



"I have no clue what I drunk last night"

Using Smartphone technology to compare in-vivo and retrospective recorded alcohol consumption.

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Executive Summary

Background

The significance of self-reports in alcohol research means it is important to scrutinize the conditions which impact their accuracy. Recent years have shown a marked increase in the use of mobile technology in this field. However, to date it has not been determined the extent to which Smartphone technology can be used to provide a real-time measurement of consumption, and how such in-vivo reporting compares with memory-dependent accounts of alcohol consumption. Furthermore, the contextual factors which may mediate accuracy of self-reported alcohol consumption have not been examined hitherto.

Method

Building on previous investigations, this research utilised specifically designed Smartphone technology to measure alcohol consumption in de facto real-time via a method that recorded contextual influences. These real-time reports were then compared with retrospective reports of alcohol consumption (both daily and weekly) to assess the consistency of these different accounts.

Results

Overall results suggest that in-vivo and retrospective reports of alcohol consumption are not consistent with each other. Specifically, participants' reports about their previous day's drinking were significantly lower than the accounts supplied during that day (in-vivo responses). This effect was also apparent when participants were asked to recall their previous week's consumption.

Daily retrospective reports for beer/cider, wine, and spirits all appeared to be significantly under-reported when compared with in-vivo accounts. This effect was particularly apparent in certain environmental contexts (bars/pubs/blubs, parties, other's homes), whilst reports from other environmental contexts (home and work) did not appear to be associated with significant retrospective under-reporting in comparison to in-vivo assessment.

For weekly drinking reports the observed difference between in-vivo and retrospective reports appeared to be driven by the fact that the number of beer or cider reportedly consumed was significantly lower retrospectively, whilst other drink types (wine, spirits, other) did not appear to vary significantly between report periods.

Follow up and qualitative reports from participants indicate that participants enjoyed taking part in the research and found the application easy to use. However, they reported that the task of recalling their past drinking was difficult (both the day and the week after in-vivo assessment), and suggested that there may have been some degree of guessing. These qualitative data appear to corroborate the quantitative findings.

Conclusions

Retrospective self-reports regarding personal alcohol consumption may not provide a reliable account of in-vivo alcohol consumption, a problem which is evident in both daily and weekly retrospective accounts. Furthermore, the difficulties in recalling one's alcohol consumption from the previous day may be exacerbated when drinking has occurred in environments such as bars and parties. Caution may therefore be warranted with regards to the extent to which retrospective alcohol consumption measures are reliable, or when such reports form the basis of clinical categorization. The alcohol research community has been overly reliant on retrospective self-report measures which appear to differ from consumption levels measured in real time. Nevertheless, the use of Smartphone technology offers a viable and contextually sensitive solution to measuring real-time alcohol consumption. By introducing novel cost effective ways of measuring alcohol consumption, this research possibly constitutes a first-step towards the development of more robust alcohol measurement techniques.

Introduction

Self-report measures are the bedrock of much research in the addictions (Greenfield & Kerr, 2008) and it is generally accepted that this approach can be used as a reliable and valid method (Del Boca & Noll, 2000; Giovannucci et al. 1991). This involves participants recalling and recording their previous consumption. However, the environments in which such assessments take place are often far removed from the setting in which the drinking occurs, by nature of their post hoc design (Verster, Tiplady, & McKinney, 2012). This may be problematic for a number of reasons. First, the task of retrospective recall may encourage fabrication in an effort to satisfy the demands of the researchers – with participants guessing when they cannot remember or altering their responses to meet the perceived purpose of the research (Davies & Best, 1996). Second, such a task can be very demanding cognitively, particularly if extended periods of time have passed prior to recall. Given the demonstrated fallibility of autobiographic or episodic memory (e.g. Loftus & Hoffman, 1989), results based on this methodology may be less accurate than real-time accounts. This problem may be exacerbated by the alcohol consumption itself, which may further impair memory (c.f. Walker & Hunter, 1978). Finally, the difficulty of retrospective recall may be heightened by the absence of any associated environmental stimuli which may aid recall (c.f. Godden & Baddeley, 1975). The researchers' own findings suggest that variations in alcohol-related memory and cognition would be expected across contexts (Monk & Heim, in press; 2013a; 2013b). Accordingly, much of the research based on retrospective accounts of alcohol consumption may not necessarily generalise to real world drinking contexts.

The use of ecological momentary assessment (EMA) addresses the limitations of autobiographical memory which may be evident in the findings from traditional research such as diary studies (Shiffman, Stone, & Hufford, 2008) and retrospective recording. For example, a diary study which utilised covert photoreceptors found a 90% response rate for their study, yet, in fact, only 11% had actually complied with the task instructions (Stone & Shiffman, 2002). Such research suggests that diary based methods of EMA may be prone to “parking-lot compliance” where participants retrospectively answer questions in order to fulfil task requirements (Smyth & Stone, 2003). Conversely, smartphone based EMA may be particularly useful for providing instantaneous, rich and useful data (Katz & Aakus, 2002) which is electronically time-stamped to prevent such retrospective accounts. The smartphone's familiarity, proximity, social importance and high frequency of use also increase the ease and likelihood of research participation (Miller, 2012). EMA using Smartphone technology is also ‘context-aware’ (Miller, 2012)

meaning that it can monitor dynamic changes across contexts, which may be particularly useful for monitoring behaviours which are episodic and contextually bound (c.f. Monk & Heim, in press).

Alcohol use is but one example of such a contextually bound behaviour and it has been historically difficult to assess owing to problems of self-report bias and demand characteristics (Verster et al., 2012). Further, it has been noted that alcohol-related questioning often occurs in an environment which is far removed from the setting in which the drinking occurred (ibid). Real-time assessments in a naturalistic setting may therefore be useful and illuminate the contextual differences which may not be captured within the laboratory. Alcohol-impaired cognitive functioning during participation (Weissenborn & Duka, 2003) may also be addressed using smartphone technology, as it provides a familiar, straightforward method of question and response which is easy to access (Collins, Kashdan, & Gollnisch, 2003), meaning cognitive load is low. Smartphone-based EMA is therefore likely to produce both richer and more ecologically valid data.

Recently, studies have attempted to provide more ecologically valid environments for research. For example, simulated bars (e.g. Larsen et al., 2012) and wine tasting events (e.g. Kuntsche & Kuendig , 2012) have been used as test environments, with the purpose of increasing the validity and reliability of research. Yet the participants in such situations do not have the choices they would usually have in real-life (Verster et al., 2012). For example, typically participants are not able to choose what and with whom they drink. Studies where researchers actively observe and record consumption (e.g. Bond et al., 2010; Teunissen et al., 2012) or breathalyse participants (e.g. LaBrie, Grant & Hummer, 2011) have also been employed. However, these methods can be invasive, are time/resource intensive, and remain vulnerable to demand characteristics when participants know they are being watched (c.f. Davies, 1997). There is therefore little research which conducts in-vivo, real-time assessments of drinking, or the factors mediating consumption.

The purpose of this research was therefore to investigate the utility of using smartphone technology in order to meet three research goals: First, to establish the extent to which the traditional self-report approach of measuring alcohol consumption can be developed using smartphone technology to record de facto real-time drinking. Second, to examine whether there are differences between real-time and retrospective accounts of alcohol consumption. Third, to assess the factors which may impact alcohol consumption in real life contexts, using context aware methodologies hosted on smartphone applications.

Methods

Design

A within participants design was utilised to investigate the difference between participants' in-vivo recorded alcohol consumption and their retrospective accounts of consumption (daily and weekly retrospective). The effect of environmental and social contexts on participant responses was also assessed.

Participants

69 participants (18-36 years, $M = 21.47$, $SD = 4.47$) were recruited on a university campus. The majority of this sample were White British (95%) students (85.5%). 59% of this sample were male, their mean AUDIT score¹ was 9.19 ($SD = 4.72$) and their standardised average positive outcome expectancy score was 4.13 ($SD = .68$). Both AUDIT and expectancy measures were taken prior to participation. Participants were offered monetary reimbursement (£7) or course credit by way of remuneration. Prior to further analyses, participants who failed to activate the application, or failed to complete at least two full response sessions on a single drinking occasion ($n = 18$) were removed from the data file. Preliminary analyses revealed that there were no significant demographic or reported consumption differences between these excluded participants and those that remained in the data set.

Equipment and measures

A smartphone application was designed specifically for this research and it enabled participants to respond to questioning via the use of their own mobile phone. The application utilised a website built using HTML and JavaScript, the interface and functionality were designed using JavaScript's jQuery mobile library and the 'web-app' was web-standards compliant. Phone Gap was used to convert the web-based application into a native application that could be downloaded onto the users' own device by scanning a QR code. Local storage within the application was used to temporarily store all the users' answers. These data were then remotely transferred to Google Analytics at the end of each response session. This meant that data could be retrieved without

¹ The AUDIT is a well established tool for assessing alcohol consumption which can be used in both clinical and non clinical samples. Its items assess 3 areas: harmful alcohol use, hazardous alcohol use and dependence symptoms. Its raw score can be used to classify respondents based on their drinking. A score exceeding 8 (or 10 in some cases) is considered indicative of hazardous drinking.

having to access the participants' phones directly. This also provided metrics such as start and end times. Individual participants' responses were tracked using a unique alias which was randomly generated by the application. This data were linked to a memorable date and demographic details provided by participants when they signed up for the study. This facilitated data anonymity whilst also allowing researchers to track individual level data. Participants were instructed to activate the application when they began a drinking session.

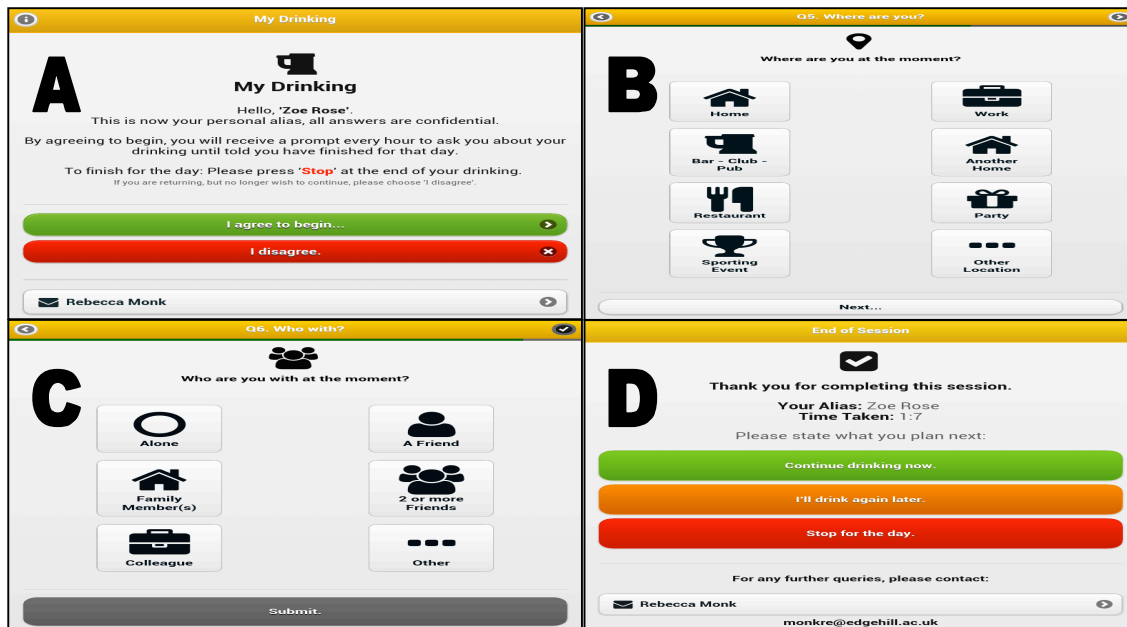


Figure 1

Example of in-application response mechanism: Activation screen, with on-screen instructions (a), Social and environmental context response (b + c), and end-of-session response options (d).

This would then trigger hourly prompts for participants to respond. At each response session, participants' current location, who they were with (social and environmental contexts), and the type and number of drinks they had consumed during the last hour were recorded (see Figure 1). The application delivered hourly prompts until participants indicated that they had finished the drinking session. Drinking cessation was assessed by the application, which asked participants to indicate their future plans every time they responded. Here there were three options available to participants: intend to continue drinking (in which case they would be prompted again an hour later); finish drinking for now but will continue later (in which case there would be a 3 hour delay before the next prompt); finish drinking for the day (in which case prompts would cease).

The application was designed to make the user interface as intuitive/user friendly as possible and there were no default answers set

(non-completed items remained blank in the data set), in accordance with recommendations (c.f. Palmblad & Tiplady, 2004). The functionality and response mechanisms of the application were carefully designed and piloted to assess the usability of the application. Short questions were provided alongside multiple choice answers which were represented using simple, large, touch-screen response items accompanied by pictorial representations (see Figure 2 for example response mechanisms for recording alcohol consumption).

Measures

Prior to taking part in the research, participants were asked standard questions about their age, gender, status on campus (student or non student). They were also asked questions about their drinking practices and related beliefs. These were assessed using two standardised questionnaires: First, the Alcohol Outcomes Expectancy Questionnaire (Leigh & Stacy, 1993) was utilised. This is a 34-item questionnaire which asks about participants' beliefs about alcohol consumption, specifically the positive and negative outcomes that they expect to result from drinking. All items are rated on a 6-point likert scale (1 = no chance, and 6 = certain to happen).

Figure 2 displays three panels of the application interface for recording alcohol consumption. Each panel shows a list of drink types with a pictorial representation and a numerical response scale (0 to 10).

- Panel 1 (Left):** Titled "Q4. Drinks Consumed". It asks "What drinks have you consumed in the last hour? Scroll down for more options...". It lists:
 - 1/2 Pint (Beer / Cider) with a glass icon and a scale from -1 to +1.
 - Pint (Beer / Cider) with a glass icon and a scale from -1 to +1.
 - Sml. Bottle (Beer / Cider) with a bottle icon and a scale from -1 to +1.
- Panel 2 (Middle):** Titled "Q4. Drinks Consumed". It lists:
 - Sngl. Spirit + Mixer (25ml) with a glass icon and a scale from -1 to +1.
 - Dbl. Spirit + Mixer (50ml) with a glass icon and a scale from -1 to +1.
 - Shot / Single (25ml) with a glass icon and a scale from -1 to +1.
 - Other Drink (if not listed) with a glass icon and a scale from -1 to +1.
- Panel 3 (Right):** Titled "Q4. Drinks Consumed". It lists:
 - Lrg. Bottle (Beer / Cider) with a bottle icon and a scale from -1 to +1.
 - Sml. Glass Wine (125ml) with a glass icon and a scale from -1 to +1.
 - Lrg. Glass Wine (250ml) with a glass icon and a scale from -1 to +1.
 - Sngl. Spirit + Mixer (25ml) with a glass icon and a scale from -1 to +1.

Figure 2

Example of response mechanism for in-vivo, self-reported alcohol consumption

Second, the AUDIT was administered. This is an alcohol consumption self-report measure which can be used to classify respondents based on their reported drinking patterns and behaviours. Finally, at the end of the week, a series of experiential statements were provided and participants were asked to rate their agreement (For example, "I enjoyed taking part in this research"). Ratings were provided on a 6-point likert scale (1 = strongly disagree, and 6 = strongly agree). An open-ended question was also provided so that participants could provide qualitative feedback on their experiences.

The application itself asked participants a number of multiple choice questions which enquired about the respondents' current location (response options: Home, Work, Another's Home, Restaurant, Bar-Pub-Club, Party, Sporting event, Other) and who they were with (response options: Alone, Colleague(s), Family, 1 friend, 2 or more friends, Other). Participants were also presented with labelled, pictorial representations of different drink types (see Figure 2). Numerous options were given alongside a description of standard measurements (response options: 1/2 pint beer/cider, 1 pint beer/cider, small bottle beer/cider, large bottle beer/cider, small glass wine, large glass wine, small spirit and mixed, large spirit and mixer, 1 short/shot, cocktail, other). Participants were asked to select the types and quantity of alcohol they had consumed in the last hour.

Procedure

Following ethical approval, participants were recruited through opportunity sampling on a university campus and through online participation requests. Those who signed up to take part attended a briefing session. During this session the participant was instructed on how to download the application onto their own device. A brief demonstration of the smartphone application and the response mechanisms was then provided. Participants were given the opportunity to ask any questions and were informed how to withdraw from the study without penalty. Participants' demographic details and information about their drinking – using the AUDIT and Alcohol Outcome Expectancies Questionnaire - were also obtained by way of an electronic questionnaire (using Bristol Online Survey).

Participants were asked to use the application to report as many separate drinking occasions as possible over the participation week. When participants started a response session this triggered an email alert to be forwarded to the researchers. This enabled the research team to contact participants (via email) 24 hours after the drinking session had finished. This email asked the participants to recall the type and number of alcoholic beverages they had consumed in their most recent drinking session (the date of this past drinking session was also provided to aid this retrospective recall). This process was repeated for every drinking occasion that the participants documented. At the end of the participation week, a final email was sent to participants. This asked participants to record the type and quantity of alcohol they had consumed over the course of the previous week. The same response options were provided in both the single-session and weekly assessment emails (with both type and quantity of alcohol consumed being recorded, as with the smartphone application). This opportunity was also utilised to examine participants' user-experiences and to

assess the overall consensus regarding using the application to record their drinking.

Results

For the purposes of the analyses reported here, participants' in-vivo records of the type and quantity of alcohol consumed were compared with their daily and weekly retrospective self-reports. In order to facilitate this, drinks of the same type that were consumed in different quantities were combined into broader categories. For example, reports of consuming ½ pint of beer or cider, 1 pint of beer or cider, and small or large bottles of beer or cider were combined into a single category (beer/cider). The same was done to create a further 3 categories: Wine (combining small and large glasses of wine), Spirits (combining single-25ml and double mixed-50ml-drinks and shots). Daily and weekly overall totals were also calculated for both in-vivo and retrospective drinking records. Descriptive statistics for these data are represented in Table 1. Separate multivariate analyses were conducted in order to assess potential differences between real-time and retrospective consumption records.

Table 1

Participants' reported alcohol consumption across drink type and assessment time period.

Drink Type	Daily Reports		Weekly Reports	
	In-vivo	Retro	In-vivo	Retro
Total	4.90 (4.20)	3.94 (2.28)	10.42 (6.32)	8.26 (6.18)
Beer/Cider	4.67 (4.55)	1.81 (2.44)	6.00 (5.06)	3.06 (3.15)
Wine	1.29 (2.40)	0.86 (1.69)	1.46 (2.53)	2.06 (2.72)
Spirits	1.49 (2.47)	1.02 (1.69)	1.96 (3.84)	2.36 (4.34)
Other	0.67 (1.58)	0.59 (1.16)	1.00 (2.25)	0.78 (2.25)

Alcohol Consumption

Daily accounts

In-vivo reports were taken every hour on days where the application was activated by respondents. Analyses of daily consumption here therefore represent the total number of drinks that participants' reported consuming (in real-time) over the course of their first day using the application. This was calculated by summing every hourly response and contrasting this calculation with participants' daily retrospective accounts for that day (i.e. their self-reported consumption the day after). Research suggests that such real-time contexts may impact

alcohol-related beliefs (Monk & Heim, 2013c). The effect of the participants' social and environmental context at the time of their in-vivo assessment was therefore also assessed. Table 2 demonstrates these descriptive statistics.

Table 2

Participants' in-vivo and retrospective reported alcohol consumption across environmental context

Response Time	Environmental Context						
	Home	Other's Home	Work	Restaurant	Bar/Pub/ Club	Party	Other
In-vivo	6.00 (4.32)	7.25 (2.50)	5.00 (1.06)	2.1 (1.02)	10.94 (6.18)	13.67 (5.03)	1.1 (1.02)
Retro	4.86 (3.80)	4.75 (2.36)	4.00 (1.41)	2.1 (2.3)	3.75 (1.81)	3.75 (1.81)	1.0 (1.3)

Analyses therefore consisted of a 5 (Alcohol consumption record: Total, Beer/cider, wine, spirits, other) x 7 (Environmental contexts) x 4 (Social contexts) x 2 (Time period: In-vivo, daily retrospective) mixed ANOVA. This revealed that overall retrospective accounts were significantly lower than in-vivo reports ($F(1,200) = 19.67, p < .01, \eta_p^2 = .29$). Significant main effects of drink type ($F(4,200) = 28.83, p < .001, \eta_p^2 = .37$) and environmental context ($F(6, 35) = 2.88, p < .05, \eta_p^2 = .33$) were also revealed, although reports did not vary significantly across social contexts ($p > .05$). These results were qualified by a significant 2-way interaction between time period and drink type ($F(4, 200) = 11.31, p < .001, \eta_p^2 = .13$) and a significant 3-way interaction between time period, drink type and social context ($F(24, 140) = 3.52, p < .001, \eta_p^2 = .38$). Specifically, post hoc analyses (adjusted $p = .01$) revealed that numbers of beer/cider ($t(50) = 5.29, p < .001$), wine ($t(50) = 1.88, p < .001$), spirits ($t(50) = 1.99, p < .05$) and the overall total number of drinks ($t(50) = 2.13, p < .05$) reportedly consumed was significantly higher in in-vivo records than in retrospective accounts the following day. The number of drinks recorded and classified as "other" did not differ significantly between in-vivo and retrospective records ($p > .05$), possibly because of the relatively low numbers of participants using this response option (See Figure 4). This suggests that consumption reports taken the day after a drinking session may under-represent the number of real-time drinks recorded during the drinking episode.

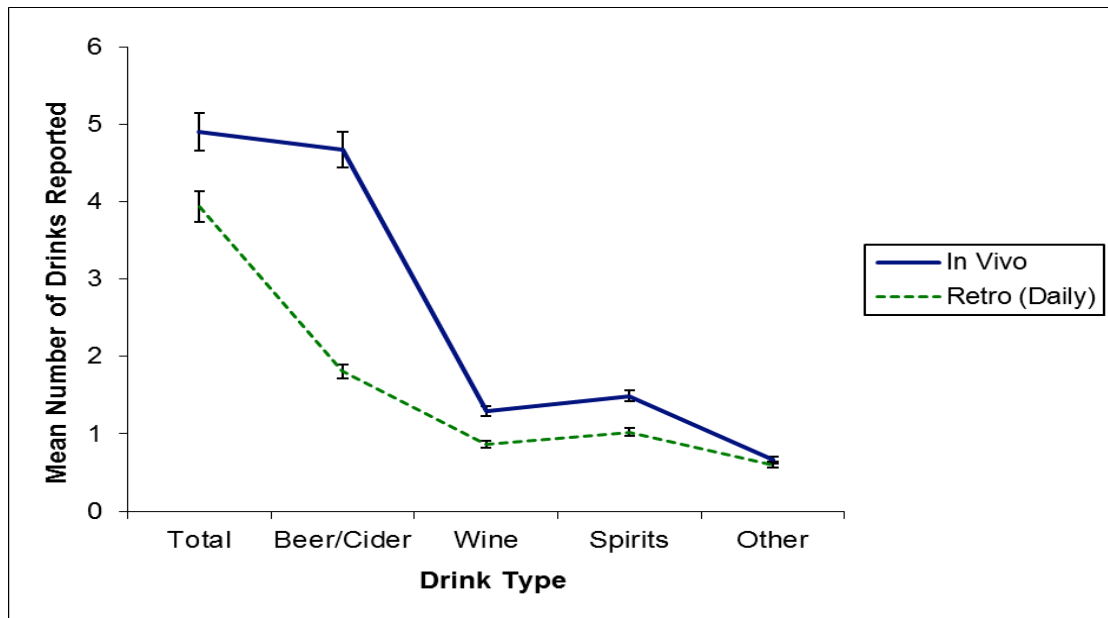


Figure 3

Daily in-vivo and retrospective recorded consumption across drink type

Simple man effects analyses also revealed that in-vivo reports of drinking were significantly greater when the drinking in question took place within bars/pubs/clubs ($F(1, 15) = 23.55, p < .001, \eta_p^2 = .61$), parties ($F(1, 2) = 23.00, p < .001, \eta_p^2 = .61$), or others' homes ($F(1, 3) = 25.00, p < .05, \eta_p^2 = .79$) (See Figure 4). Notably, in-vivo consumption reports recorded in other environmental contexts (home and work) did not differ significantly ($p > .05$) from retrospective reports. This suggests that retrospective under-reporting may be a particular concern when participants are attempting to recall drinking in certain environments.

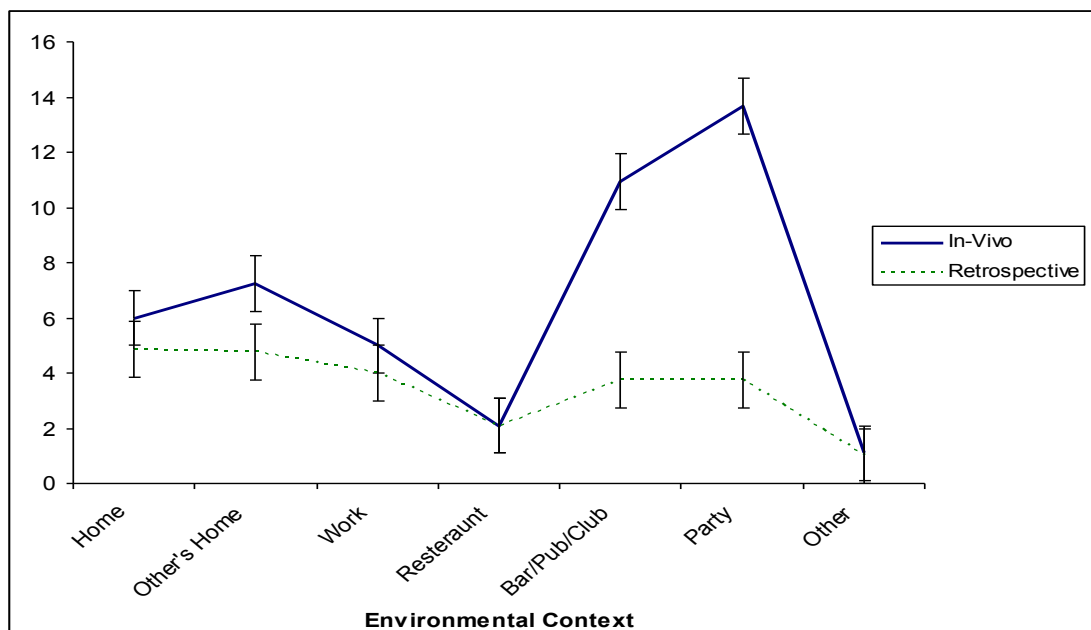


Figure 4

Daily in-vivo and retrospective recorded consumption across environmental contexts

Weekly accounts

Participants were asked to provide in-vivo reports every day that they consumed alcohol over the course of one week. Resultantly, in-vivo reports were taken every hour on days where the application was activated. At the end of that week, they were then asked to provide retrospective account of their consumption across the entire week. Analyses of weekly consumption here therefore compared participants' weekly-total drinks by summing the total number drinks recorded in-vivo, and contrasting these with participants' total weekly retrospective report. A 5 (Alcohol recorded: Total, Beer/cider, Wine, Spirits, Other) x 2 (Time period: In-vivo, Weekly Retrospective) repeated measures ANOVA revealed that the quantities of alcohol retrospectively recorded for the past week were significantly lower than the quantities reportedly consumed in-vivo ($F(5, 196) = 57.28, p < .001, \eta_p^2 = .54$). A significant main effect of time period ($F(1, 196) = 5.64, p < .05, \eta_p^2 = .10$), and a qualifying significant 2-way interaction between time period and drink type ($F(4, 196) = 63.41, p < .001, \eta_p^2 = .16$) were also found (see Figure 5). Specifically, post hoc analyses (adjusted $p = .01$) revealed that numbers of beer/cider ($t(50) = 4.67, p < .001$) and the overall total number of drinks ($t(50) = 2.49, p < .05$) were significantly higher within in-vivo recording than in weekly retrospective accounts. The numbers of wine, spirits and other drinks reportedly consumed did not differ significantly between in-vivo and retrospective accounts (all $p > .05$). This suggests that participants may have retrospectively under-reported the number of beers/ciders that they consumed the week before. However, this effect may not generalise to all types of alcohol, a somewhat counterintuitive finding in light of results relating to daily retrospective reports.

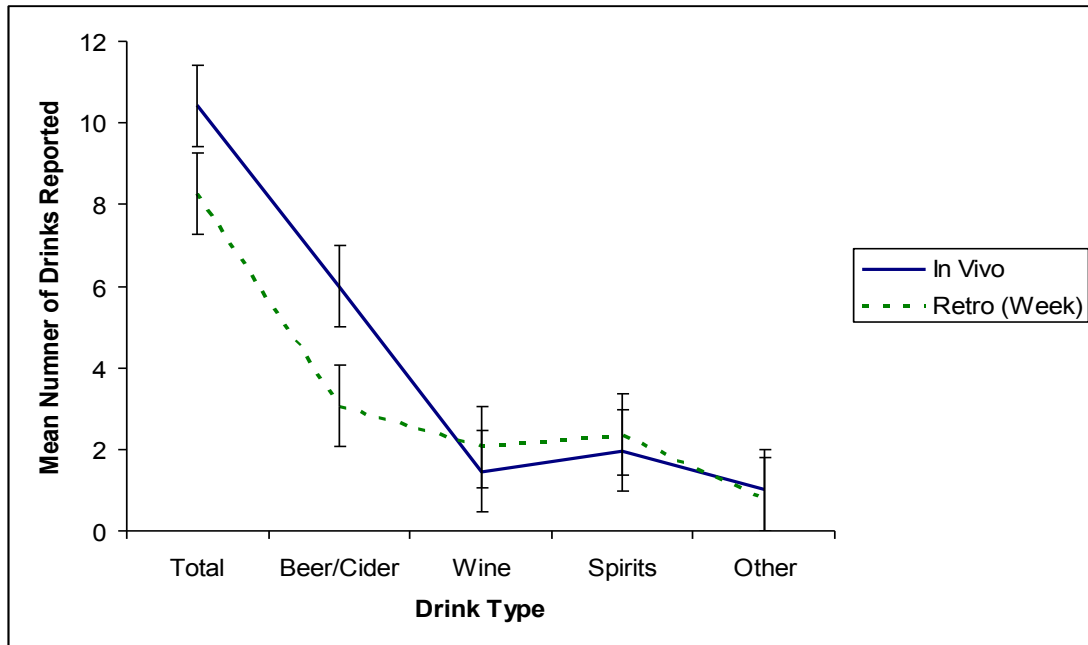


Figure 5
Weekly in-vivo and retrospective recorded consumption across drink type

User Experiences

This research constitutes the first research of its type to systematically compare in-vivo accounts of alcohol consumption and contrast them with retrospective accounts facilitated via a specially designed Smartphone application. It was therefore important to assess the users' experiences of using the application, in order to maximise the utility of the research. Respondents were therefore asked a number of closed questions about the application and their experiences of taking part in the research. The large majority of respondents reported enjoying taking part in the research and findings the application easy and convenient to use. A breakdown of participants' responses to each question can be seen below in Table 3. Users were also given the opportunity to provide written feedback in regard to their experiences of taking part in the research and/or using the application.

Table 3

Participants' self-reported experiences of taking part in the research and using the Smartphone application (responses in %)

	Response Options		
	Strongly agree	Agree	Neither agree nor disagree
Enjoyed taking part	53.8	34.6	11.5
Successful in taking part	32.7	61.5	5.8
The App was user-friendly	42.3	48.1	6.6
I liked the layout of the App	42.3	48.1	9.6
The App was convenient to use	36.5	50	13.5
It was easy to input data using the App	38.6	59.6	1.9
The App was comfortable to use	36.5	55.8	7.7

Aside from a number of comments pertaining to mobile-specific technical issues that were encountered (n=6), the remaining comments related to the users' experiences. One participant commented that they would liked to have taken part for longer, whilst a number of participants commented on the difficulties they had faced when retrospectively recalling what they had drunk the night/week before. For example, one respondent commented, "If I'm honest, this is just a guess as I have no idea what a drunk last night, let alone last week" and similarly another testimony stated that "it was hard to remember what I had specifically". Whilst these limited testimonies cannot be taken to be representative of the entire sample, they are interesting and perhaps represent an illuminating description of participants' quantitative responses.

Discussion

Generally, results from this research suggest that both daily and weekly retrospective reports regarding the quantities of alcohol consumed are not in line with records provided in real-time (in-vivo). Specifically, participants' appear to retrospectively under-report the number of drinks that they reportedly consumed in real-time. Follow-up qualitative reports from participants indicate that they enjoyed the process of taking part in the research and found the application easy to use. However, respondents suggested that it was difficult when trying to recall their drinking (both the day and the week after) and guessing tactics may have been employed. Such an opportunity to provide feedback is not typically supplied when participants are asked to recall their alcohol consumption for research or therapeutic purposes. Rather, in these cases, responses here are often taken as relatively reliable and accurate testimonies (Del Boca & Noll, 2000). Nevertheless, both the

qualitative and quantitative responses detailed within this report suggest that this may be fallacious. Furthermore, specific comments in relation to task difficulty were unsolicited. Nonetheless, these comments suggest that participants were keen to highlight their concerns. Such results may therefore support the concerns that self-reports may not be fully representative accounts of real-time drinking, perhaps because they remove drinking from the setting in which it typically occurs (Verster et al., 2012). The currently observed discrepancies between real-time and retrospective reports also appear to add weight to the fears that retrospective recall may encourage fabrication (Davies & Best, 1996). They may also suggest that consumption reports may be fallible due to the large cognitive demands exerted (e.g. Loftus & Hoffman, 1989), particularly as the alcohol consumption itself may further impair memory (c.f. Walker & Hunter, 1978). Alongside the quantitative results, findings of this report therefore suggest that the concerns regarding the reliability of alcohol consumption self-report measures may be warranted.

Examining these results in more detail, it is also apparent that there may be variations in alcohol consumption reports depending on the time-delay between drinking and recall, the type of drink consumed, and the environmental context in which daily drinking occurs. For daily retrospective reports, beer/cider, wine, and spirits all appeared to be significantly under reported when contrasted with in-vivo accounts. This effect was particularly apparent in certain environmental contexts (bars/pubs/blubs, parties, other's homes), whilst other reports from environmental contexts (home and work) did not appear to demonstrate significant retrospective under-reporting. The current findings therefore suggest that the environment in which drinking occurs may alter retrospective accounts of consumption. Specifically, being in alcohol-related environments such as bars/pubs/clubs (licensed premises), parties and social contexts (other's homes), appears to be associated with variations in drinking reports. One explanation of this finding may be that alcohol consumption is higher in such contexts (e.g., licensed premises) resulting in retrospective memory impairments (Walker & Hunter, 1978; Weissenborn & Duka, 2003). Another explanation may be offered by alcohol myopia theory, which states that alcohol impairs perception and attention - with the resulting myopia enhancing social responses, self-evaluations, and reducing anxiety (Steele & Josephs, 1990). Contextual variations in attention may therefore mean that whilst drinking can be recorded in real-time, subsequent retrospective accounts are impeded, causing under-reporting. Conversely, when such contextual factors are not present (e.g. when at home) the same attention issues may not arise, explaining why differences between daily in-vivo and retrospective reports were not found in such contexts. This research is also seemingly in line with previous research which suggests that alcohol-related

cognitions appear to vary across different environmental contexts or when exposed to different contextual cues (Monk & Heim, 2013a; 2013b; 2013c; Wall, McKee, & Hinson, 2000; Wall, Hinson, McKee, & Goldstein, 2001).

Contextual comparisons were not conducted for weekly consumption reports, owing to the vast variability of drinking contexts over the course of a week. Nonetheless, the observed difference between in-vivo and retrospective reports remained. However, these discrepancies appeared to be driven by the fact that the numbers of beer and ciders reportedly consumed were significantly lower retrospectively, whilst other drink types (wine, spirits, other) did not vary significantly. If it was merely a case of time-decayed memory, it would be expected that the retrospective inconsistencies recorded for daily consumption would be replicated, if not exacerbated, during weekly recall. However, this was not the case. Indeed, the reporting of other drink types, such as wine, did not differ significantly between the two assessment types. This suggests that retrospective under-reporting evident in daily alcohol reports may not be universally evident in weekly reports.

It has been suggested that harder tasks elicit more effortful processing – which is associated with better task performance (Hasher & Zacks, 1979). The heightened complexity of recalling weekly, as opposed to a daily, consumption (Lemmens, Tan, & Knibbe, 1992) may therefore be an important determinant of performance. Furthermore, items which are more unusual within memory have been postulated to have an attentional draw, i.e. they are more salient, meaning that they elicit more detailed encoding for the purpose of long term memory (Robinson, 1995; Navalpakkam, & Itti, 2005). In the case of the current findings, drinks which were not frequently recorded within this cohort (e.g., wine) may therefore be recalled more accurately because of their relative salience. This may account for the observed diminished discrepancy between in-vivo and retrospective accounts. Conversely, drinks that were more typically consumed within this cohort (such as beer or cider) may not have the same salience within memory. This would place a limitation on recall capacity, resulting in under-reporting of beer/cider. Coupled with the greater effortful process elicited by the task of weekly recall (as opposed to daily), item salience may therefore provide one possible explanation of why participants appeared to demonstrate retrospective under-reporting of weekly consumption that was limited only to beer/cider, whilst this pattern of results was largely universal when examining daily retrospective reports.

Further research in regard to this discrepancy between weekly and daily retrospective accounts is strongly recommended, as well as further research to support the development of real-time data collection methods. Nonetheless, smartphone technology provides researchers

with the capacity to collect real-time reports which are not subject to memory decay (Davies & Best, 1996) or limited by the lack of contextual cues (Godden & Baddeley, 1975). However, these in-vivo accounts are still based on self-reports. Therefore, despite the high level of anonymity in the current research, it must be acknowledged that such reports may be subject to demand characteristics, as is the potential for all substance-use research where responses may elicit negative perceptions or stigma (Davies, 1997; Davies & Best, 1996). The use of objective measures of consumption, such as a breathalysers or Secure Continuous Remote Alcohol Monitors (SCRAM) would therefore be a recommended addition to future research designs. This would allow researchers to validate participants' responses using objective measures. An expansion of the current research utilising a wider number of non-students would also be advisable as differences in the student drinking culture (Borsari & Carey, 2001) may mean that results cannot be generalised to the wider population. For example, research suggests that younger people may dislike certain alcohol beverages such as wine (Silva, Figueiredo, Hogg, & Sottomayor, 2014). Variations in drinking preferences may therefore account for some of the observed variability in drinking reports across alcohol type – findings which may not necessarily be replicated in older participants.

Conclusions

The general discrepancy between in-vivo and retrospective accounts of consumption suggests that the use of self-report measures requires careful consideration within alcohol research. Certainly, by comparing retrospective self-reports with in-vivo accounts, the current findings suggest that such data may under-represent actual real-time consumption. Furthermore, this issue may be further complicated by the type of alcohol consumption being recalled and the environmental context in which this consumption occurred. However, the introduction of novel and cost effective ways of measuring alcohol consumption appears promising. This research therefore constitutes a first-step towards the development of research methods that have the potential to prove more robust than traditionally exploited retrospective self-report measures.

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