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Research report

Stimulus control and affect in dietary behaviours. An intensive longitudinal study☆

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ABSTRACT

Background: Dietary behaviours are substantially influenced by environmental and internal stimuli, such as mood, social situation, and food availability. However, little is known about the role of stimulus control for eating in non-clinical populations, and no studies so far have looked at eating and drinking behaviour simultaneously. *Method:* 53 individuals from the general population took part in an intensive longitudinal study with repeated, real-time assessments of eating and drinking using Ecological Momentary Assessment. Eating was assessed as main meals and snacks, drinks assessments were separated along alcoholic and non-alcoholic drinks. Situational and internal stimuli were assessed during both eating and drinking events, and during randomly selected non-eating occasions. Hierarchical multinomial logistic random effects models were used to analyse data, comparing dietary events to non-eating occasions. *Results:* Several situational and affective antecedents of dietary behaviours could be identified. Meals were significantly associated with having food available and observing others eat. Snacking was associated with negative affect, having food available, and observing others eat. Engaging in activities and being with others decreased the likelihood of eating behaviours. Non-alcoholic drinks were associated with observing others eat, and less activities and company. Alcoholic drinks were associated with less negative affect and arousal, and with observing others eat. *Conclusions:* Results support the role of stimulus control in dietary behaviours, with support for both internal and external, in particular availability and social stimuli. The findings for negative affect support the idea of comfort eating, and results point to the formation of eating habits via cue–behaviour associations.

Introduction

Every day, and in an abundance of situations, we find ourselves confronted by stimuli relating to food such as food items in shop displays, advertisements for food, or seeing other people eat. These stimuli are highly relevant, because it has been acknowledged that our dietary behaviours are predominately driven by environmental cues rather than by a motivation to restore energy homoeostasis; or, put another way, that we do not eat because we are hungry, but because we see something or encounter a situation that prompts us to eat (Weingarten, 1985).

This approach to understanding eating and other dietary behaviours including drinking is an example of *stimulus control*; it assumes that external factors (e.g., seeing others eat, seeing food in the environment) rather than internal states (hunger, thirst) influence our dietary behaviours or even make us feel hungry (Sobik, Hutchison, & Craighead, 2005). The present study is a first attempt at providing an integrative approach at describing stimulus control effects on a wide range of dietary behaviours in a non-clinical population – it examines environmental (external) and affective (internal) factors that are associated with eating (both during main meals and between meals) and drinking (both alcoholic and non-alcoholic beverages).

Stimulus control and eating

Stimulus control in eating behaviour is hypothesized to be driven by the automatic processing of food-related cues and/or cognitions (King, 2013; Lowe & Butryn, 2007): it is theorized that individuals can misinterpret their psychological responses to such internal and external food-related cues as signals of biological hunger and respond accordingly (Lutter & Nestler, 2009). External cues may include seeing or smelling food, seeing other people eating, food advertising, or being at a location where one has consumed food in the past; internal cues refer to psychological desires for rewarding experiences or to lessen negative mood states (e.g., eating to

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regulate negative affect, or 'comfort' eating; Parker, Parker, & Brotchie, 2006).

There is good evidence for the importance of external cues in eliciting eating behaviour. For example, Cleobury and Tapper (2014) found external cues to be the most important predictors of eating unhealthy snacks in an intensive longitudinal diary study of overweight and obese adults. Similarly, there is evidence that supports the idea that internal cues such as negative affect motivate us to eat, and it has been suggested that energy-dense foods in particular can serve the purpose of down-regulating negative affective states (Parker et al., 2006). Or, put more simply: that people eat in order to decrease negative effect. It has also been shown that experiencing negative affect increases selective attention to food-related stimuli (Hepworth, Mogg, Brignell, & Bradley, 2010), which might explain this association. However, other research suggests that the association between affect and eating might not be as straightforward, but could in fact depend on internal resources such as self-regulatory capacities (Sproesser, Strohbach, Schupp, & Renner, 2011).

Stimulus control and drinking non-alcoholic beverages

Whereas there is rich literature on the role of external and internal stimuli for eating (both regular meals and snacks between meals) and drinking alcohol (more below), there is comparatively little research on the role of stimulus control for drinking non-alcoholic beverages. One study found that having coffee might be cued by situational factors such as going on a cigarette break (Lane, 1996), and there is some evidence that being exposed to an environment that has non-alcoholic beverages available increases the likelihood of having a non-alcoholic beverage (Tucker, Vuchinich, & Sobell, 1979). Further, it has been suggested that being exposed to drink-related cues such as brand logos activates neural pathways similar to those activated during reward processing, at least in more habitual soft drink consumers (Burger & Stice, 2014). This is in line with evidence from a study on adolescents that found that being in locations (e.g., school) or social situations (e.g., with friends), or being bored, which had previously been associated with soft drink consumption, can all increase the likelihood of the consumption of sweetened drinks (Grenard et al., 2013). However, more research is needed to better understand the role of situational factors in the consumption of non-alcoholic drinks.

Stimulus control and drinking alcohol

Compared to non-alcoholic drinks, there is more research on the role of stimulus control for consuming alcoholic beverages. However, the majority of this research has been conducted in clinical populations and it is unclear whether stimuli are similar between clinical and non-clinical drinkers. Only few studies to date have explored drinking alcohol in non-clinical samples. For example, there is evidence that social drinkers (i.e., people who mainly consume alcohol in social situations) experience higher craving in social situations (Papachristou, Nederkoorn, Corstjens, & Jansen, 2012), which in turn might lead to subsequent alcohol consumption. Social cues such as interacting with friends may also play a role in promoting alcohol consumption in non-clinical populations (Aan Het Rot, Russell, Moskowitz, & Young, 2008). In addition, having alcohol readily available or being in an environment where alcohol is easily obtainable has been shown to increase the likelihood of alcohol consumption (Gruenewald, Remer, & Lascala, 2014). It has further been suggested that in non-clinical populations, alcohol might serve as mood-regulation agent, similar to the effects of calorie-dense food discussed above – i.e., experiencing negative affect makes alcohol consumption more likely, as people might drink to improve negative affect (Kassel, Jackson, & Unrod, 2000; Peacock, Cash, Bruno, & Ferguson, 2015) or as a result of high arousal (Swendsen et al., 2000).

Study aims

Previous studies have examined stimulus control on specific dietary behaviours, but to date, no study has examined the role of external and internal stimuli on a comprehensive set of dietary behaviours. Furthermore, only few studies on stimulus control and eating to date have broken down eating into main meals and snacking, the latter being the type of eating arguably most likely to be affected by situational variables, given that it can be viewed as being more discretionary (Cleobury & Tapper, 2014). In this study, we differentiate between eating during main meal periods (i.e., breakfast, lunch, dinner) and snacking (defined as spontaneous additions to the diet; Nielsen, Siega-Riz, & Popkin, 2002). Snacks are typically higher in energy and lower in nutrient content than meals eaten during main meal times (Gearhardt, Grilo, Dileone, Brownell, & Potenza, 2011). Increased snacking frequency has been associated with obesity (Miller, Benelam, Stanner, & Buttriss, 2013), and snack-dominated meal patterns seem to lead to higher intakes of energy, alcohol, sugars, and sucrose, and lower intake of micronutrients (Ovaskainen et al., 2006).

Previous studies on stimulus control and eating behaviour also tended to rely on retrospective assessments such as food frequency questionnaires (Flint, Cummins, & Matthews, 2013), clinical interviews (Lowe et al., 2009), written food diaries (O'Connor, Jones, Conner, McMillan, & Ferguson, 2008; Verhoeven, Adriaanse, Evers, & De Ridder, 2012), or laboratory experimentation and/or observation (e.g., Werthmann et al., 2011), but it has been argued that such methods lead to under-reporting of food intake, particularly snacks (Heitmann & Lissner, 1995). Ecological momentary assessment (EMA; Shiffman, Stone, & Hufford, 2008) procedures – where participants record events in real-time as they go about their day-to-day life – allow researchers to study behaviours in more detail, in real-world settings, and close to real-time. EMA methods to assess food intake have been used previously in eating-disordered populations (Norton, Wonderlich, Myers, Mitchell, & Crosby, 2003), but only few studies so far have used EMA in non-clinical populations (Grenard et al., 2013; Hofmann, Adriaanse, Vohs, & Baumeister, 2013; Thomas, Doshi, Crosby, & Lowe, 2011). In this study, we aim to examine dietary behaviours close to real-time and within the environment in which the behaviours are performed, thus providing a more ecologically valid approach to examining stimulus control of eating and drinking including a wider range of dietary behaviours than previous studies. Further, as previous work has been mainly conducted in clinical samples, our study targeted a non-clinical sample from the general population.

Method

We employed EMA methods to study eating patterns in a community sample. Participants carried a programmable electronic device throughout the day and logged episodes of eating and drinking as well as responded to randomly-timed non-eating/non-drinking prompts. This allows comparing the presence and intensity of a range of internal and external stimuli between consumption logs and random prompts (Shiffman et al., 2014). With training, participants can be highly compliant with such procedures (Schüz, Walters, Frandsen, Bower, & Ferguson, 2014).

Participants and procedure

For this longitudinal intensive assessment EMA study, 53 participants (41.51% female) aged 18–60 years ($M = 28.17$ years, $SD = 11.15$) with a BMI range between 17.7 and 37 ($M = 23.9$,

$SD = 4.14$) were recruited through advertisements at an Australian university and through ads on the Facebook® social media website (see Frandsen et al. 2013) asking for individuals interested in participating in a study examining "eating patterns". Inclusion criteria were being over 18 years of age, having no history of an eating disorder, and not currently trying to change or restrict eating patterns (e.g., being on a diet). Ethical approval was obtained from the Tasmanian Social Sciences Human Research Ethics Committee (H.0012474).

During an initial meeting (approx. 45 minutes) and after providing informed consent, participants' height and weight were measured (for later calculation of BMI). All participants were then provided with a smartphone with the EMA software (HBART: http://www.utas.edu.au/pharmacy/research/bsrg/hbart) and received individual training on how to use the monitoring device.

The monitoring procedure was based on Schüz et al. (2014) and Thomas et al. (2011). Participants were asked to carry the EMA device during waking hours for up to ten consecutive days and log every instance of eating and drinking. When logging eating behaviour, participants could choose between reporting a meal (breakfast, lunch, or dinner), or a snack, which was defined as any item of food eaten between the main meals of breakfast, lunch, or dinner (Nielsen et al., 2002). Participants were instructed to log events immediately before consumption. In addition to logging their eating and drinking, participants were required to respond to 3–5 randomly timed prompts during the day. Each reported event was date- and time-stamped for analysis.

After approximately two days to familiarize themselves with the protocol, participants returned for a brief re-training session (10–15 minutes). A third and final study visit was conducted approximately a week later (~10 days after enrolment). During this final visit participants returned the EMA device, were thanked for their involvement in the study, and received up to AU$40 reimbursement.

Measurement instruments

During each log of food or drink consumed and for each random prompt, participants were asked to indicate their affect and arousal state *at the time they decided to eat* using 14 adjectives derived from the circumplex model of affect (Russell, 1980). Individual items were presented on-screen, one item at a time, and answered using a slider (e.g., "Happy?" with a visual analogue slider scale ranging from "No!!" [0] to "Yes!!" [100]). The items were adapted from previous EMA studies on smoking patterns and stimulus control using the same set of items in intermittent and daily smokers (Shiffman et al., 2014; Shiffman, Ferguson, Gwaltney, Balabanis, & Shadel, 2006). Responses to the individual items were then converted to z-scores (within-subject; $M = 0$, $SD = 1.00$), and a maximum likelihood factor analysis (using geomin rotation) controlling for non-independence of observations using the TYPE = COMPLEX option in MPlus was used to extract two factors based on eigenvalues >1 (affect, Cronbach's alpha = .82 and arousal, Cronbach's alpha = .71), with higher scores indicating more negative affect or higher arousal, respectively.

Participants were further asked to indicate the context they were in at the time they decided to eat in four domains – social setting (e.g., whether they were with partner or with friends), activities (e.g., working, engaging in leisure activities, or being between activities), social cues (seeing someone else eat), and the availability of different foodstuffs (e.g., savoury foods, confectionary) in the environment. The assessment of the first four domains were based on context factors identified in smoking-related EMA work (Ferguson & Shiffman, 2011; Shiffman et al., 2014); the assessment of the availability of foodstuffs was based on previous EMA work on eating (Grenard et al., 2013).

Analytical procedure

Our primary objective was to examine the influence of external and internal stimuli on dietary behaviours. To do so, we compared which of these internal and external covariates were present during eating events to those present during non-eating/ non-drinking occasions (i.e., random prompts).

For each measurement occasion (random prompt, or log of food or drink), the likelihood of this report being a specific dietary behaviour report (that is, meal, snack, non-alcoholic drink, alcoholic drink) or a random prompt was predicted from internal and external covariates (see Shiffman et al., 2008, 2014 for examples of similar analyses looking at nicotine dependence). Measurement occasions were coded 1 (alcoholic drink), 2 (non-alcoholic drink), 3 (snack log), 4 (meal log), or 5 (random prompt). As EMA data are hierarchically structured (measurement occasions are nested within individuals), we used random effects (random intercepts) multinomial logistic regression analysis in MPlus with maximum likelihood estimation and robust standard errors (MLR) to account for this structure (Hox, 2010).

Whether random effects analyses were needed in the first place was established by examining the intraclass coefficient (ICC). The ICC indicates the ratio of variance within one measurement point to variance on the level of the participant (variance in the likelihood for a measurement occasion to be a random prompt, meal report, snack report, drink report, or alcoholic drink report), i.e., the degree to which this variance is due to the measurement occasion or the participant. The ICC of the likelihood of a measurement occasion being a specific food report or a random prompt was estimated to be $\rho = .05$, which indicates a non-ignorable multilevel structure of the data and the need for random effects analyses (Hox, 2010).

We then analysed the covariates of dietary behaviours in two separate parts: First, a random effects (random intercepts) multinomial logistic regression model including all covariates (food availability, company, observing others eat, activities, affect, arousal) was analysed to estimate the overall effects of the different affective and situational covariates. The availability of food was coded as 1 (food present), 0 (no food present), social setting was coded as 1 (other people present), 0 (no other people present), activities were coded as 1 (engaging in activities), 0 (being between activities), and social cues to eating were coded as 1 (seeing others eat) or 0 (not seeing others eat). The factor scores for affect and arousal were entered as described above.

In the second part, the covariates from the first step of the analysis containing multiple indicators (social setting, availability of food, activities) were examined in three separate random effects (random intercepts) multinomial logistic regression models while controlling for the other blocks of situational covariates and affect. The first of these models examined whether the availability of food items in the environment (confectionery, savoury, dairy products, biscuits, fast food, or others; all coded 1 = present, 0 = not present) predicted the likelihood of snacks and meals compared to random prompts. The second model considered the presence of others (family, friends, co-workers, others; all coded 1 = present, 0 = not present) in predicting the likelihood of dietary behaviours against random prompts. Finally, the activities participants engaged in (work, leisure, interactions, being between activities, other activities; all coded 1 = present, 0 = not present) were examined as predictors of the likelihood of dietary behaviours against random prompts.

Results

Overall, there were 638 participant days of monitoring. Consistent with previous EMA studies (see Schüz et al., 2014), we excluded from analysis individual days where poor compliance was

Table 1
Summary of random effects multinomial logistic regression analyses: dietary behaviours regressed on internal and external stimuli using random prompts as reference category on the within-participants level.

Dietary behaviour	Predictor	Parameter estimate (*SE*)	Odds ratio (95% CI)
Meal	Negative affect[a]	.02 (.08)	1.02 (.88–1.19)
	Arousal	−.01 (.09)	.99 (.83–1.18)
	Availability of food	1.35 (.17)***	3.87 (2.76–5.42)
	Having company	−.49 (.15)**	.61 (.46–.81)
	Observing others eat	1.76 (.16)***	5.81 (4.25–7.94)
	Engaging in activities	−1.09 (.14)***	.34 (.26–.44)
Snack	Negative affect[a]	.24 (.10)*	1.27 (1.04–1.56)
	Arousal	.06 (.11)	1.06 (.86–1.30)
	Availability of food	1.49 (.23)***	4.42 (2.81–6.96)
	Having company	−1.02 (.16)***	.36 (.26–.50)
	Observing others eat	1.66 (.15)***	5.23 (3.90–7.01)
	Engaging in activities	−.67 (.22)**	.51 (.33–.79)
Drink (non-alcoholic)	Negative affect[a]	−.21 (.15)	.81 (.61–1.10)
	Arousal	−.31 (.18)	.74 (.52–1.05)
	Availability of food	.36 (.29)	1.43 (.82–2.50)
	Having company	−1.02 (.31)**	.36 (.20–.67)
	Observing others eat	2.00 (.24)***	7.40 (4.64–11.80)
	Engaging in activities	−.75 (.23)**	.47 (.30–.74)
Drink (alcoholic)	Negative affect[a]	−1.23 (.25)***	.29 (.18–.47)
	Arousal	−.72 (.24)**	.49 (.30–.78)
	Availability of food	−.08 (.43)	.93 (.40–2.15)
	Having company	.36 (.59)	1.43 (.45–4.56)
	Observing others eat	3.12 (.52)***	22.54 (8.14–62.40)
	Engaging in activities	−.24 (.45)	.79 (.32–1.92)

Note: Models included all covariates (affect, arousal, food availability, company, observing others eat, activities). Reference Category = Random Prompt.
[a] Higher values indicate more negative affect.
* $p < .05$;
** $p < .01$;
*** $p < .001$.

observed (defined as answering <50% of random prompts; 5.80% of monitored days). This left an evaluable sample of 601 participant-days of observation (mean of 11.91 days per person, SD = 2.62). Participants completed an average of 13.78 hours (SD = 12.75) of monitoring per day. A total of 2057 random prompts were issued over the course of the study; an average of 3.42 prompts (SD = 0.58) per participant per day; 93.00% (n = 1870) of these random prompts were completed and hence are available for analysis.

Dietary behaviours

Overall, during the monitoring period, a total of 1327 meals, 1056 snacks, 661 non-alcoholic drinks, and 112 alcoholic drinks were reported.

Dietary behaviours, environmental stimuli and affect

In the first part of the random effects multinomial logistic regression analyses, we regressed the dietary behaviours on affect, arousal, availability of food, having company, observing others eat, and engaging in activities (Table 1) with random prompts as reference category. This means that each Odds Ratio indicates how much more or less likely it is that the measurement occasion is a specific food report as opposed to a random prompt if this specific covariate is present. Introducing random effects (random intercepts) accounts for the possibility that participants differ in the baseline likelihood of these events occurring. Table 1 shows that the likelihood of meals was increased almost four-fold if food was available, and decreased when participants were in the in the company of others or engaging in activities. If others were eating, the odds of an observation being a meal report increased more than five-fold compared to random prompts.

Similarly, the availability of food and observing others eating were both also associated with sizeable (four and five-fold, respectively) increases in the odds of snacking; whereas having company or engaging in activities decreased the likelihood of snacks, again compared to random prompts (Table 1). Higher levels of negative affect also significantly predicted the odds of snacking, with an increase of negative affect by 1 standard deviation (within-individuals) being associated with a 1.27 fold increase in the odds of a snack report.

Observing others eat increased the likelihood of having a non-alcoholic drink, and having company and engaging in activities decreased this likelihood. Finally, the likelihood of a specific measurement occasion being a report of an alcoholic drink as opposed to a random prompt was decreased around three-fold if participants had higher levels (one within-individual standard deviation above individual mean) of negative affect, and around two-fold if participants were more aroused (one within-individual standard deviation above individual mean). Similar to the other dietary behaviour reports, observing others eat significantly increased the likelihood of alcoholic drinks as opposed to random prompts.

In the second set of analyses, we examined separate random effects multinomial logistic regression analyses predicting dietary behaviours from the specific categories of foodstuffs available, social partners, and different activities while holding the covariates from the previous step constant.

Figure 1 shows that, compared to random prompts, snacks were significantly more likely if sweets or “other” foodstuffs were available at the time of data assessment. Meals on the other hand were significantly more likely if savoury or “other” foodstuffs were available.

Figure 2 illustrates the relation of activities to dietary behaviours. In particular, engaging in “interaction” activities increased the likelihood of alcoholic drink logs compared to random prompts, as did being in between activities. Being between activities also increased the likelihood of non-alcoholic drinks compared to random prompts. For snacks, being between activities significantly increased the likelihood when compared to random prompts, and engaging in “other” activities significantly decreased the likelihood of snacks. Meals were significantly less likely if engaging in “work” activities, and significantly more likely if being between activities.

The last set of analyses examined social covariates of dietary behaviours (Fig. 3). Being with friends significantly increased the likelihood of a measurement occasion being an alcoholic drink report compared to a random prompt. Being with family or partner significantly decreased the likelihood of drinks compared to random prompts. Snacks were less likely in situations where participants were with their friends, family, coworkers or partners. Meals finally were less likely compared to random prompts if participants were with friends.

Discussion

This study examined stimulus control and individual dietary behaviour over a period of ~10 days in 53 non-clinical individuals from the general population using EMA methods to assess real-time associations between situational antecedents, affect, as well as arousal – ‘cues’ – and eating or drinking. The study supports a significant role of the availability of foodstuffs in the environment for eating. It also supports the role of social cues and suggests that observing others eating is significantly associated with higher likelihoods of having a meal, eating a snack, having a drink or having alcoholic drinks. Further, this study underlines the importance of

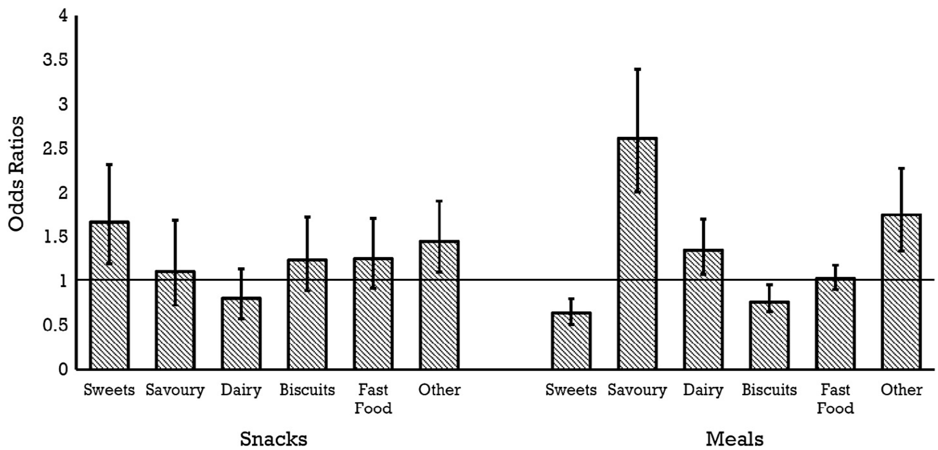

Fig. 1. Odds ratios of the availability of food types in predicting snacking and meals compared to random prompts with 95% confidence intervals (controlled for affect, arousal, company, activities, seeing others eat) on the within-participants level.
Note: Solid line indicates OR = 1 (i.e., no association). If the 95% confidence interval includes 1, the OR is not significantly different from 1 (i.e., no association).

affect for dietary behaviours, with higher levels of negative affect associated with an increased likelihood of having a snack, but lower likelihood of alcoholic drinks.

Stimulus control and eating meals and snacks

Our findings support previous research that found eating behaviour to be highly context-dependent (e.g., Ferriday & Brunstrom, 2011), and provides further support for the notion that social, emotional, locational, and activity context influence eating behaviour. Observing others eat and having food available were the factors strongest associated with having a meal, whereas having company or engaging in activities reduced the likelihood thereof. For snacking, a similar pattern of predictors emerged, with the addition of negative affect being associated with a higher likelihood of snacking.

The finding that seeing other people eat increased the likelihood of eating and snacking around five-fold is in line with previous research (e.g., Lumeng & Hillman, 2007). Observing others eat has been discussed as creating an "eating norm", which in turn would make eating or snacking more appropriate in this particular situation (Prinsen, De Ridder, & De Vet, 2013). Watching other people eat also implies the presence of food-related cues, which in turn have been shown to increase the likelihood of food intake (Ferriday & Brunstrom, 2011). An interesting side note supporting the influence of food-related cues is the finding that the availability of foodstuffs in the environment was associated with an increased likelihood of a matching food event – the presence of savoury foodstuffs was associated with a more than 2.5-fold increase in the likelihood of a "meal" occurring and the presence of sweets was associated with a more than 1.5-fold increase in the likelihood of snacks, whereas the presence of sweets actually decreased the likelihood of a meal occurring. Findings for the presence of "other" foodstuffs are less conclusive as our data do not allow further disentangling this category.

The finding that the presence of family and partners reduced the likelihood of snacking can be indicative of two working mechanisms – one being that during interactions with these groups of individuals, participants might have either been engaged in work activities or participated in "real" meals in the company of family and partners. Meals such as the main meals of the day have been distinguished from snacks by the fact that they involve more time

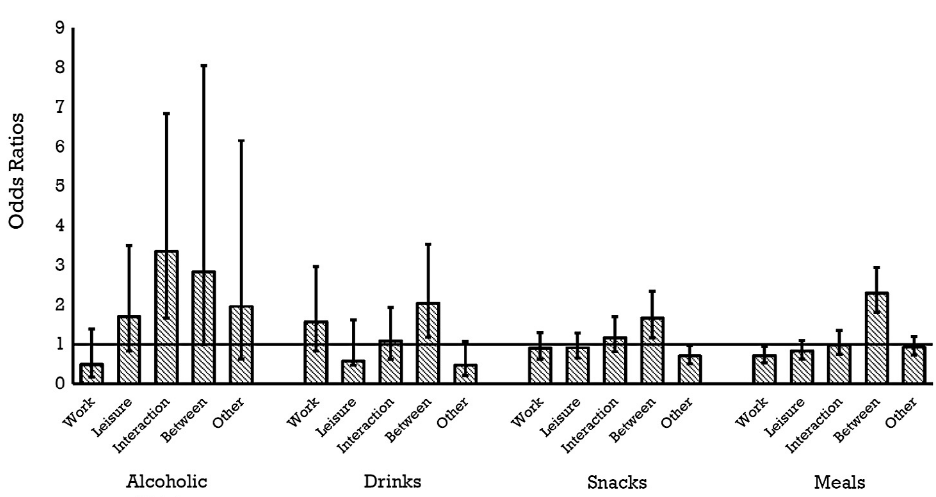

Fig. 2. Odds ratios of different activities in predicting dietary behaviours compared to random prompts with 95% confidence intervals (controlled for company, availability, affect, arousal, seeing others eat) on the within-participants level.
Note: Solid horizontal line indicates OR = 1. If the 95% confidence interval includes 1, the OR is not significantly different from 1 (i.e., no association).

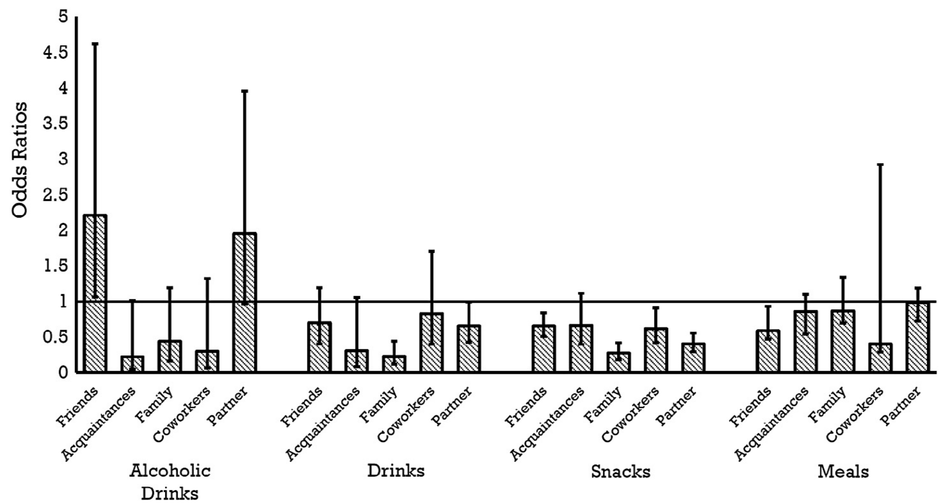

Fig. 3. Odds ratios of different social partners in predicting dietary behaviours compared to random prompts with 95% confidence interval (controlled for availability, affect, arousal, activities, seeing others eat) on the within-participants level.
Note: Solid horizontal line indicates OR = 1. If the 95% confidence interval includes 1, the OR is not significantly different from 1 (i.e., no association).

spent on eating and social interactions (Wansink, Payne, & Shimizu, 2010). The only social factor significantly associated with the likelihood of meals was being with friends, which reduced the likelihood of meals. We can only speculate about the reasons for this, but suggest that social activities engaged in with friends could include going out for drinks rather than meals, which is supported by the significant associations of being friends and consuming alcoholic beverages. Alternatively, many meals might be consumed habitually during set times and in fixed settings, whereas meeting friends could suggest a break of such routines.

The finding that negative affect was associated with an increased likelihood of snacking is in line with research supporting the idea of comfort eating (Parker et al., 2006), that is, eating in order to regulate negative affect. However, it has to be noted that the literature on this effect is not entirely conclusive, and that moderating factors such as self-regulatory competencies might moderate the relation between affect and eating energy-dense foods (Sproesser et al., 2011).

Our study also suggests that being between activities increases the likelihood of snacking and eating. This is consistent with previous research suggesting that breaks between activities might be preferred times for consuming food (e.g., Hampl, Heaton, & Taylor, 2003). The finding that engaging in "other" activities reduced the likelihood of snacking deserves further exploration – unfortunately, our study did not include a qualitative assessment of these "other" activities and can therefore not be further commented upon.

There are several pathways that have been discussed in the literature that might underlie these effects of cues on eating. The environment might provide cues that trigger habitual eating (Verhoeven et al., 2012). Alternatively, it has been suggested that operant conditioning underlies the effects of environmental cues on eating by which foods – particularly highly palatable foods high in sugar, salt and/or fats – trigger dopaminergic pathways and are therefore experienced as rewarding. It is argued that cues that are repeatedly associated with food can thus trigger food cravings and overeating (Blumenthal & Gold, 2010), and positive affective experiences during eating (hedonic responses) contribute to a reinforcement process that makes the individual crave rewarding food (Berridge, Ho, Richard, & Difeliceantonio, 2010). Further work is required in order to test these pathways.

Stimulus control and non-alcoholic beverages

An increased likelihood to consume non-alcoholic drinks was associated with observing others eat, being between activities and having no company (particularly not of one's own family). These results are intuitive insofar as observing others eat was also associated with an increased likelihood to eat, which in turn increases the likelihood to drink something with food. Similar to the increased likelihood of eating during work breaks (Hampl et al., 2003), drinking when thirsty would most likely occur between activities. As there is very little previous research on social determinants of drinking non-alcoholic beverages, we can only speculate on the finding that being with family decreased the likelihood of drinking – looking at the relatively low rate of drinks reported, it might be that particularly in social situations, participants were less likely to log drinks, which would render this finding an artefact of a low response rate with regard to drinks.

Stimulus control and alcoholic beverages

Our findings on alcohol consumption suggest a reverse pattern to the findings on snacking – i.e., higher negative affect was associated with a three-fold *de*crease in the likelihood to have alcoholic drinks (also see Peacock et al., 2015). Similarly, higher arousal was associated with a twofold decrease in the likelihood of consuming alcoholic drinks. This results pattern seems to be contradicting research suggesting that people use alcohol as self-medication to cope with negative affect (Kassel et al., 2000) and research that has suggested that arousal is associated with more alcohol consumption (Swendsen et al., 2000). However, we propose that this finding might rather indicate that at least in non-clinical samples, alcohol consumption is most likely to occur in recreational social settings (in our study indicated by the positive Odds Ratio of "being with friends"; Fig. 3), which in turn increase positive affect and decrease arousal. This line of reasoning is supported by previous research that found social interactions involving alcohol consumption to be associated with positive mood ratings (Aan Het Rot et al., 2008). The substantial effects of interaction activities, being with friends and seeing others eat on alcoholic drinks are in line with previous research suggesting that consuming alcohol is dependent on social settings (DeMartini, Prince, & Carey, 2013). In particular the large effect of "seeing others eat" on alcohol consumption implies a social situation in which alcohol might be readily available or easily obtainable, which in turn has been shown to increase the likelihood of alcohol consumption (Gruenewald et al., 2014). The substantial size of this effect (OR = 22.54) might be a result of the relatively smaller number of logs of alcoholic drinks compared to random prompts, which is also indicated in the large range of the 95% confidence interval (8.14–62.40).

Strengths and limitations

A key strength of this study is that it was the first to examine stimulus control of situational and affective covariates of dietary behaviours in non-clinical participants using EMA technology. The use of EMA poses significant advantages over previous diary- and recall-based assessments, as it allows for assessments of eating and eating-related cognitions close to real time (Thomas et al., 2011). Furthermore, EMA might be able to overcome shortcomings of more traditional measures of food consumption such as diaries or food frequency questionnaires, which have been shown to be particularly susceptible to the underreporting of snacks (Heitmann & Lissner, 1995). By using a combination of event logs and randomly timed assessments, EMA allows contrasting the assumed antecedents of eating or drinking which participants experienced during engaging in these behaviours with those experienced during a random assessment. This allows researchers to model the determinants of eating and drinking behaviour in more detail than using recall methods and within the situation the target behaviour is performed (Shiffman et al., 2008).

Despite these strengths, there are some limitations to this study that affect our interpretation of the results. First, the sample size of our study was relatively limited ($N = 53$), but intensive longitudinal designs such as this are economical: based on simulation studies, the number of participants in our study should have sufficed to obtain reliable estimates of parameters (Maas & Hox, 2005), as the number of measurement occasions within individuals was substantial. Nevertheless, the relatively small – and predominately white and well-educated – sample does limit the degree to which we can generalize our results to the wider community; these results warrant replication with a larger, and more representative, sample.

Conceptually, the assessment of cues together with the report of the eating or drinking episode might have made it difficult for participants to identify causes and correlates of dietary behaviours. Even though participants were asked to think about the situation when they decided to eat, this assessment might be confounded by factors resulting from food or drink intake. Further, some instances of dietary behaviours might be highly habituated (van't Riet, Sijtsema, Dagevos, & De Bruijn, 2011) and not the result of deliberate decisions, which makes it difficult to disentangle causal and consequential effects of cues in these situations.

Our assessment of external and internal stimuli most likely is incomplete. For example, due to space limitations, we have not assessed recurring stressors such as daily hassles, which have been shown to predict snacking behaviour (O'Connor et al., 2008) and have not included measures of inhibitory control, which has been associated with responses to environmental and affective cues to eating (Hofmann et al., 2013; Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010; Sproesser et al., 2011). Further, this study relied on a-priori definitions of snacks and food, which might not necessarily reflect participants' perceptions of whether food consumed was a snack or a meal (Wansink et al., 2010).

Implications and conclusion

Despite these limitations, we think that our study has important implications both for theory and practice. Our results stress the role of environmental and social cues for dietary behaviours, in particular eating, snacking, and consuming alcoholic beverages. Seeing others eat emerged as one of the strongest predictors of all dietary behaviours, followed by the availability of food. The study also suggests that snacking might serve the function of emotion regulation, as negative affect predicted snacking. The role of environmental predictors points to the importance of habits, cue-driven behaviours, which have been shown to be stronger predictors of snacking than individual difference variables such as power of food (Verhoeven et al., 2012). It is clear that further research is required to understand the social and psychological contexts of dietary behaviours. Our results suggest that interventions need to go beyond individual social-cognitive predictors of behaviour and need include environmental cues into behavioural interventions (Papies & Hamstra, 2010) in order to be maximally effective.

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