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Ecological momentary assessment of food perceptions and eating behavior using a novel phone application in adults with or without obesity

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ABSTRACT

We developed a smart phone application to measure participants' food-reward perceptions and eating behavior in their naturalistic environment. Intensity ratings (0 - not at all to 10 - very strongly) of perceived anticipation of food (wanting) and food enjoyment at endpoint of intake (liking) were recorded as they occurred over a period of 14 days. Moreover, food craving trait, implicit and explicit attitude towards healthy food, and body composition were assessed. 53 participants provided complete data. Participants were classified by percentage of body fat; 33 participants with lower body fat (L-group) and 20 with higher body fat (H-group; ≥25% body fat for males and ≥32% for females). L-group participants reported 6.34 (2.00) food wanting events per day, whereas H-group participants recorded significantly fewer food wanting events (5.07 (1.42)); both groups resisted about the same percentage of wanting events (L-group: 29.2 (15.5)%; H-group 27.3 (12.8)%). Perceived intensity ratings were significantly different within the L-group in the order liking (7.65 (0.81)) > un-resisted wanting (leading to eating) (7.00 (1.01)) > resisted wanting (not leading to eating) (6.02 (1.72)) but not in the H-group. Liking scores (L-group: 7.65 (0.81); H-group: 7.14 (1.04)) were significantly higher in L-group than in H-group after controlling for age. Our results show that individuals with higher percentage of body fat show less food enjoyment after intake and reveal no differentiation in intensity ratings of perceived anticipatory and consummatory food reward. These results are consistent with a hypothesized reward deficiency among individuals with higher percentage of body fat.

1. Introduction

In obesity, the mechanisms behind the failure of the homeostatic regulatory system to maintain energy balance in the face of hedonic incentives and drives towards consumption of food are still debated (Mela, 2006; Münzberg, Qualls-Creekmore, Yu, Morrison, & Berthoud, 2016; Yu et al., 2015). To prevent and treat obesity, increasing attention is paid to understanding reward driven eating. Reward response in eating has been divided into anticipatory reward, wanting, which is connected to the intensity of motivation to engage in eating, and consummatory reward, liking, which relates to the pleasure derived from eating (Berridge & Robinson, 2003; Mela, 2006; Stice, Spoor, Ng, & Zald, 2009). Brain imaging studies suggest that subjects with obesity compared with lean subjects have a higher anticipatory reward response to food cues (Nummenmaa et al., 2012; Stice, Spoor, Bohon, Veldhuizen, & Small, 2008). Nevertheless, the meso-limbic reward system showed less activation in response to food intake in individuals with obesity, suggesting that consummatory reward deficiency could be a contributing factor in overeating (Stice et al., 2008). An overarching finding is the involvement of alterations in dopamine dependent brain circuits thought to be influential in the observed alteration in reward anticipation, learning, and response (Berridge, 2009; Volkow et al., 2008; Wang et al., 2001). It is hypothesized that, as a result of overexposure, altered incentive salience in people with obesity leads them to expect more reward from a particular food than consumption of it delivers (Berridge, 2009).

These studies of anticipatory and consummatory food reward were conducted in artificial laboratory situations. Reward perceptions of individuals in their own environment with their unique externally and self-imposed food cues and choices have rarely been investigated. This might provide a different behavioral context to further our understanding of interactions between incentives and reward outcomes to

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add clarity to existing theories of the role of food reward in obesity.

Ecological momentary assessment (EMA), which is described as repeated real-time sampling of a person's current behavior and/or experiences in their natural environment, has been used to explore some aspects of eating behavior in relation to obesity (Engel et al., 2016). Goldschmidt et al. (2017) studied non-hunger eating and perceptions of overeating in adults with obesity. However, perceived food wanting, including food wanting that was resisted, has not yet been investigated in real life situations.

To address the gap in our understanding of people's eating behavior we developed a smartphone application to allow participants to record the spontaneously occurring patterns of food wanting and liking in real-time in their natural environments. We recorded the intensity and frequency of explicit food wanting, the perceived motivation to consume food. Uniquely, the phone application enables participants to rate the intensity of their wanting of food whenever it reaches consciousness and to record whether it leads to food intake or not. Using this measure, hedonic wanting is not differentiated from homeostatic aspects (e.g. hunger). Liking ratings recorded here capture the perceived pleasure or enjoyment derived from eating and includes palatability and physiological responses from the gastro-intestinal (GI) and endocrine systems. It is measured at the endpoint of food intake and is therefore considered to be a measure of consummatory reward. To complement the phone application data and to improve the potential for interpretation, we additionally measured participants' food craving trait and their implicit and explicit attitudes towards healthy food. These are known to be relevant for food choice and eating behavior and are particularly altered in individuals with obesity (Pelchat, 2002; Roefs & Jansen, 2002). Identification of participants with obesity was based on percentage of body fat (Seger et al., n.d.).

We hypothesized that participants with higher percentage of body fat (H-group) would display reduced consummatory reward perception (liking ratings) compared with participants with lower percentage of body fat (L-group) in accordance with the reward deficiency theory. Secondly, because we expected that individuals with a higher percentage of body-fat would be more driven by hedonic motivation, we hypothesized that food wanting and food craving would be more strongly associated among participants with a higher percentage of body-fat than among individuals with a lower percentage of body-fat.

2. Material and methods

2.1. Participants

The protocol of this study was approved by the North Wales Research Ethics Committee in accordance with the Declaration of Helsinki, REC 13/WA/0236. Participants were adults from the North Wales area, aged 18–65, who responded to adverts in university and health board sites. Smartphone users in all weight categories were invited to apply. Eligibility of potential participants was assessed by phone prior to arrangement of their initial appointment. Participants with conditions known to influence appetite, including diabetes, cancer, depression and eating disorders were excluded, as were participants on medications known to influence appetite, such as antidepressants and corticosteroids. Additionally, people who worked on night shifts and those who could not access their phones while at work were excluded.

In total 84 participants were recruited, 28 of whom dropped out of the study, and three were excluded because of equipment malfunction or atypical dietary practice, such as fasting. The remaining 53 participants provided complete data. Participants were classified by percentage of body fat according to the Obesity Algorithm (Seger et al., n.d.). Females with a percentage of body fat $\geq 32\%$ and males with a body fat percentage $\geq 25\%$ are classified as having obesity (H-group). Classification by body fat percentage was chosen as a more specific measure of adiposity than the more commonly used proxy measure of Body Mass Index (BMI), which does not differentiate between fat and lean tissue (Kyle, Piccoli, & Pichard, 2003; Shah & Braverman, 2012). Body fat percentage has been shown to be of importance in food reward (Stice & Yokum, 2016). Data from 33 participants with low percentage of body fat (L-group) and 20 with high percentage of body fat (H-group) were analyzed.

2.2. Measures and procedures

Baseline characteristics of age, sex, weight, height and body composition were recorded at entry. Body composition and weight were assessed by researcher via bio impedance measurement (TANITA BC 418 MA system) to estimate percentage of body fat. Height was measured using a wall stadiometer. Furthermore, questionnaires and the computer task were completed once prior to the start of phone application recordings.

2.2.1. Food craving

Participants completed the reliable and validated Food Craving Questionnaire (FCQ-T) (Cepeda-Benito, Gleaves, Williams, & Erath, 2000); with 39-items, craving is measured as a multi-factorial concept using a 6-point Likert-type scale from 1 (never) to 6 (always). The FCQ-T estimates the strengths of the following domains: (T1) intentions and plans to consume food; (T2) anticipation of positive reinforcement that may result from eating; (T3) anticipation of relief from negative states and feelings as a result of eating; (T4) possible lack of control over eating if food is eaten; (T5) thoughts or preoccupation with food; (T6) craving as a physiological state; (T7) emotions that may be experienced before or during food cravings or eating; (T8) environmental cues that may trigger food cravings; and (T9) guilt that may be experienced as a result of cravings and/or giving into them. The total sum score estimates trait craving intensity across the 9 dimensions.

2.2.2. Explicit attitude

The explicit attitudes towards healthy food questionnaire was adapted from Courneya and Bobick (2000) by David Markland, Bangor University (Alshubrami, Alrajhi, Cox, & Kubis, 2017). When previously used with participants with obesity, this questionnaire predicted weight loss (Alshubrami et al., 2017). This questionnaire assesses explicit attitudes towards low fat, low sugar, high fibre foods, categorized as 'healthy', by asking participants to scale their attitudes to these foods. Eight elements were included in the questionnaire (e.g., enjoyable/not enjoyable, good/bad) to determine the main concept: "For me, eating healthy food is…" The scale ranged from 1 (extremely–bad/not enjoyable) through 4 (neither) to 7 (extremely-good/enjoyable). Higher scores indicate a more positive explicit attitude towards healthy food.

2.2.3. Implicit attitude

Implicit Association Task (IAT) indirectly assesses attitudes towards an object by measuring the strengths of associations among concepts through the reaction speed to the presentation of stimuli associated with the concepts. Inquisit 3.0 which measures response latencies to keyboard presses with millisecond accuracy was used to generate the test and collect the data. The IAT was presented in seven blocks, five of which were practice trials, to acquaint subjects with the stimulus materials and categorization rules. The target category exemplars comprised images of unhealthy (e.g., pizza, burger, chips) and healthy (e.g., salad, fruit, vegetables) foods; trials and analysis were performed according to Sartor et al. (2011).

2.2.4. Phone application

Participants were asked to download the Mind Eating mobile phone application (Fig. 1) from the Apple store for IOS platform users, or to receive it as a file by email for Android users, and were individually instructed in its use. All inputs were prompted by the participants themselves; no cues to initiate inputs were generated by the program.