Tracking snacking in real time: Time to look at individualised patterns of behaviour

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Abstract

Background: Identifying when and where people overeat is important for intervention design, yet little is known about how unhealthy behaviours unfold in real life.

Aim: To track the activities, social contexts and locations that co-occur with unhealthy snacking.

Methods: 64 adults (49F, mean age= 38.6 years) used electronic diaries to record snacking, location, social context and current activity every waking hour over 7 days. The proportion of snacking episodes that co-occurred with each location/activity/context were calculated by group and individual.

Results: Over the group, snacking was most frequent whilst socialising (19.9% of hours spent socialising) or using the TV/computer (19.7%), when with friends (16.7%) and when at home (15.3%). All intra-class correlation statistics for cued behaviour were low, indicating the importance of within-person variability. There were marked individual differences between people in what constituted a 'typical' context for snacking.

Conclusions: People show substantial differences in the contexts in which they snack. Tailoring interventions to these individual patterns of behaviour may improve intervention efficacy.

Keywords: snacking; overweight; obesity; context; individual differences; real time

INTRODUCTION

Behaviour does not occur in a vacuum, rather, it unfolds over time within a particular social and environmental context (Ball, Timperio & Crawford, 2006). Contemporary theories of behaviour increasingly recognise that behaviour arises as a result of both individual and environmental level factors. For example, Strack and Deutsch's Reflective Impulsive Model (RIM; 2004) posits that behaviour reflects the combined output of two systems – a reflective, effortful system where information is consciously processed and used to inform a rational choice; and an impulsive system where behaviour is prompted automatically by cues in the environment (referred to as system 2 and system 1 thinking, respectively). This latter, automatic elicitation of behaviour in the presence of relevant external cues is also known as stimulus control, and there is good evidence that key health behaviours such as eating can be triggered by features of the external environment (Weingarten, 1985) in both normal body weight (Schuz, Bower & Ferguson, 2015) and overweight and obese individuals (Cleobury & Tapper, 2014). As the modern, western environment is characterised by the ready availability of energy dense foods and a proliferation of labour-saving devices and sedentary jobs, it is likely that many 'impulsive', stimulus-controlled behaviours in the modern context will be unhealthy (Swinburn, Sacks, Hall et al, 2011).

In line with this, people eat more when foods are closer and more accessible (Maas, de Ridder, de Vet et al, 2012); when portion sizes are larger (Zlatevska, Dubelaar & Holden, 2014); when confronted with cues to purchase and consume food (e.g. adverts, Cohen, 2008) and may use contextual cues such the presence of empty wrappers (indicating that others have eaten) to determine food choice (Prinsen, de Ridder & de Vet, 2013). Environmental and social contexts are likely to play a key role in cueing these unhealthy consumption behaviours as people display different patterns of eating when engaged in different activities (e.g. when watching TV / computer / phone screens; Marsh, Ni Mhurchu & Maddison, 2013); when in different social contexts (e.g. when eating alone versus with others; Higgs & Thomas, 2016); and when in different physical locations (e.g. when eating at home versus out-of-home; Naska, Katsoulis, Orfanos et al, 2015).

Despite a large body of evidence demonstrating the importance of such social, contextual and environmental determinants of unhealthy behaviour, the vast majority of research in this field looks only at differences between the average behaviour of groups of people exposed to different environments. This is problematic because people living and working within the same environments vary markedly in their susceptibility to weight gain (Blundell, Stubbs, Golding et al, 2005). As such, it is highly likely that there will be substantial variability in how different people respond to similar environmental cues and situations, and in how behaviours unfold within individuals over time in terms of frequency and consistency. Real time monitoring of behaviour or 'ecological momentary assessment' (EMA) offers one potential method of tracking such responses in real time. In EMA studies, people are tracked in real time as they go about their everyday lives, to determine when, where and in which contexts they engage in particular behaviours. The present study uses this approach to investigate and descriptively summarise variability in the activities, social contexts and locations which co-occur with high calorie snacking in a sample of the general public over 7 days. The study focuses on the consumption of 'non-core' foods (i.e. foods not recommended for daily consumption, Bell, Kremer, Magary et al, 2005) as high consumption of these foods is associated with a higher caloric intake overall/weight gain (Vernarelli, Mitchell, Rolls et al, 2015; McCrory, Fuss, McCallum et al, 1999), and may displace healthier foods like fruits and vegetables from the recommended core diet (Kraak, Story & Swinburn, 2013).

METHOD

Design

A 7-day real time, within-person, ecological momentary assessment study. The study was conducted as part of the larger SNAPSHOT (SNAcking, Physical activity, Self-regulation, and Heart-rate Over Time) study, details of which are published elsewhere (McMinn & Allan, 2014; Powell, McMinn & Allan, 2017). Here, only those methods related to the presented results are described.

Participants and recruitment

68 participants were recruited between February 2013 and 2014 in and around Aberdeen city (UK) using advertisements in local and national media. All met the study eligibility criteria (≥18 years and fluent in English). One individual withdrew from the study due to illness, and data from 3 participants were lost due to technical problems with the measurement equipment, leaving a final sample of 64 participants from a diverse range of educational, occupational and socioeconomic backgrounds. (see Table 1 for sample characteristics). The *a priori* sample size determination was based on the main hypothesis of the parent study (McMinn & Allan, 2014; Powell, McMinn, & Allan, 2017) which suggested that a sample of at least 50 participants, each with between 65 and 85 observations, would be sufficient to achieve > 80% power.

Procedure

Volunteers attended a laboratory session at the start of the study to meet with a member of the research team. At this session, participants gave informed consent, received detailed instructions about the study procedures and methods, and were supplied with an electronic diary (a Pro-Diary). Participants made hourly diary reports of their snacking, current activity, social context and location during waking hours for 7 consecutive days from this initial session.

Measures and measurement equipment

Equipment

Each participant was supplied with an electronic Pro-Diary (Cambridge Neurotechnology) to wear for 7 consecutive days. The Pro Diary (Cambridge Neurotechnology) is a compact wrist-worn electronic diary measuring 5.1 x 3.4 x 0.8 cm and weighing 16g. Its interface allows questions to be displayed on-screen and responses given using either multiple choice or visual analogue rating scales. In validation studies, responses made via the Pro-Diary interface do not differ from those made using pen and paper scales (Hampton & Middleton, 2011). The Pro-Diary was programmed to give an auditory alarm every hour between 7am and 10pm over the 7-day measurement period to prompt participants to report their snack intake, location, social context and current activity. Participants could postpone their response for 20 min if unable to respond by selecting the 'snooze' function on the diary.

Measures

Unhealthy snacking was defined by consumption of 'non-core' foods outside of main meals; that is, foods not recommended for daily consumption (i.e. biscuits, cakes, sweets, chocolate, crisps, pies, pastries, soft drinks; Bell, Kremer, Magary et al, 2005). Upon each prompt (an audible alarm), participants used the ProDiary to indicate (yes/no) whether they had eaten any of the following non-core foods over the last hour as a snack rather than as part of a main meal: (1) chocolate/sweets (2) biscuits/cakes/pastries, (3) crisps/savoury snacks, (4) pies/pastries, (5) takeaway /fast food, or (6) soft drinks. Snack consumption was defined as a binary outcome (snack consumed: yes/no).

Activities, Social Context and Location: Participants were asked during each Pro-Diary entry to indicate: (1) what they were doing (response options - working, domestic chores, childcare, socialising, travelling, TV/computer, sports/exercise, eating/drinking, nothing, other); (2) who they were with (response options - alone, friends, family, colleagues, other); and (3) where they were (response options - home, work, outdoors, car, shops/pub/restaurant, other).

Analysis

Descriptive exploratory analysis was conducted to determine the activities, social contexts and locations that co-occurred with consumption of high calorie snack foods: both the percentage of total snacks consumed in each context, and the percentage of total time in each context spent snacking. In order to examine the variance within and between persons for snacking-in-context, intra-class correlation (ICC) coefficients were computed from variance estimates of null multilevel models nesting the daily number of snacks consumed within individuals (i.e. 2 levels). A separate model was computed for each context (i.e. number of snacks at home; number of snacks at work, etc.) with a lower ICC indicating high within-person variability relative to between-person variability. Diary entries were made on 4912 occasions out of a possible 6284 (21.83% missing data). Analyses included only the available data, and were carried out using SPSS Version 25.

RESULTS

The sample characteristics are shown in Table 1.

[INSERT TABLE 1 HERE]

Over the whole group, accounting for time spent in each known context, snacking frequency was highest whilst socialising (19.9% of hours spent socialising) or using the TV/computer (19.7%), when with friends (16.7%) and when at home (15.3%). There was considerable between-person variation however in what constituted a 'typical' snacking situation. Group-level patterns and examples of three different individual level patterns of snacking behaviour are illustrated in Figure 1.

[INSERT FIGURE1 HERE]

While group level summaries suggest that snacking occurs across a diverse range of different contexts, the selected individual-level examples highlight that people show marked differences in what they are doing, who they are with and where they are while snacking (Fig 1). Individual data for all 64 participants is shown in Electronic Supplementary Materials (Figures S1-S3).

As illustrated in Table 2, the activities, social contexts and locations that most commonly accompany episodes of unhealthy snacking at the group level, show little consistency at the individual level. For example, while many unhealthy snacks overall were consumed in the workplace / while working, the number of individuals who never snack at work exceeds the number of individuals who frequently snack at work (i.e. consumed >50% of their snacks at work). The reported intraclass correlations are low indicating considerable within-person variation in the activities, social contexts and locations that accompany high calorie snacking.

[INSERT TABLE 2 HERE]

DISCUSSION

The present study tracked a diverse sample of the general public as they went about their daily lives and found considerable individual variation in the contexts and situations which accompanied a 'typical' snacking episode. Group-level (average) summaries of behaviour conceal this potentially important variation.

Small reductions in energy dense snacking have the potential to produce long-term, sustainable changes in weight and health (World Cancer Research Fund, 2007), particularly if changes can be incorporated into daily life to become habitual over time. However, interventions can only be developed and targeted effectively if we understand the contexts and situations in which target behaviours occur (or do not occur). For example, dietary interventions may be best targeted at times and places where eating already occurs (so they are feasible) but where there is scope for healthier choices (capacity to benefit). Similarly, interventions which target particular contexts will (likely) not benefit the subset of individuals who do not perform the target behaviour in that particular context. Although the group level data from the present study shows that unhealthy snacks are, on average, frequently consumed in the workplace / while working, the individual data illustrates that many individuals never snack in this context and consequently would be unlikely to benefit from workplace focused interventions.

The present results suggest that interventions should be designed using a personalised, environmentally tailored approach rather than a traditional 'one size fits all' approach. This is in line with recent papers emphasising the need for interventions that take account of individual patterns of behaviour (McDonald, Quinn, Vieira et al, 2017) and suggesting that the most effective strategies to combat weight gain and obesity will be those which are "…tailored to the preferences, behavioural, socioeconomic, and demographic characteristics of the people they seek to support" (Hawkes, Smith, Jewell et al, 2015).

While tailoring and personalisation has already been adopted to some extent by intervention designers, this typically involves tailoring to groups of people or to general, stable, characteristics of people (e.g. providing dietary advice tailored to men, or to those with a busy lifestyle). It is still unusual to see tailoring according to the contexts and situations which trigger, or at least, co-occur with targeted behaviours within individuals over time. An exception to this is the QSense intervention (www.qsense.phpc.cam.ac.uk; Naughton, Hopewell, Lathia et al, 2016) where GPS technology is used in combination with smartphone diary reports to learn when and where people smoke so that behavioural support can be proactively delivered at moments and in places where quit attempts are most likely to fail. Such interventions are able to intervene 'just in time', during or immediately after high risk contexts are encountered.

The present results suggest that a similar approach could be usefully employed in attempts to reduce obesity-related behaviours such as high calorie snacking. There is a large and rapidly growing mHealth literature (using mobile phones or other mobile devices to improve health and health behaviours) which suggests that mobile apps can be effective in supporting weight loss and changing related dietary and activity behaviours (Lyzwinski, 2014; Vandelanotte, Muller, Short et al, 2016). However, within this literature, the tailoring offered by apps is largely limited to the provision of feedback/information based on a user's goals/interests and the receipt of messages within personally specified convenient time windows. None of the apps reviewed were able to detect and respond to a user's physical location or context. It may be possible in future to develop an app that for example, delivers responsive messages and prompts when a user enters a context previously associated with unhealthy eating. With the dramatic rise of smartphone ownership and the increasing sophistication of mobile technology, it is now possible in principle to monitor and respond to individual patterns of behaviour in real time, enabling interventions to be delivered when and where unhealthy behaviours are most likely to occur. However, it should be noted that the present study looked only at one discrete category of dietary behaviour (consumption of 'non-core' snack foods) and comprehensive real time assessment of dietary intake would be less feasible via smartphone.

In terms of limitations, diary reports in the study, while made in near real time, still required participants to retrospectively recall consumption over the preceding hour and may therefore be open to retrospective recall bias. Similarly, only basic information on the type and amount of each snack food consumed was collected so factors such as food quality and the relative contribution of snack consumption to total dietary intake could not be explored. Although none of the participants in the present study showed evidence of disordered eating in measures taken as part of the parent study, participants were not formally screened for the presence of an eating disorder. Consequently, it is possible that the sample contains participants with an eating disorder who may respond differently to contextual cues. Finally, it should be noted that while context was measured contemporaneously at each diary entry, snacking was recorded over the preceding hour. It is possible therefore that short term changes in context around the snacking events of interest were not captured.

To conclude, it has been estimated that reducing energy intake by as little as 100 kcals a day would be sufficient to prevent weight gain in the majority of the population (Hill, Wyatt, Reed et al, 2003). By detecting activities, social contexts and locations where high consumption is particularly likely, interventions could be targeted more effectively, increasing the chances that behaviour change is achieved.

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Authors' contributions: JA and DM designed and developed the parent study, DM collected the study data, DP analysed the data, JA drafted the manuscript and all authors revised and approved the manuscript.

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FIGURE 1

Snacking in context. *Figure presents (A) what the participant was doing while snacking; (B) who they were with; and (C) where they were. Group level data is shown on the left and data from 3 selected individuals on the right. Pie charts (i) show the proportion of snacking episodes in each context. Stacked bar charts (ii) show the % occasions in each context where snacking did (black) or did not occur (white).*

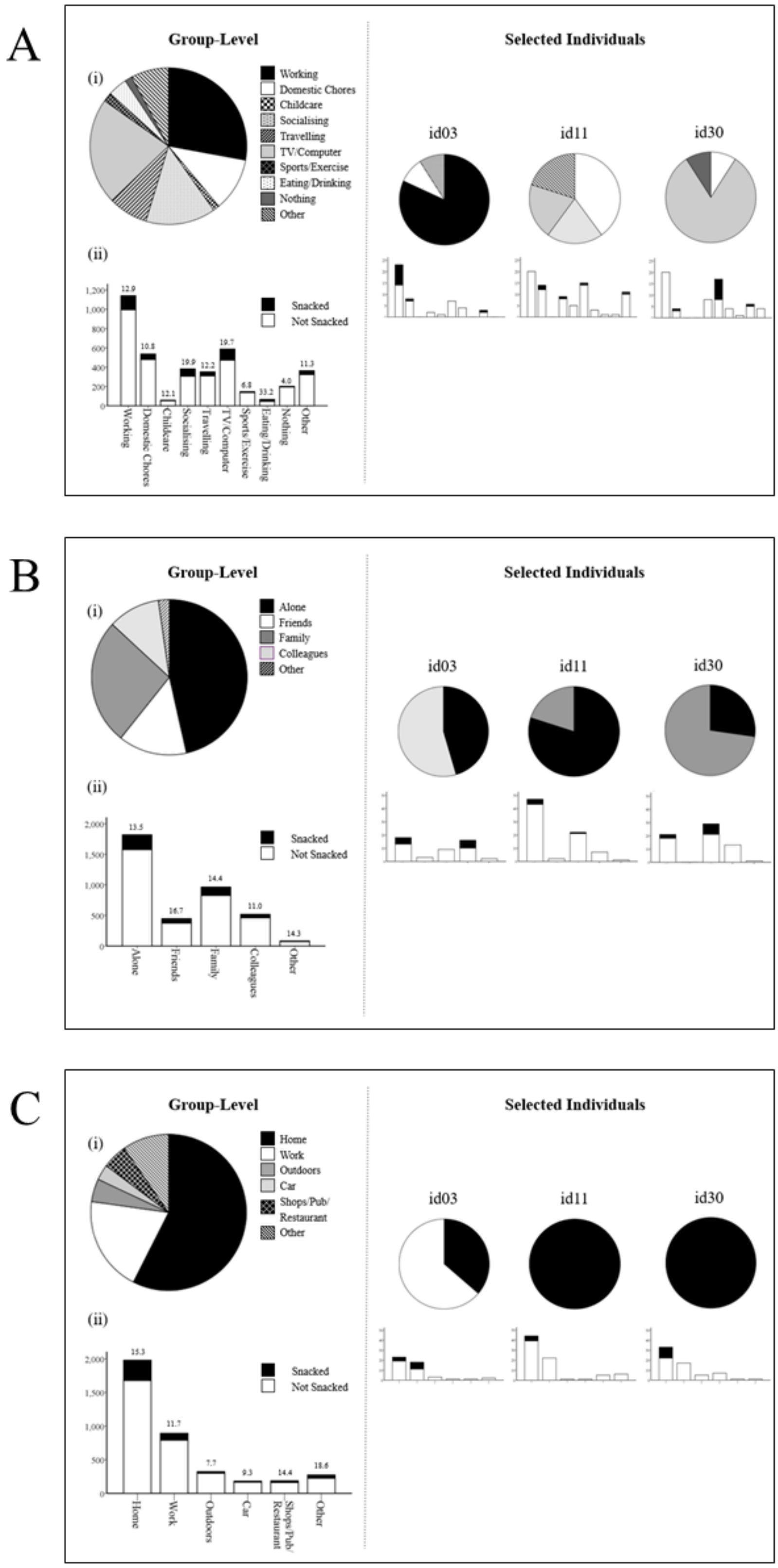

TABLE 1 Sample demographic information

	Count/Mean	SD	Range
Gender			
Female	49		
Male	15		
Age	38.58	15.54	18.0 – 70.0
BMI	25.67	4.83	17.5 – 39.6
Underweight (< 18.5)	1		
Normal weight (18.5 – 24.9)	30		
Overweight (25.0 – 29.9)	23		
Obese (> 30.0)	10		
Years in formal education	16.94	3.10	10.0 – 23.0
Household income			
£0 – 20,000	20		
£21,000 – 40,000	20		
£41,000 – 60,000	7		
£61,000 – 80,000	5		
£81,000 – 100,000	4		
£100,000 +	5		
Current employment			
Paid employment	39		
Student	18		
Retired	4		
Housewife/househusband	2		

TABLE 2: Variability in the activities, social contexts and locations that accompany unhealthy snacking.

	N of snacks	Mean (% of total snacks)	*N* individuals where ≥ 50% snacks consumed within context	*N* individuals where =0% snacks consumed within context	Mean (% of total time in context spent snacking)	ICC of number of snacks per day[a]
Unhealthy snacking	527					.275
Alone	245	46.49	31	7	13.45	.201
With Family	138	26.19	9	27	14.43	.217
With Friends	75	14.23	14	35	16.70	.196
With Colleagues	57	10.82	2	40	10.98	.157
With Other	12	2.28	3	52	14.29	.001
At Home	303	58.67	43	5	15.31	.190
At Work	104	28.21	16	20	11.65	.183
At Pub/Shops/Restaurant	27	5.17	0	40	14.44	[b]
Outdoors	25	5.25	2	46	7.74	.093
In the Car	17	3.02	0	52	9.34	.083
Other location	51	10.13	4	34	18.61	.043
Working	147	27.89	15	20	12.88	.184
Using TV/Computer	116	22.01	11	20	19.73	.149
Socialising	76	14.42	2	24	19.90	.033
Doing Domestic Chores	58	11.01	4	29	10.80	.052
Travelling	43	8.16	2	40	12.22	.065
Eating/Drinking	21	3.98	1	48	33.18	.117
Doing Sports/Exercise	10	1.90	1	55	6.80	.045
Doing Nothing	8	1.52	0	55	3.96	[b]
Doing Childcare	7	1.33	0	60	12.07	.173
Doing Other	41	7.78	4	35	11.26	.046

[a]Intra-class correlation (ICC) computed based on number of snacks (in each context) on each of the 7 days for each participant. A larger intra-class correlation statistic (closer to 1.0) indicates low within-person variability relative to between-person variability; lower ICCs (closer to 0.0) indicate high within-person variability relative to between-person variability.

[b]Insufficient clustering of observations within individuals to model at 2 levels (model did not converge).