Finally, but perhaps most importantly, alcohol intoxication at encoding did not significantly increase the number of incorrect details reported. Contrary to popular opinion (see Benton et al., 2006; Evans et al., 2009), this suggests that witnesses who were intoxicated at encoding may not be inherently unreliable, because they are not more likely to recall inaccurate information. Our meta-analysis suggests that witnesses who were alcohol intoxicated during the crime may provide less *complete* testimony in that they recall fewer correct details. Nevertheless, it is important to emphasise that two papers did not report the number of incorrect details recalled by participants, which may limit our ability to draw a firm conclusion. However, in both of these papers, the researchers stated that the amount of incorrect details did not differ significantly between groups (Hildebrand Karlén et al., 2017; Yuille & Tollestrup, 1990). Therefore, it seems unlikely that inclusion of these two studies in our meta-analysis would have led to a different conclusion.

Our findings have important implications for the legal system because, contrary to commonly held views in the legal system that intoxicated witnesses are unreliable, our results suggest that while intoxicated compared with sober witnesses provide testimony that is less complete, their testimony is no more likely to contain inaccurate details. On the basis of our findings, we highly encourage law enforcement, policymakers, and the judiciary to consider their treatment of intoxicated witnesses and victims. Dismissing testimony simply because the witness or victim was alcohol intoxicated during the crime may result in the loss of accurate memory evidence and valuable intelligence. In violent crimes, such as rape, witnesses and victims are frequently intoxicated (e.g., Palmer, Flowe, Takarangi, & Humphries, 2013). By discounting the trustworthiness of testimonial evidence on the basis of witness/victim alcohol intoxication alone, justice officials may be losing vital information. Further, police guidance specifically for interviewing intoxicated victims and witnesses is warranted. Worldwide, there is little to no guidance on interviews with witnesses and victims who were alcohol intoxicated during the crime. Guidance would enable interviewers to obtain better quality memory evidence from these witnesses and victims. For instance, in the interest of building a better case, police may strive to obtain the most comprehensive account possible from interviewees and press them to remember as many details as possible (e.g., McMillan & Thomas, 2009). Guidance that provides police interviewers with the knowledge that intoxicated compared with sober witnesses and victims will likely give less complete accounts may curb this tendency, which is important because there is some evidence that people who were alcohol and intoxicated when they witnessed an event may be more likely to yield to a questioner's suggestions (see van Oorsouw, Merckelbach, & Smeets, 2015).

In conclusion, given the mixed picture of alcohol intoxication's effects on eyewitness memory encoding in the literature, we conducted a meta-analysis to compare intoxicated and sober groups on measures of free and cued recall in studies that used an eyewitness memory paradigm. Alcohol intoxication reduced the number of correct details recalled (with a moderate effect size) but did not significantly increase the number of incorrect details recalled. Moreover, our results suggest that the detrimental effect of alcohol on the number of correct details recalled depends on a range of moderating factors, such as the level of witness intoxication at encoding, the centrality of information reported by witnesses, and the type of questioning used by interviewers. We encourage legal practitioners to evaluate their policies and practices with regard to intoxicated victims and witnesses to improve the quality of memory evidence in their cases that involve alcohol.

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