Contextual cues prompt greater improvements in alcohol consumption recall for people with higher working memory capacities

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ABSTRACT

Objective: Alcohol research often relies on surveys to assess how much alcohol participants consume. Therefore, improving accuracy in surveys is a priority for researchers. The aim of this study was to assess the relationship between working memory and self-reported alcohol consumption.

Method: Two hundred and eighty-five respondents (203 female, mean age = 55.60, SD = 7.35) were recruited online to complete three working memory tests and two alcohol consumption measures: one included contextual cues (Within-Location Beverage Specific; WLBS) and the other did not (Graduated Frequency; GF).

Results: Contrary to expectations, while all respondents reported higher alcohol consumption in response to the WLBS than the GF, those who scored high on working memory measures gained greater benefits from the inclusion of contextual cues than those who scored low.

Conclusions: Thus, while contextual cues in alcohol consumption surveys elicit higher levels of reported consumption, they may still lead to under-reporting by those with poorer working memories.

KEY POINTS

What is already known about this topic:
(1) People under-report their alcohol consumption
(2) Providing contextual cues in surveys can help
(3) Working memory influences ability to recall behaviours like alcohol consumption

What this topic adds:
(1) Increased contextual cues help those with better working memory
(2) While increasing contextual cues increase reported consumption, it does so disproportionately for those with good working memory
(3) While increased contextual cues lead to higher reported consumption they may also lead to increased under-reporting of a range of behaviours in those with poor working memory, relative to those who do not have poor working memory.

As a leading risk factor for global mortality (World Health Organization [WHO], 2009), alcohol consumption is responsible for 4.5% (6,600 deaths) in Australia (Australian Institute of Health and Welfare, 2018). Given the heavy demands alcohol places on healthcare systems worldwide, gaining accurate data is vital to help better understand the epidemiology of alcohol consumption and develop change programs and interventions to reduce negative health outcomes (Brener et al., 2003; WHO, 2000). Gathering accurate consumption data poses challenges because it relies predominantly on self-report, and individuals tend to under-report the amount of alcohol they consume (Greenfield & Kerr, 2008). Indeed, comparison of reported consumption volume with the per capita consumption calculated from sales data (amount of alcohol sold in a given country (alcohol production + imports – exports) divided by the number of adults; WHO, 2000) indicates that self-report surveys underestimate consumption by approximately 40–60% (Stockwell et al., 2004). Improving the accuracy of reporting is thus a priority for alcohol consumption research.

The Graduated Frequency (GF) questionnaire is a commonly used measure of alcohol consumption (Dawson, 2003; Rehm, 1998). The GF questionnaire asks respondents to report how often they have consumed different amounts of alcohol (e.g., 5–6 standard drinks) in the last 12 months (Hilton, 1989). The GF questionnaire captures 55% of...
alcohol sales data (Livingston & Callinan, 2015), suggesting respondents are substantially underestimating their alcohol consumption when using this commonly administered measure.

Both purposeful under-reporting and memory failure may contribute to the inaccuracies in reported consumption of alcohol. For example, an individual may intentionally alter the level of consumption disclosed to better align with perceived societal expectations and social norms for drinking behaviour (Greenfield & Kerr, 2008; Hilton, 1989; Monk & Heim, 2014). Whilst such intentional under-reporting has been well measured, work on how memory impacts reporting of alcohol consumption is rare. Recalling what was drunk and how often it was drunk is a cognitively demanding task that requires working memory to retrieve consumption information from long-term memory (e.g., Unsworth et al., 2013). Indeed, there is evidence to suggest that people will report drinking more alcohol if they are able to report it during the drinking occasion than if they are asked to recall how much the drank the next day (Dulin et al., 2017; Monk et al., 2014). While not definitive, these findings, combined with those that demonstrate that survey-based estimates of consumption are consistently lower than sales figures, suggest that consistently low reports of alcohol consumption in surveys are made in error. Working memory capacity consequently influences recall abilities; people with higher working memory capacities exhibit better recall and retrieval abilities than people with lower working memory capacities (Unsworth & Engle, 2007). Not surprisingly then, working memory capacity influences the accuracy of self-reported alcohol consumption (Stone et al., 1999). Factors that facilitate working memory are thus likely to enhance the accuracy of self-report measures of alcohol consumption.

As alcohol consumption is situation-specific, providing contextual cues (e.g., the setting in which drinking takes place) improves reporting accuracy (Casswell et al., 2002). When retrieving consumption information in response to a questionnaire item, people are thought to engage in a decision-making process in which they separate relevant from irrelevant information (Unsworth & Engle, 2007). Because this discrimination process increases the demands placed on working memory (Zacks et al., 1987), it requires greater attention and control than simple tasks (Borella et al., 2008). Providing contextual cues (environment or external influences that prompt individuals to remember behaviour; Casswell et al., 2002) can thus aid participants’ recall (Unsworth & Engle, 2007), facilitating the process of discrimination and enhancing reporting accuracy. Accordingly, the Within-Location Beverage Specific (WLBS; Casswell et al., 2002) questionnaire uses contextual cues about where alcohol was consumed (own home, someone else’s home, licenced premises) when asking respondents about their consumption. The WLBS captures 86–94% of taxable alcohol sales (Casswell et al., 2002; Livingston & Callinan, 2015), a marked improvement on the proportions reported using the QF questionnaire (49.8%) and the GF questionnaire (55%). The higher amounts of reported consumption in the WLBS is argued to reflect the benefits of contextual cues in aiding memory recall (Casswell et al., 2002; Stone et al., 1999), reducing the gap between reported alcohol consumption and actual sales data.

In addition to location-based contextual cues, time-based contextual cues (e.g., asking about consumption on weekdays vs. weekends) also have the potential to decrease the gap between self-reported alcohol consumption and more objective sales measures. As individuals tend to consume more alcohol on weekends than on weekdays (Lau-Barraco et al., 2016; Woodyard & Hallam, 2010), using specific time cues as memory prompts should assist recall of alcohol consumption. Moreover, knowledge of the size of a standard drink for different beverage types (e.g., spirits, wines, beer) is poor (Kerr & Stockwell, 2012), with individuals typically pouring up to 25% more alcohol than the standard (Casswell et al., 2002). Providing respondents with information about the container types equivalent to specific beverages thus helps them to convert the amount of alcohol consumed into standard drinks (Dawson, 2003). In doing so it reduces the complexity of the task by assisting working memory (Midanik & Hines, 1991), making it easier for individuals to accurately report their consumption levels.

As contextual cues improve memory recall, alcohol consumption measures that provide contextual cues should obtain a higher level of self-reporting than would otherwise be captured (Dawson, 2003; Livingston & Callinan, 2015; Midanik & Hines, 1991; Monk & Heim, 2014; Stone et al., 1999). This difference is likely to be more pronounced for individuals with lower working memory capacities; as increased working memory capacity is linked to greater recall (Unsworth et al., 2013), the commonly used self-report measures of alcohol consumption (e.g., GF questionnaire) may be systematically underestimating alcohol consumption in people with poorer working memory capacities. Examination of the effects of contextual cues on recall of alcohol consumption is thus needed to determine whether the benefits of inclusion (and equally, the costs of exclusion) of contextual cues
differentially affect people with higher and lower working memory capacities.

The present study was thus designed to examine the influence of working memory capacity on self-reported alcohol consumption. Working memory was assessed using a forward digit span task to test the phonological loop (Baddeley, 1983, 2000), a backward digit span task to assess the central executive (Best, 2010; Gathercole & Pickering, 2000), and a mental rotation task to examine the visuospatial sketchpad (Geiser et al., 2006; Turgut, 2015). By comparing responses to two self-report measures of alcohol consumption, one that reduces the demands on working memory by including multiple contextual prompts (WLBS) and another that includes few contextual cues (GF), the study sought to determine whether poorer working memory capacity is associated with greater underreporting of alcohol consumption. Because the WLBS provides more contextual cues, it was expected to result in greater reporting of alcohol consumption than the GF across participants, with a proportionally higher reporting benefit for people with lower working memory capacities.

Method

Participants

A G*Power calculation was used to estimate the number of participants needed to achieve sufficient power (Faul et al., 2007). According to these calculations using an alpha (α) set at .05 and power of .80, a minimum of 270 participants was required to detect a medium effect size (d = 0.15) for a multivariate linear regression analysis. Participants were recruited from the general population using a Facebook advertisement. The wording of the ad was “Have you consumed alcohol within the past 12 months? Complete our short survey for a chance to win one of 3 $50 Coles vouchers”. Of the 1,766 potential participants who clicked the link, 640 consented to participate and 503 met the inclusion criteria (aged 30–65 years, live in Australia, be competent in understanding English). Recruitment began from 30 years of age due to younger adults being more likely to have inconsistent drinking patterns (Tucker et al., 2003), and fewer working memory deficits (Borella et al., 2008; Park et al., 2002). Furthermore, with Facebook usage significantly decreasing in individuals 65 years and older (Sensis, 2018), a cut off was made at 65 years of age to prevent a long tail with increasing age. Of the 503 respondents who met the inclusion criteria, 194 respondents dropped out of the survey before completing the alcohol and memory measures that are the core of this study and were removed. Of the remaining 309 participants, a further 15 (4.9%) were missing data on the questions on alcohol consumption and were excluded. After data cleaning, explained further in the results section, 25 respondents (8.1%) were removed. In the final sample of 268 respondents, 75.8% identified as female and there was a mean age of 55.4 (SD = 7.5).

Materials

All measures were administered online using the Qualtrics software program.

Self-report alcohol consumption measures

Graduated Frequency Questionnaire (GF; Hilton, 1989).

The GF questionnaire assesses drinking pattern and volume by measuring the frequency of alcohol intake across a range of quantities. It asks eight questions regarding how often (i.e., response options are every day, 5–6 days a week, 3–4 days a week, 1–2 days a week, 2–3 days a month, about 1 day a month, less often, never) participants consumed different amounts of alcohol (i.e., less than 1 standard drink, 1–2 standard drinks a day, 3–4 standard drinks a day, 5–6 standard drinks a day, 7–10 standard drinks a day, 11–19 standard drinks a day 20 or more standard drinks a day) within the past 12 months. A drinking session of 20+ standard drinks is conservatively assumed to be 21 drinks. Respondents are asked “Please record how often in the last 12 months you have had each of the following number of standard drinks in a day?” As the GF questionnaire asks participants to report levels of consumption in standard drinks, a link was provided to a standard drinks chart.

Total volume (amount of pure alcohol) is calculated by multiplying the mid-point of each drinking level (e.g., 5–6 standards drinks = 5.5) with the midpoint of frequency per year (1–2 times per week = 1.5 × 52 = 78 days per year) to get the number of standard drinks per year (Greenfield et al., 2009). As suggested by Greenfield (2000), a capping approach is used for any participants who provided more than 365 drinking days. This starts from the highest reported quantity per occasion and works downwards, capping once responses total more than 365 drinking occasions.

Within-Location Beverage Specific Questionnaire (WLBS; Casswell et al., 2002)

The WLBS questionnaire measures the frequency and quantity of alcohol consumption across different locations. Participants are asked to report how much alcohol (frequency) they usually consume on
a weekend (Friday-Sunday) and a weekday (Monday-Thursday) at three locations (own home, someone else’s home, licenced premises such as a bar, pub, restaurant or special event). These locations were chosen because they are thought to cover 89% of alcohol consumption in Australia (Callinan et al., 2016).

For each location participants select the types of alcohol (e.g., regular/full strength beer, cider, cask wine), and the container(s) from which they drank the beverage(s) (e.g., 330–375 ml can, pint glass) on a usual drinking occasion at that location. Participants are then asked how much they would usually consume for each beverage and container type chosen. For example: “How many 330–375 ml cans of regular/full strength beer would you usually have in your own home on the weekend?”.

The WLBS measure continually guides participants through the process of estimating consumption levels using contextual cues (location and time; weekend vs. weekday) to prompt memory recall. The total volume (amount of pure alcohol) is calculated by multiplying the frequency and the volume of reported alcohol consumed in each location and summing them to calculate total consumption for the year (Casswell et al., 2002).

Working memory measures

The Digit Span Forward Task (DSF; Jacobs, 1887). The DSF was included as a test of the phonological loop. The task asks participants to report a sequence of digits in the order they were presented (e.g., 4-6-7 as 4-6-7). Starting from a 3-digit sequence the number of digits increases for every correct response, up to a sequence length of 9-digits. The test ceases when either a) two incorrect responses are provided in succession, or b) when the 9-digit sequence is completed. Each incorrect response redirects participants to another sequence of the same length but with different numbers.

At the start of the test participants were provided with instructions and an example sequence of two digits. The instructions followed the model described by Buchanan (2016), modified to show the words “Ready”, ‘Ready’, ‘SET’, ‘GO’ one at a time for a duration of one second to prepare participants for the upcoming sequence. After ‘GO’ was shown the sequence of digits followed, flashing one at a time at one second intervals (Buchanan, 2016). After each sequence was complete the words ‘Your turn’ were displayed, signalling participants to click on the text-box and type out their response, using an ‘x’ to replace numbers they could not remember (Buchanan, 2016). Scores correspond to a participant’s largest sequence length, with a score of 1 assigned to every correct response and a 0 for every incorrect response. For example, a DSF score of 7 means that they correctly recalled a digit span sequence of 7.

The Digit Span Backwards Task (DSB; Jacobs, 1887). The DSB was used as a test of the central executive. The DSB presents participants with a sequence of digits, and participants are required to recall the digits in reverse order (e.g., 8-2-1 as 1-2-8). The format of the test was identical to the DSF, with the exception that the maximum sequence length was eight (Buchanan, 2016). Likewise, with 1 point given to correct responses and a 0 to incorrect responses, participants’ DSB scores are equal to the largest correctly recalled sequence length/digit sequence.

Mental Rotation Test (MRT; Vandenberg & Kuse, 1978). The MRT was included to assess the visuospatial sketchpad. Participants completed five trials with each trial containing five 3D block figures. The images included one target figure, two correct alternatives (rotated) and two incorrect figures (distractors; Thoresen et al., 2016; Vandenberg & Kuse, 1978). Participants are asked to indicate which two figures, labelled A, B, C and D, match the target figure by clicking the buttons on the display. Participants are awarded one point if both matching figures are correctly identified and 0 points if one or neither of the correct figures are identified, reducing the incentive for guessing (Vandenberg & Kuse, 1978). This results in a maximum score of five.

Demographics. A series of basic demographic questions were included, asking participants to indicate their age, gender, and highest level of education completed.

Procedure

Ethical approval to conduct this study was granted by the La Trobe University Human Research Ethics Committee (HEC19214). A Facebook advertisement was made available to individuals aged between 30 and 65 years living in Australia. The bottom of the advertisement included a link to “Learn More”, which directed potential participants to the study. Participants were first presented with the Participant Information and Consent Form which outlined the details of the study and consent procedure. Participants who wished to take part were asked to click ‘I agree, start survey’ to indicate their consent.

Respondents completed the online Qualtrics survey in their own time, at a location and with a device of their own choosing. First, screening questions were presented to determine eligibility. Respondents who met the inclusion criteria continued to the survey (respondents who did not were redirected to the end of the survey and thanked for their interest). After
completing two self-report alcohol consumption measures (GF, WLBS) and the three working memory tests (DSF, DSB, MRT), the demographic questions were presented. The order of working memory tasks was counterbalanced between participants. At the end of the survey respondents were thanked for their participation, and given the opportunity to go in a draw to win one of three AU$50 gift vouchers.

**Results**

The difference in reported volumes of the WLBS and GF was calculated by dividing the WLBS total by the GF total (hereafter termed the WLBS/GF ratio). So if a respondent reported consuming 300 standard drinks through the WLBS and 200 through the GF they would have a ratio of 1.5. A ratio >1.0 indicates that the WLBS captured a greater volume of consumption than the GF whereas a ratio <1.0 indicates that the GF captured a greater volume of consumption than the WLBS.

**Data cleaning**

Examination of outliers in the WLBS questionnaire resulted in the deletion of 25 participants because of out-of-range high values (e.g., 37,790.48, equating to 103.5 standard drinks per day), indicating errors in reporting (Callinan, 2019). Similarly, instances where the total volume was above 30 for one location on one occasion were removed because they are again likely to be errors in reporting (Callinan, 2019).

WLBS/GF ratio values outside the range of 0.10–10.00 (i.e., wherein the volume reported using one self-report measure was >10 times higher than the volume reported using the other self-report measure) were removed as they were deemed invalid responses. This was because a ratio of more than 10 between two alcohol measures was deemed less likely to reflect a genuine difference in reported consumption when asked two different ways and more likely attributable to reporting error. Furthermore, with the ratio serving as the outcome in our regression models, these respondents would be outliers.

**Descriptives**

Descriptive data for the self-report alcohol consumption measures, the WLBS/GF ratio, and the working memory measures are shown in Table 1. The average number of drinks per day reported in response to the GF questionnaire (M 2.77, SD 4.12). Indeed, as indicated in Table 1, the mean WLBS/GF ratio of 2.08 shows that on average participants reported twice as much alcohol consumption using the WLBS questionnaire than the GF questionnaire. However, it is worth noting that just over a quarter of respondents (26.87%) did report more alcohol consumption when using the graduated frequency measure.

**Data analysis**

Multivariate linear regression was used to examine the influence of working memory capacity (DSF, DSB and MRT used as predictors) on self-reported alcohol consumption (WLBS/GF ratio). All variables were entered simultaneously, and variance inflation factors were all <1.5, indicating that multi-collinearity was low.

As shown in Table 2, DSF was a significant predictor of the WLBS/GF ratio, explaining 2.50% of the variance, $\beta = .16$, $t(266) = 2.60$, $p = .010$. Similarly, DSB performance predicted WLBS/GF ratio, accounting for 2.90% of the variance, $\beta = .17$, $t(236) = 2.66$, $p = .008$. As such these data indicate that respondents with greater digit span performance had a larger difference in the volumes of alcohol reported using the WLBS questionnaires and GF questionnaires than respondents with lower digit span performance. In contrast, MRT performance was not a significant predictor,

| Variable | n  | Mean (M) | SD  | Minimum | Maximum |
|----------|----|----------|-----|---------|---------|
| GF total volume | 268 | 962.11 | 1413.16 | 9.00 | 7665.00 |
| WLBS total volume | 268 | 1376.93 | 1741.83 | 17.64 | 8644.40 |
| WLBS/GF ratio | 268 | 2.10 | 1.61 | 0.10 | 8.89 |
| DSF | 258 | 6.85 | 1.43 | 3.00 | 9.00 |
| DSB | 232 | 5.82 | 1.48 | 3.00 | 8.00 |
| MRT | 259 | 1.47 | 1.28 | 0.00 | 5.00 |

**Table 1.** Descriptive statistics showing the means, standard deviations and range of responses for the alcohol consumption questionnaires (GF, WLBS), the WLBS/GF ratio, and the working memory tests (DSF, DSB, MRT).

| Variable | GFTV | WLBS TV | WLBS GF | DSF | DSB | MRT |
|----------|------|---------|---------|-----|-----|-----|
| GF total volume | 1 | | | | | |
| WLBS total volume | 0.65*** | 1 | | | | |
| WLBS/GF ratio | –0.29*** | 0.15* | 1 | | | |
| DSF | –0.05 | 0.01 | 0.16* | 1 | | |
| DSB | –0.06 | 0.05 | 0.18** | 0.53*** | 1 | |
| MRT | –0.09 | –0.07 | –0.02 | 0.19** | 0.09 | 1 |
explaining only 0.10% of the WLBS/GF ratio, $\beta = -0.02$, $t$ (258) = $> -0.36$, $p = .716$.

Separate and Multivariate linear regression model examining the effects of the working memory predictors (DSF, DSB and MRT) on the difference in volumes of alcohol captured (WLBS/GF ratio).

| Predictor | $\beta$ | $t$   | $p$   |
|-----------|---------|-------|-------|
| DSF       | 0.10    | 1.07  | .287  |
| DSB       | 0.21    | 2.31  | .022  |
| MRT       | -0.10   | -1.15 | .557  |
| Age       | 0.01    | 0.59  | .557  |

$R^2=0.06$

DSF = Digit Span Forward, DSB = Digit Span Backward, MRT = Mental Rotation Test.

Discussion

The current study examined the influence of working memory capacity on self-reported alcohol consumption, aiming to determine whether people with poorer working memories would receive more assistance in recalling more alcohol consumption from contextual cues than people with larger working memories. Results demonstrated that all participants reported more alcohol consumption using the WLBS questionnaire, which includes location and time-based contextual cues, than the GF questionnaire. Contrary to expectation, contextual cues did not prompt increased reported consumption for people with poorer working memories; instead, people with larger working memories increased their report consumption more when given contextual cues. As such, these data suggest that though self-report measures that include contextual cues (WLBS) improve recall of alcohol consumption (inasmuch as higher reporting can be considered improved), they provide greater benefits for people with higher rather than lower working memory capacities.

On average, the WLBS questionnaire prompted higher recall of alcohol consumed than the GF questionnaire. As the WLBS includes contextual prompts cuing both location (Casswell et al., 2002) and time (Lau-Barraco et al., 2016; Woodyard & Hallam, 2010) of beverage consumption, this finding is consistent with previous research in demonstrating that contextual cues enhance recall (e.g., Casswell et al., 2002; Unsworth & Engle, 2007). The magnitude of the difference is notable, with the WLBS capturing more than double the volume of alcohol consumed than the GF. This suggests that providing respondents with contextual prompts that cue their recollection of specific drinking occasions (e.g., at my home on the weekend) has clear benefits for alcohol researchers. This is of course based on the assumption that increased reported consumption is more accurate, due to the low proportion of alcohol sales accounted for through survey responses (Livingston & Callinan, 2015).

Contrary to expectation, results revealed a positive relationship between working memory performance (DSF, DSB) and the WLBS/GF ratio: people with larger working memory capacities reported more consumption in response to contextual cues than people with smaller working memories. We expected that people with lower working memory capacities would reap a greater benefit from the WLBS’s contextual cues, reasoning that participants with higher working memory capacities would be better able to accurately recall their consumption in general and so would have less room for improvement. Instead, the data indicate that contextual cues were more beneficial for people with higher working memory capacities, presumably reflecting differences in the triggering abilities of contextual prompts. Because contextual cues are included in the WLBS to activate relevant information they may be less beneficial for people with poorer working memories because the context in which the alcohol consumption was encoded (own home, someone else’s home, licenced premises) did not match the context in which it was retrieved (Unsworth & Engle, 2007). Whilst differences in encoding and retrieval context may have a less detrimental effect on people with higher working memory capacities, they may pose particular challenges for people with lower working memory capacities: almost by definition, individuals with a larger working memory capacity have greater ability to use contextual cues to search their memory for alcohol-related information, than people with poorer working memory capacities (Unsworth et al., 2012).

Additionally, people with a lower working memory capacity may not use contextual cues as efficiently or effectively as people with higher working memories, finding greater difficulty in discriminating information that is necessary from the unnecessary (Unsworth & Spillers, 2010). People with poorer working memories may be more distracted by irrelevant information when retrieving alcohol-related information (Unsworth & Spillers, 2010), thereby inflating the likelihood of inaccurate retrieval and underreporting of their alcohol consumption. As such, they may enjoy less of a benefit of contextual cues than participants with higher working memory capacities, resulting in the smaller difference observed between the volumes
of alcohol captured by the WLBS and GF questionnaires.

Correspondingly, having a better working memory is associated with superior cognitive performance, including greater attentional ability (Borella et al., 2008; Unsworth & Engle, 2007). Differences in the ability to allocate and sustain attention may help account for the differences in the benefits of contextual cues noted as a function of working memory. As the WLBS questionnaire is considerably longer than the GF questionnaire, participants with poorer working memories may have experienced greater difficulty in effectively maintaining their attention, resulting in reduced reporting in the WLBS and a concomitant reduction in the WLBS/GF ratio. This argument appears completely consistent with the observation that the DSB was a significant predictor of the WLBS/GF ratio: the DSB is used as a measure of central executive function which itself encompasses aspects of both memory and attention (Baddeley, 1992).

Whereas DSF and DSB performance were significant predictors of the WLBS/GF ratio, the effect did not extend to the MRT. Given the nature of the questionnaire tasks, such a result is not surprising. The DSF is thought to index phonological loop capacity (Baddeley, 1983, 2000), and the DSB taxes the central executive (Best, 2010; Gathercole & Pickering, 2000); both these theoretical components of working memory are vital to recalling information about alcohol consumption cued in a written questionnaire like the WLBS or the GF. In contrast, the MRT was included as an assessment of the visuospatial sketchpad (Geiser et al., 2006; Turgut, 2015). As the visuospatial sketchpad is not likely to be heavily utilised when self-reporting alcohol consumption using written questionnaires, it is not surprising that it did not prove a significant predictor of performance.

Administering surveys online offers strengths, in terms of breadth of population sampled and ease of completion for participants, but also poses some limitations. While there is evidence that samples sourced through social media can be valid and useful (Casler et al., 2013), our drop out rate suggests that there are issues with retaining participants that should be taken into account when interpreting results. One issue is that balanced samples are hard to source – within our age range our sample was old (mean age of 55.6 in an age range of 30–65) and 71% female. Replication of this study on a more balanced sample is recommended.

Whilst the nature of the self-report questionnaire task makes it unlikely that the visuospatial sketchpad will play a dominant role in working memory performance, future research may wish to increase the number of items in the MRT and/or substitute an alternate visuospatial test that has higher internal reliability (e.g., the Corsi block-tapping task; delayed match-to-sample task; spatial delayed recognition span task). These tasks have been successfully administered online (e.g., Ma et al., 2017) and so offer an opportunity to provide convergent evidence confirming that visuospatial working memory does not predict recall of alcohol consumption. That said, if the number of items were increased researchers should be conscious of task duration as that may impact dropout rate.

One of the key benefits of presenting the tasks online is that participants’ privacy and anonymity can be maintained (Brener et al., 2003), which appears particularly important when dealing with potentially sensitive personal data like alcohol consumption. Delivering working memory tests online using computerised versions (Buchanan, 2016; Redick et al., 2012), as in the present investigation, thus has pragmatic appeal. Finally, while we counterbalanced the working memory tasks, we did not counterbalance the two methods of assessing alcohol-consumption – we recommend that future research does this to ensure that the impact of receiving contextual cues before completing a graduated frequency questionnaire can be assessed.

**Conclusions and implications**

The results of the present study offer both theoretical and practical implications for alcohol researchers. Given the significant discrepancy between alcohol sales data and self-report survey results, there is great value in improving our understanding of how to capture alcohol consumption data more accurately. The present results confirm that the WLBS questionnaire captures more than double the volume of alcohol consumption captured by the GF questionnaire, suggesting that it is the superior measure if one is hoping to decrease the gap between sales and survey measures at a population level. That said, the possibility of increased gaps between those with better working memory and those without than there would be when using more traditional measures needs to be noted at an individual level. It should be noted that higher reporting does not necessarily imply that a measure is more accurate because alcohol consumption may be overestimated (Gmel et al., 2014). However with the increased contextual cues increasing the reported consumption in the sample overall, in a variable that has been consistently subject to
underreporting in surveys compared to more objective measures, this method is a promising potential option in eliciting responses closer aligned to sales. As such, the greater volume of consumption reported in response to the WLBS measure is proposed to directly reflect the efficacy of both time and location contextual cues in facilitating recall, particularly in those with better working memory.

As underestimating alcohol consumption in self-report measures holds major concerns for the development of effective interventions (WHO, 2000), using questionnaires like the WLBS provides the opportunity for epidemiological research to more accurately monitor patterns of alcohol consumption, and better understand both the short- and long-term effects of drinking alcohol (Greenfield & Kerr, 2008). Over a quarter of respondents did report higher consumption with the GF measure than the WLBS. In both measures some inaccuracy is unavoidable – in the GF measure, respondents are asked to estimate the number of times they consume a given amount of alcohol within a range and in the IAC they are asked to give a “usual” drinking occasion – in a scenario where all respondents could recall their consumption with perfectly, some would report more one on measure and some more on the other. However, the higher average consumption from the WLBS, indicates that this measure may be better at compensating for some of the under-reporting issues that are inherent to most alcohol consumption measures. If such measures are adopted and administered internationally, the obtained data can then be used forward to key stakeholders to develop policy and change programs, targeting vulnerable and at-risk groups of alcohol-related harm (WHO, 2000). Future work comparing different alcohol measures with an interview to further ascertain the accuracy of different measures is recommended.

Overall, the present study found that individuals with higher working memory capacities benefited more from increased contextual cues in measurement of alcohol consumption than people with lower working memory capacities. However irrespective of working memory capacity, provision of contextual cues is strongly recommended in alcohol consumption research, as the WLBS questionnaire captured more than double the volume of alcohol consumption than the GF questionnaire. This finding reaffirms previous literature demonstrating the effectiveness in contextual cues capturing a greater volume of alcohol consumption (Casswell et al., 2002; Monk et al., 2015), but leaves open the question of how to improve recall for people with lower working memory capacities. The possibility of more detailed surveys provide consumption estimates closer to those from more objective measures such as sales data while also exacerbating memory-based differences in recall needs to be considered. Further research is thus needed to target this important population who are likely to be unintentionally and systematically under-reporting their alcohol consumption when assessed using self-report surveys.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

The datasets generated during the current study are not publicly available due to requirements outlined in the participant information and consent form. However, they are available from the corresponding author on reasonable request.

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