PLOS ONE

I have no clue what I drunk last night" Using Smartphone technology to compare in-vivo and retrospective self-reports of alcohol consumption

--Manuscript Draft--

Manuscript Number:	
Article Type:	Research Article
Full Title:	I have no clue what I drunk last night" Using Smartphone technology to compare in-vivo and retrospective self-reports of alcohol consumption
Short Title:	Real-time vs. retrospective alcohol reports
Corresponding Author:	rebecca Louise Monk, PhD Edge Hill University Ormskirk, UNITED KINGDOM
Keywords:	alcohol consumption, drinking pattern, assessment, methodology, surveys, smartphone, self-report measurement, ecological momentary assessment
Abstract:	Aim: This research compared real-time measurements of alcohol consumption with retrospective accounts of alcohol consumption to examine possible discrepancies and contextual influences between the different accounts. Method: Building on previous investigations, specifically designed Smartphone technology was utilized to measure alcohol consumption and contextual influences in de facto real-time. Real-time data (a total of 10,560 data points relating to type and number of drinks and current social and environmental context) were compared with retrospective accounts of alcohol consumption (both daily and weekly) to assess the consistency between the different methods. Post participation qualitative reports also gauged perceptions with regards to using the technology. Results: Results suggest that in-vivo and retrospective reports of alcohol consumption are not consistent with each other. Specifically, participants' daily retrospective reports about their drinking were significantly lower, overall, than in -vivo account supplied during that drinking session. The same pattern of results was also found when comparisons were made between weekly in-vivo and retrospective accounts. Interactions with type of drink and environmental context were also observed. Conclusions: Retrospective daily and weekly self-reports of personal alcohol consumption appear to be lower than those recorded in-vivo. Difficulties in recalling alcohol consumption from the previous day may also be exacerbated when drinking has occurred in environments such as bars and parties. A degree of caution appears warranted with regards to the extent to which retrospective alcohol consumption measures are reliable
Order of Authors:	rebecca Louise Monk, PhD
	derek Heim
	Alan Price
Suggested Reviewers:	Daniel Zhara Plymouth University daniel.zahra@plymouth.ac.uk
	Jack Melson Dundee University a.melson@dundee.ac.uk
Opposed Reviewers:	N/A N/A N/A N/A
Additional Information:	
Question	**Response**
Financial Disclosure	This research was funded by Alcohol Research UK. http://alcoholresearchuk.org/ The funders had no role in study design, data collection and analysis, decision to

Please describe all sources of funding that have supported your work. A complete funding statement should do the following: Include **grant numbers and the URLs** of any funder's website. Use the full name, not acronyms, of funding institutions, and use initials to identify authors who received the funding. **Describe the role** of any sponsors or funders in the study design, data collection and analysis, decision to publish, or preparation of the manuscript. If they had no role in any of the above, include this sentence at the end of your statement: "*The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript*." If the study was **unfunded**, provide a statement that clearly indicates this, for example: "*The author(s) received no specific funding for this work*." * typeset	publish, or preparation of the manuscript.
Competing Interests You are responsible for recognizing and disclosing on behalf of all authors any competing interest that could be perceived to bias their work, acknowledging all financial support and any other relevant financial or non-financial competing interests. Do any authors of this manuscript have competing interests (as described in the PLOS Policy on Declaration and Evaluation of Competing Interests)? **If yes**, please provide details about any and all competing interests in the box below. Your response should begin with this statement: *I have read the journal's policy and the authors of this manuscript have the following competing interests:* **If no** authors have any competing interests to declare, please enter this statement in the box: "*The authors have*	The authors have declared that no competing interests exist

declared that no competing interests exist." * typeset	
Ethics Statement You must provide an ethics statement if your study involved human participants, specimens or tissue samples, or vertebrate animals, embryos or tissues. All information entered here should **also be included in the Methods section** of your manuscript. Please write "N/A" if your study does not require an ethics statement. **Human Subject Research (involved human participants and/or tissue)** All research involving human participants must have been approved by the authors' Institutional Review Board (IRB) or an equivalent committee, and all clinical investigation must have been conducted according to the principles expressed in the Declaration of Helsinki. Informed consent, written or oral, should also have been obtained from the participants. If no consent was given, the reason must be explained (e.g. the data were analyzed anonymously) and reported. The form of consent (written/oral), or reason for lack of consent, should be indicated in the Methods section of your manuscript. Please enter the name of the IRB or Ethics Committee that approved this study in the space below. Include the approval number and/or a statement indicating approval of this research. **Animal Research (involved vertebrate animals, embryos or tissues)** All animal work must have been conducted according to relevant national and international guidelines. If your study involved non-human primates, you must provide details regarding animal welfare and steps taken to ameliorate suffering; this is in accordance with the recommendations of the Weatherall report, "The use of non-human primates in research." The relevant guidelines followed and the committee that approved	Edge Hill University Department and Faculty ethics committees

the study should be identified in the ethics statement. If anesthesia, euthanasia or any kind of animal sacrifice is part of the study, please include briefly in your statement which substances and/or methods were applied. Please enter the name of your Institutional Animal Care and Use Committee (IACUC) or other relevant ethics board, and indicate whether they approved this research or granted a formal waiver of ethical approval. Also include an approval number if one was obtained. **Field Permit** Please indicate the name of the institution or the relevant body that granted permission.	

Dear Publishers,

Please accept this paper for consideration for publication at PLOS One

Authors: Rebecca L Monk, Derek Heim and Alan Price of Edge Hill University, U.K.
Each author has contributed significantly to this work and agrees to the submission.

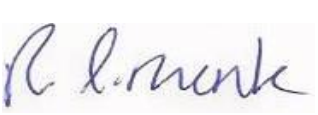
Correspondence concerning this article should be addressed to Rebecca Monk, School of Psychology, Edge Hill University, St Helens Road, Ormskirk, L39 4QP, U.K.
Email:monkre@edgehill.ac.uk.

This paper contains original material and is not submitted for consideration, in press or published anywhere else and the authors declare no conflict of interest. If accepted, it will not be published elsewhere including electronically in the same form, in English or in any other language, without the written consent of the copyright-holder

This research was funded by Alcohol Research UK. http://alcoholresearchuk.org

The authors declare no conflicts of interest.

Kind regards.



R.L.Monk D.Heim

Title:

"I have no clue what I drunk last night"

Using Smartphone technology to compare in-vivo and retrospective self-reports of alcohol consumption

Authors and Affiliations:

Rebecca L. Monk, Derek Heim, & Alan Price

of Edge Hill University, UK

Author Note

Rebecca Louise Monk & Derek Heim, Department of Psychology, Edge Hill University, St. Helens Road, Ormskirk, Lancashire, L39 4QP, UK

Correspondence concerning this article should be addressed to Rebecca Monk, Department of Psychology, Edge Hill University, St. Helens Road, Ormskirk, Lancashire, L39 4QP, UK. Email: monkre@edgehill.ac.uk. Tel: +44 (0)1695 65 0940

Word count: 3,499

Running Head: Real-time vs. retrospective alcohol reports

Key Words: alcohol consumption, drinking pattern, assessment, methodology, surveys, self-report measurement, ecological momentary assessment

Abstract

Aim: *This research compared real-time measurements of alcohol consumption with retrospective accounts of alcohol consumption to examine possible discrepancies and contextual influences between the different accounts.* ***Method:*** *Building on previous investigations, specifically designed Smartphone technology was utilized to measure alcohol consumption and contextual influences in de facto real-time. Real-time data (a total of 10,560 data points relating to type and number of drinks and current social and environmental context) were compared with retrospective accounts of alcohol consumption (both daily and weekly) to assess the consistency between the different methods. Post participation qualitative reports also gauged perceptions with regards to using the technology.* ***Results:*** *Results suggest that in-vivo and retrospective reports of alcohol consumption are not consistent with each other. Specifically, participants' daily retrospective reports about their drinking were significantly lower, overall, than in –vivo account supplied during that drinking session. The same pattern of results was also found when comparisons were made between weekly in-vivo and retrospective accounts. Interactions with type of drink and environmental context were also observed.* ***Conclusions:*** *Retrospective daily and weekly self-reports of personal alcohol consumption appear to be lower than those recorded in-vivo. Difficulties in recalling alcohol consumption from the previous day may also be exacerbated when drinking has occurred in environments such as bars and parties. A degree of caution appears warranted with regards to the extent to which retrospective alcohol consumption measures are reliable.* ..

Introduction

Self-report measures are the bedrock of much research in the addictions [1], and it is generally accepted that this approach can be used as a reliable and valid method [2, 3]. 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 [4]. Accordingly, the task of retrospective recall may encourage fabrication in an effort to satisfy the demands of the researchers [5, 6]. Such a task may also be very cognitively demanding, particularly where alcohol consumption itself may have impaired memory [c.f. 7, 8] and in the absence environmental stimuli which may aid recall [c.f. 9]. Indeed, research suggests that variations in response to alcohol-related questions can be expected across contexts [10-12] and that both social and environmental facctors are important determinants of a variety of alcohol-related cognitions and practices [c.f. for exmaple,13-16]. Resultantly, retrospective accounts of alcohol consumption may be expected to differ from those obtained in real world drinking contexts.

The use of ecological momentary assessment (EMA) reduces the demands placed on autobiographical memory [c.f.17-18] and removes the potential for "parking-lot compliance" [19]. Building on this design, Smartphone based EMA may be particularly useful for providing instantaneous, rich and useful data [20] which are electronically time-stamped to help minimise reliance on retrospective accounts. The EMA using Smartphone technology is also 'context-aware' [21] meaning that it can monitor dynamic changes across contexts, which may be particularly useful for monitoring behaviours which are episodic and contextually bound [16]. Nonetheless, there is little research which has conducted technology-enabled, in-vivo assessments of drinking [22]. However, real-time assessments in naturalistic settings may be

useful and illuminate possible contextual differences which may not be captured by hitherto more widely used methods. Smartphone technology provides a promising avenue in this regard [23]. The purpose of this research was therefore use Smartphone technology to record de facto real-time drinking, contrast this with retrospective accounts, and to examine the role of contextual factors.

Method

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). Environmental and social contexts in which participant responded were also recorded.

Participants

69 participants (18-36 years, M = 21.47, SD = 4.47) were recruited on a university campus. The majority of this sample was White British (95%) students (85.5%). 59% were male. 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 2 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 who remained in the data set. Furthermore, the structured nature of the data meant that there were a substantial proportion of data points remaining for analytical purposes. Data regarding the number of each presented drink type, current social context and present environmental location were provided in each in-vivo hourly response session, meaning that participants provided 12 pieces of information about their drinking and current location every hour that they responded (12 data points). Given that participants completed an average of 4 sessions per drinking day, all participants provided an averaged minimum of 48 data pieces of

information during the research. 22 participants provided responses for one day's drinking (1056 data points), 16 provided responses for two drinking days (2158 data points), 8 provided responses for three drinking days (3158 points); and 4 provided responses for four days (4224 data points). In short, participants included within subsequent analyses provided 10, 560 data points during their in-vivo responding.

Equipment

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 and interface were built using HTML and JavaScript and JavaScript's jQuery mobile library. 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, before data were remotely transferred to Google Analytics. To facilitated data anonymity and allow researchers to track individual level data, individual participants' responses were tracked using a unique alias which was randomly generated by the application. The application was carefully designed and piloted to make the user interface as intuitive/user friendly as possible and there were no default answers set, in accordance with recommendations [c.f., 24].

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 [AOEQ, 25), which is 34 item questionnaire (rated a 6 point likert scale: 1 = no chance, and 6 = certain to happen) asking about the positive and negative outcomes that participants expect to result from drinking. A standardised,

average of participants' responses to positive items was calculated, giving a range of 1-6 (M = 4.13, SD = .68). Second, the AUDIT was administered, which is well established tool for assessing alcohol consumption, 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 [26]. The current participants'' mean AUDIT score was 9.19 (SD = 4.72). Finally, at the end of the week, a series of experiential statements (for example, "I enjoyed taking part in this research") were provided and participants were asked to rate their agreement 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 experience of taking part in the research.

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/Partner, 1 friend, 2 or more friends, Other). Participants were also asked to select the types and quantity of alcohol they had consumed in the last hour. Here, the application presented numerous drink options as labelled, pictorial representations of different drink types 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). Using the same response forms, follow up emails for the purposes of retrospective self-reports (24 hours and 1 week post hoc), also asked participants to record the type and quantity of alcohol consumed.

Procedure

Following ethical approval from the University's ethics boards, participants were recruited though opportunity sampling on a university campus and through online adverts (intranet and social media). All participants gave fully informed written consent. Those who signed up to take part attended a briefing session where they were instructed how to download and use the application. Participants' demographic details and information about their drinking (AUDIT and AOEQ) were also obtained by way of an electronic questionnaire.

Participants were asked to use the application to report as many separate drinking occasions as possible over the participation week. Once activated, the application triggered hourly prompts for participants to respond to, until participants indicated that they had finished the dinking 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 research team emailed participants 24 hours after the drinking session had finished, asking them to complete a short online survey which asked them to recall the type and number of alcoholic beverages they had consumed they day before. 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 to obtain their weekly retrospective reports and user-experiences.

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, 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 summarized in Table 1.

INSERT TABLE 1 HERE

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[1]. This was calculated by summing every hourly response. Participants' daily retrospective accounts for that day (i.e., their self-reported consumption the day after) then provided the daily retrospective measure for analytical purposes. Initial correlation analyses revealed that participant's pre-testing AUDIT scores (r = .24, p = .14) and AUDIT-C (r = .15, p = .34) scores did not significantly correlate with daily or weekly in-vivo accounts of alcohol consumption respectively. Multivariate analyses were subsequently conducted in order to facilitate a detailed exploration of potential differences in-vivo and retrospective accounts. The effect of the participants' social and environmental context at the time of their in-vivo assessment was therefore also assessed (See Table 2 for descriptive statistics).

[1] Day 1 of participation was selected in order that the maximal amount of data could be included within the analyses - not all participants (n = 22) took part for more than one day (i.e. recorded more than one drinking session).

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.

INSERT TABLE 2 HERE

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 effects 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 were 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 1). 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.

INSERT FIGURE 1 HERE

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 2). Notably, however, 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.

INSERT FIGURE 2 HERE

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 consisted of participants' weekly-total drinks (by summing the total number drinks recorded in-vivo), and participants' weekly retrospective reports. Initial correlation analyses revealed that participant's pre-testing AUDIT scores ($r = .08$, $p = .63$) and AUDIT-C ($r = .21$, $p =$ 19) scores did not significantly correlate with daily or weekly in-vivo accounts of alcohol consumption respectively. In order to examine potential differences between in-vivo and retrospective weekly reports in more detail, multivariate analyses in the form of 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 3). 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 dinks 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.

INSERT FIGURE 3 HERE

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 felt 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 break down 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.

INSERT TABLE 3 HERE

Aside from a number of comments pertaining to mobile-specific technical issues that were encountered (n = 6), the remaining comments (n = 12) 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 to note as they appear to illuminate 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-rime (in-vivo). Specifically, participants' appear to retrospectively under-report the number of drinks that they reportedly consumed in real-time. Such findings may therefore add weight to concerns surrounding retrospective accounts of substance-use behaviours [27]. 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 suggest that it was difficult when trying to recall their drinking (both the day and the week after). Such an opportunity to provide feedback is not typically supplied when participants are asked to recall their alcohol consumption for research or therapeutic purposes and specific comments in relation to task difficulty were unsolicited. However, findings here suggest that this may be fallacious. It is also interesting to note that daily and weekly in-vivo reports of consumption failed to correlate with either the AUDIT or AUDIT-C scores which may be an indication that AUDIT measures more long-term drinking behaviours.

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 were all 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. One explanation of this finding may be that alcohol consumption is higher in certain contexts (e.g., licensed premises) resulting in relatively greater retrospective memory impairments [7, 8]. Another explanation may be offered by alcohol myopia theory [28] which may suggest that contextual variations in attention impede later recall. These findings are also inline with previous research indicating a contextual variation in alcohol-related cognitions [11, 12, 29, 30, 31].

The observed difference between in-vivo and retrospective reports remained for weekly retrospective accounts. However, this appeared to be driven by under-reporting of beer and ciders, whilst other drink types (wine, spirits, other) did not vary significantly. The retrospective under-reporting evident in daily alcohol reports therefore does not appear to be universally evident in weekly reports. Item salience combined with task difficulty may offer an explanation here. Greater effortful processing is associated with better task performance [31]. The greater difficulty of recalling weekly as opposed to daily drinking [32] may therefore be an important determinant of performance. Furthermore, items which are more unusual within memory have been postulated to have an attentional draw, meaning that they elicit more detailed encoding for the purpose of long term memory [34, 35]. In the case of

the current findings, drinks which were less frequently recorded within this cohort (e.g., wine) may therefore be recalled more accurately because of their relative salience. On the other hand, more frequently consumed drinks (e.g. beer/cider) may be less salient, thus they remain poorly recalled and under-reported.

Further research in regard to this discrepancy between weekly and daily retrospective accounts is strongly recommend, as well as further research to support the development of real-time data collection methods. Extending this research to examine longer time recording frames may also be beneficial. It should also be noted that 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 still be subject to demand characteristics [5]. The addition use of objective measures of consumption, such as a breathalysers or Secure Continuous Remote Alcohol Monitors (SCRAM), alongside in-vivo self-monitoring, would therefore be recommended. This would also allow an examination into how intoxication moderates the impact of retrospective misperception, which cannot be assessed presently. An expansion of the current research to increase the current sample size would also be recommended, although it is believed that some of the potential concern in this regard has been ameliorated by the large number of data points supporting the current statistical analyses, and the relatively strong effect sizes revealed. Utilising a wider number of non students would also be advisable as differences in the student drinking culture [36] may mean that results cannot be generalised to the wider population.

Overall 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. However, the introduction of novel and cost effective ways of measuring alcohol consumption appears promising. This research

therefore constitutes a first-step towards to the development of research methods that may prove to be more valid than retrospective self-report measures.

Acknowledgments

This research was funded by Alcohol Research UK. http://alcoholresearchuk.org/

The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Declaration

The authors declare no conflicts of interest. This material has not been published in whole or in part elsewhere, not is the paper being currently being considered for publication elsewhere. All authors have been personally and actively involved in substantive work leading to the report, and will hold themselves jointly and individually responsible for its content. All relevant ethical safeguards have been met in relation to patient or subject protection, or animal experimentation, including, with a full review by an appropriate ethical review committee. This research complies with the World Medical Association Declaration of Helsinki.

References

1 Greenfield, T.K., & Kerr, W.C. (2008). Alcohol measurement methodology in epidemiology: Recent advances and opportunities. Addiction: 103, 1082-1099

2 Del Boca, F.K., & Noll, J.A. (2000). Truth or consequences: The validity of in health services research on addictions. Addiction 95: 347-360.

3 Glovannucci, E., Colditz, G., Stampfer, M.J., Rimm, E.B., Litin, Sampson, L., & Willet, W.C. (1991). The assessment of alcohol consumption by a simple self-administered questionnaire. Am J Epidemiol 133: 810-817.

4 Verster, J.C., Tiplady, B., & McKinney, A. (2012). Mobile technology and naturalistic study designs in addiction research (Editorial). Current Drug Abuse Reviews 5: 169-171.

5 Davies, J.B. & Best, D.W. (1996). Demand characteristics and research into drug use. Psych and Health 11: 291-299.

6 Schwarz, N. (1999). Self-report; how the questions shape the answers. Am Psychol 54: 93-105.

7 Walker, D.W. & Hunter, B.E. (1978). Short-term memory impairment following chronic alcohol consumption in rats. Neuropsychologia 16: 545-553.

8 Weissenborn, R., & Duka, T. (2003). Acute alcohol effects on cognitive function in social drinkers: their relationship to drinking habits. Psychopharmacology 165: 306-312.

9 Godden, D.R., & Baddeley, A.D. (1975). Context-dependent memory in two natural environments: On land and underwater. Brit J Psychol 66*:* 325-231**.**

10 Monk, R. L., & Heim, D. (in press). A real-time examination of context effects on alcohol cognitions. Alcohol Clin Exp Res.

11 Monk, R.L., & Heim, D. (2013a). A critical systematic review of alcohol-related outcome expectancies. Subst Use Misuse 48*:* 539-557.

12 Monk, R.L., & Heim, D. (2013b). Panoramic projection; affording a wider view on contextual influences on alcohol-related cognitions. Exp Clin Psychopharm 21*:* 1-7.

13 Arterberry, B. J., Smith, A. E., Martens, M. P., Cadigan, J. M., & Murphy, J. G. (2013). Protective behavioral strategies, social norms, and alcohol-related outcomes. Addic Res Theory 21: 507-515.

14 Buckingham, S. A., Frings, D., & Albery, I. P. (2013). Group membership and social identity in addiction recovery. Psychol Addict Behav 27: 1132-1140.

15 Lau-Barraco, C. & Dunn, M.E. (2009). Environmental context effects on alcohol cognitions and immediate alcohol consumption. Addic Res Theory 17: 306-314.

16 Lau-Barraco, C., & Linden, A.N. (2014). Drinking buddies: Who are they and when do they matter? Addic Res Theory 22: 57-67.

17 Shiffman, S., Stone, A.A., & Hufford, M.R. (2008). Ecological momentary assessment. Annu Rev Clin Psycho 4: 1-32.

18 Stone, A.A., & Shiffman, S. (2002). Capturing momentary self-report data: A proposal for reporting guidelines. Ann of Behav Med 24: 236-243.

19 Smyth, J.M., & Stone, A.A. (2003). Ecological momentary assessment research in behavioural medicine. Journ Happiness Stud 4: 35-52.

20 Katz, J.E., & Aakus, M. (2002) Framing the issues. In: J.E. Katz & M. Aakhus (Eds), *Perpetual Contact: Mobile communication, private talk, public performance*. Cambridge, London: Cambridge University Press.

21 Miller, G. (2012). The smartphone psychology manifesto. *Perspectives on* Psych Sc 7*:* 221-237.

22 Alessi, S.M., & Petry, N.M. (2013). A randomized study of cellphone technology to reinforce alcohol abstinence in the natural environment. Addiction *108*: 900-909.

23 Kuntsche, E. & Labhart, F. (2014). The future is now—using personal cellphones to gather data on substance use and related factors. Addiction. *Early Online.* doi: 10.1111/add.12540.

24 Palmblad, M. & Tiplady, B. (2004). Electronic diaries and questionnaires: Designing user interfaces that are easy for all patients to use. Qual Life Res 13: 1199-1207.

25 Leigh, B.C., & Stacy (1993). Alcohol outcome expectancies: Scale construction and predictive utility in higher order confirmatory models. Psychol Assessment 5: 216-229

26 Babor, T. F., Higgins-Biddle, J. C., Saunders, J. B., & Monteiro, M. G. (2001). Audit. *The Alcohol Use Disorders Identification Test (AUDIT): Guidelines for use in primary care*. World Health Organisation.

27 Davies, J.B. (1997). *The Myth of Addiction* (2nd edition). Amsterdam: Harwood Academic Publishers.

28 Steele, C.M., & Josephs, R.A. (1990). Alcohol myopia: Its prized and dangerous effects. Am Psychol 45: 921-933.

29 Monk, R.L.**,** & Heim, D. (2013c). Environmental context effects on alcohol-related outcome expectancies, efficacy and norms: A field study. Psychol Addict Behav 27: 814-818.

30 Wall, A.M., Hinson, R.E., McKee, S.A., & Goldstein, A. (2001) Examining alcohol outcome expectancies in laboratory and naturalistic bar settings: a within-subjects experimental analysis. Psychol Addict Behav 15: 219-226.

31 Wall, A.M., Mckee, S.A., & Hinson, R.E. (2000). Assessing variation in alcohol outcome expectancies across environmental context: An examination of the situational-specificity hypothesis. Psychol Addict Behav 14: 367-375.

32 Hasher, L., & Zacks, R. T. (1979). Automatic and effortful processes in memory. J Exp Psychol Gen 108: 356-388.

33 Robinson, P. (1995). Attention, memory, and the "noticing" hypothesis. Language Learn 45: 283-331.

34 Lemmens, P., Tan, E.S., & Knibbe, R.A. (1992). Measuring quantity and frequency of drinking in a general population survey: a comparison of five indices. J Stud Alc Drugs 53: 476-486.

35 Navalpakkam, V., & Itti, L. (2005). Modeling the influence of task on attention. Vision Res 45: 205-231.

36 Borsari, B., & Carey, K. B. (2001). Peer influences of college drinking: A review of the research. J Subst Abuse 13: 391-424.

Tables

Table 1
Participants' reported alcohol consumption across drink type and assessment time period.

	Daily Reports		Weekly Reports	
Drink Type	*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)

Table 2

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

	Environmental Context						
Response Time	**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)

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

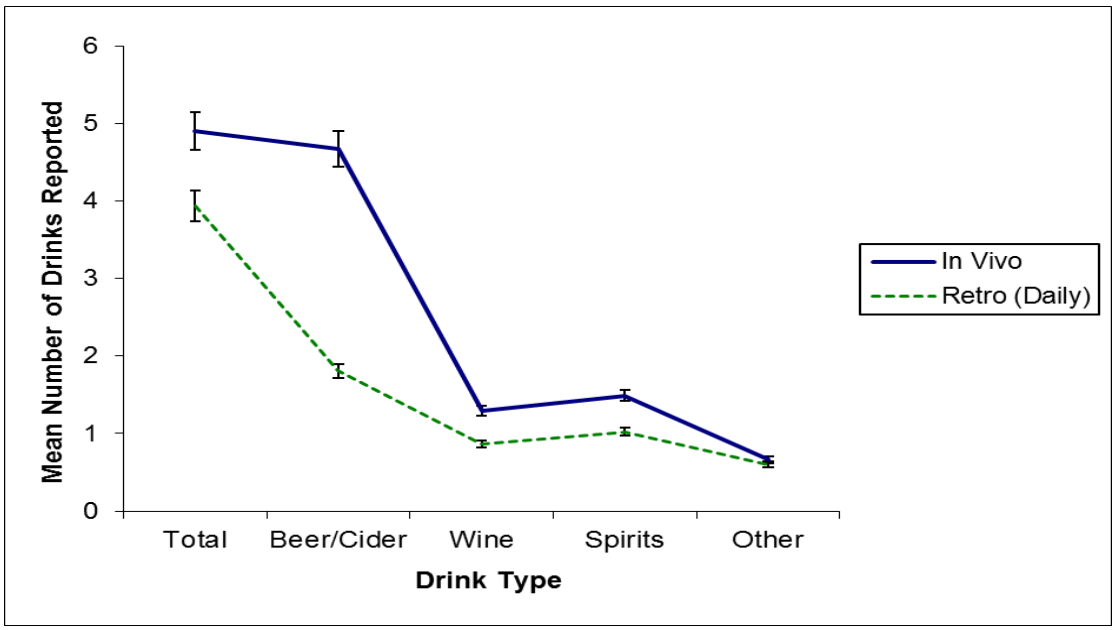


Figure 1
Daily in-vivo and retrospective recorded consumption across drink type.

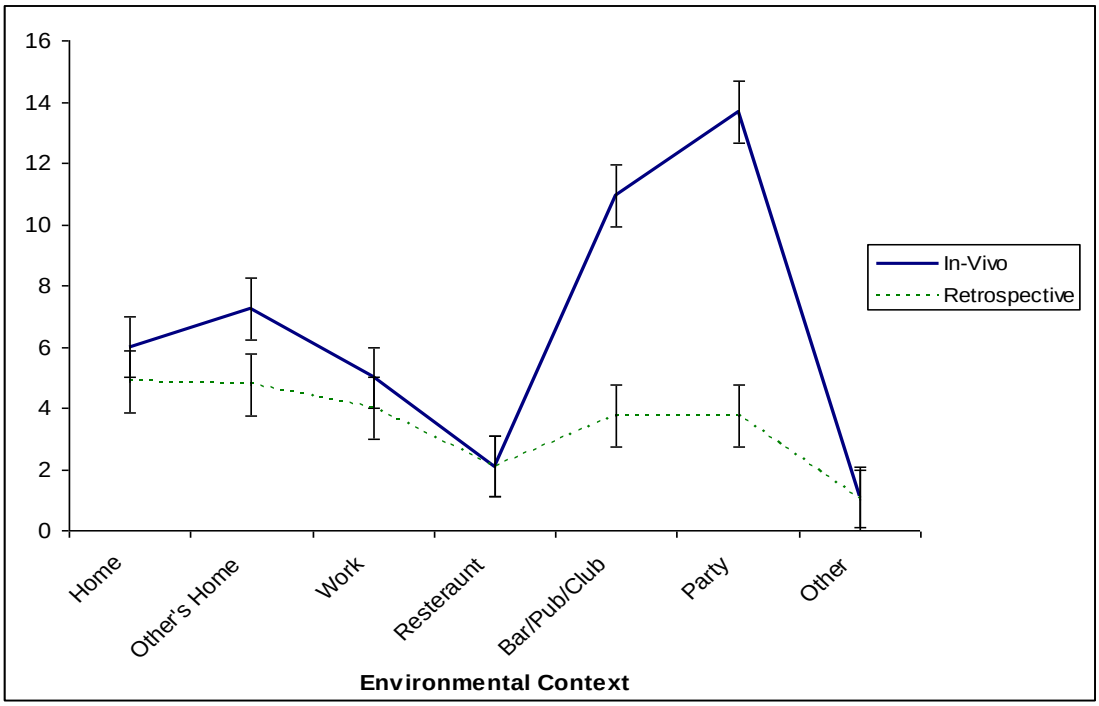


Figure 2
Daily in-vivo and retrospective recorded consumption across environmental contexts.

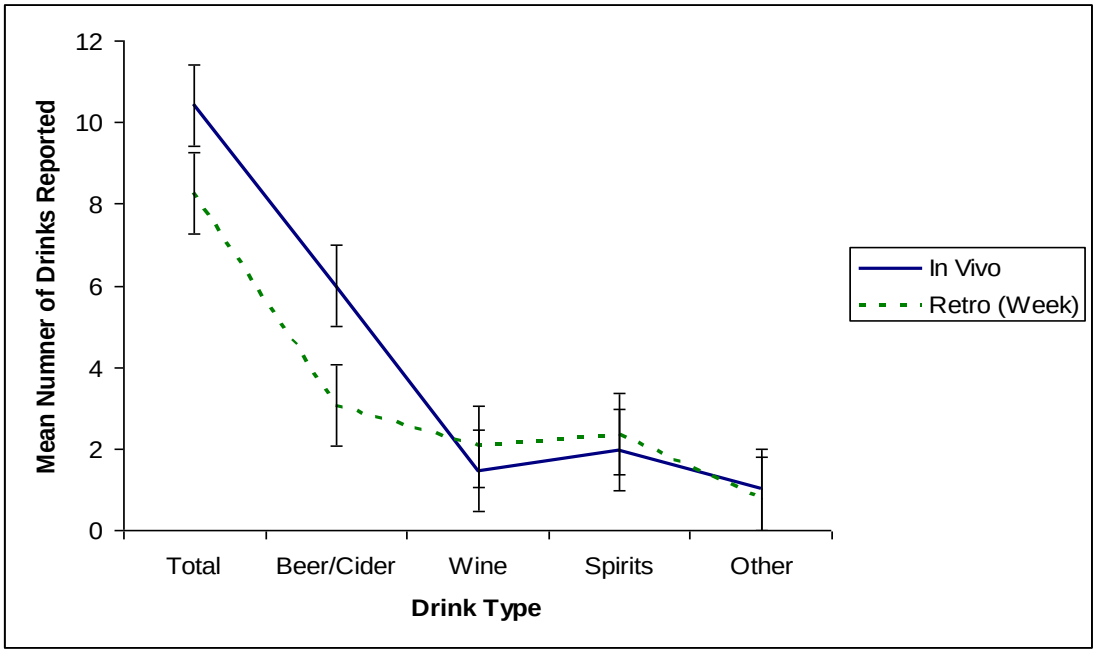


Figure 3
Weekly in-vivo and retrospective recorded consumption across drink type