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Research report

Moderate alcohol consumption stimulates food intake and food reward of savoury foods

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ABSTRACT

The aim of this study was to investigate whether food reward plays a role in the stimulating effect of moderate alcohol consumption on subsequent food intake. In addition, we explored the role of oral and gut sensory pathways in alcohol's effect on food reward by modified sham feeding (MSF) or consumption of a preload after alcohol intake.In a single-blind crossover design, 24 healthy men were randomly assigned to either consumption of vodka/orange juice (20 g alcohol) or orange juice only, followed by consumption of cake, MSF of cake or no cake. Food reward was evaluated by actual food intake measured by an *ad libitum* lunch 45 min after alcohol ingestion and by behavioural indices of wanting and liking of four food categories (high fat, low fat, sweet and savoury).Moderate alcohol consumption increased food intake during the *ad libitum* lunch by 11% (+338 kJ, $P = 0.004$). Alcohol specifically increased intake (+127 kJ, $P < 0.001$) and explicit liking ($P = 0.019$) of high-fat savoury foods. Moreover, moderate alcohol consumption increased implicit wanting for savoury ($P = 0.013$) and decreased implicit wanting for sweet ($P = 0.017$) before the meal. Explicit wanting of low-fat savoury foods only was higher after alcohol followed by no cake as compared to after alcohol followed by cake MSF ($P = 0.009$), but not as compared to alcohol followed by cake consumption ($P = 0.082$). Both cake MSF and cake consumption had no overall effect on behavioural indices of food reward.To conclude, moderate alcohol consumption increased subsequent food intake, specifically of high-fat savoury foods. This effect was related to the higher food reward experienced for savoury foods. The importance of oral and gut sensory signalling in alcohol's effect on food reward remains largely unclear.

Introduction

Consistent evidence shows that alcohol stimulates short-term food intake when it is consumed before or with the meal (Westerterp-Plantenga & Verwegen, 1999; Yeomans, 2004, 2010a). This effect may relate to reduced satiety signalling after alcohol consumption. However, there is only limited evidence in humans to support such a hypothesis (Raben, Agerholm-Larsen, Flint, Holst, & Astrup, 2003; Röjdmark, Calissendorff, & Brismar, 2001). Another potential mechanism through which alcohol may stimulate food intake is by increasing the rewarding value of food via its effects on reward systems. Food reward comprises two components: 'liking' and 'wanting', which can be divided both psychologically and neurologically (Berridge, 2009). Psychologically, liking refers to the pleasantness of food and the pleasure derived from tasting the food, and wanting to the intrinsic motivation to eat. Neurologically, liking has been shown to be influenced by opioid, endocannabinoid and GABA neurotransmission, whereas wanting appears to mainly depend on dopaminergic neurotransmission (Berridge, 1996, 2009; Cooper, 2005). Alcohol may stimulate both liking and wanting as it has been shown to enhance opioid release, and stimulate GABA and dopaminergic neurotransmission (Kumar et al., 2009; Melis, Diana, Enrico, Marinelli, & Brodie, 2009; Oswald & Wand, 2004). However, previous studies observing an increased food intake

Abbreviations: BAC, Blood alcohol concentration; LFPQ, Leeds Food Preference Questionnaire; MSF, Modified sham feeding.

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showed no influence of alcohol on the pleasantness nor on pleasure of eating either a savoury or a mixed (savoury and sweet) meal (Caton, Marks, & Hetherington, 2005; Yeomans, Hails, & Nesic, 1999). The effect of alcohol on food wanting has not been measured previously.

Oral nutrient sensing plays an important role in food reward. Orosensory stimulation by food may induce a cephalic phase response but it may also increase the hedonic and rewarding value of food (Berthoud, 2008; Morton, Cummings, Baskin, Barsh, & Schwartz, 2006). Gut nutrient sensing may also increase the rewarding value of food, although evidence is less strong as compared to oral nutrient sensing (Sclafani & Ackroff, 2012; Spetter, de Graaf, Mars, Viergever, & Smeets, 2014). Recently, the effects of oral and gut sensory stimulation on brain reward systems were compared in a study performed in pigs, showing that oral and gut stimulation influenced diverse reward regions (Clouard, Meunier-Salaün, Meurice, Malbert, & Val-Laillet, 2014).

To our best knowledge, no studies have been conducted on the effect of moderate alcohol consumption on the satiety or reward response of orally sensed food. A method to study orosensory stimulation is the modified sham feeding (MSF) technique, in which food is smelled, chewed and tasted, but not swallowed (Joosten, de Graaf, Rietman, Witkamp, & Hendriks, 2010; Teff & Engelman, 1996; Wijlens et al., 2012). By the use of MSF after alcohol consumption the role of orosensory stimulation in alcohol's effect on food intake and food reward can be investigated. Typically, the rewarding value of food decreases with food intake, ultimately causing the person to stop eating. Therefore, we predicted that orosensory stimulation only and oral plus gut sensory stimulation would reduce food intake of the next meal, since both conditions will initiate a reward response. The role of oral and gut stimulation could be explored by comparing food intake after alcohol consumption in combination with cake MSF and in combination with cake consumption.

Rewarding food is often highly palatable food, such as sweet and high-fat food, although savoury food, such as pizza, may also be rewarding (Egecioglu et al., 2011; Tetley, Brunstrom, & Griffiths, 2010). Finlayson, Bordes, Griffioen-Roose, de Graaf, and Blundell (2012) studied the effect of equi-palatable savoury and sweet drinks on food reward and observed no difference in liking and wanting between the drinks. However, exposure to savoury taste has a stronger modulating effect on subsequent food preferences as compared with exposure to sweet taste (Griffioen-Roose, Finlayson, Mars, Blundell, & de Graaf, 2010). In addition, sweet and savoury intake may activate different reward-related brain systems (Spetter, de Graaf, Viergever, & Smeets, 2012). Therefore, we hypothesized that alcohol could differentially influence the rewarding value of specific food categories based on taste or fat content. Previous studies, however, do not show a difference in taste preference after alcohol intake. Studies showing an increased food intake after alcohol consumption mainly used mixed meals and observed no difference in food preferences (Caton, Ball, Ahern, & Hetherington, 2004; Caton et al., 2005), though Caton et al. (2004) showed an elevated intake of high-fat savoury food (crisps) after 4 glasses of alcohol.

The primary aim of this study was to investigate if moderate alcohol consumption stimulates subsequent food intake via an increased food reward. Food reward was evaluated by explicit ratings of wanting and liking and an implicit measure of wanting. Second, we investigated the role of oral and gut sensory stimulation in alcohol's effect on food reward. This was evaluated by comparing food reward after only alcohol consumption with food reward after alcohol consumption followed by oral stimulation or followed by both oral and gut stimulation (normal consumption). We hypothesized that alcohol increases food intake via an increased food reward (both explicit and implicit measures of wanting and liking) of high-fat and sweet foods and that alcohol mediates food reward mainly via orosensory pathways. Both oral stimulation and oral plus gut stimulation were predicted to induce a reward response and thereby decrease food intake of the next meal. The combined oral and gut stimulation was expected to have a larger effect.

Method

Participants

Healthy men (n = 24, age 25–50 y, BMI 20–25 kg/m^2) participated in the study. The participants were recruited from a pool of volunteers at CHDR (Centre for Human Drug Research) in Leiden, The Netherlands, and by advertising in newspapers. Eligible participants did not use any medication, habitually consumed alcohol (5–20 glasses/week, equal to ±50–200 g alcohol/week (Kalant & Poikolainen, 1999)) and had no (family) history of alcoholism. Additionally, participants had to like all the food products used in the study. They were excluded if they scored above average (>2.26) on the restraint eating scale of the Dutch Eating Behaviour Questionnaire (DEBQ). The reasons for including only male participants were the stronger association of moderate alcohol consumption with body weight in men than in women and the possible influence of hormonal fluctuations in women on food intake and reward (Bryant, Truesdale, & Dye, 2006; Sayon-Orea, Martinez-Gonzalez, & Bes-Rastrollo, 2011).

The study was conducted at CHDR in Leiden, The Netherlands, and was performed according to the International Conference on Harmonisation Guidelines for Good Clinical Practice. The study also complied with the Declaration of Helsinki and was approved by an independent Medical Ethics Committee (The Medical Ethics Committee of the University Medical Centre of Leiden). Written informed consent was obtained from all participants. The study is registered at ClinicalTrials.gov (NCT): NCT01738906.

Study design

The study used a single-blind randomized crossover design, with the intervention factors alcohol (alcohol vs. alcohol-free) and food exposure (no cake vs. cake MSF vs. cake consumption). Participants came 6 times to CHDR to have all intervention combinations.

Each participant participated in all 6 experimental conditions, which occurred at least 2 days apart. Participants were randomly allocated to one of the 6 groups with different intervention orders according to a 6 × 6 Williams square design. Randomized allocation was performed by statisticians of CHDR by the use of a computer-generated randomization scheme.

Interventions

Alcohol intervention

The alcohol intervention consisted of either 200 mL vodka orange juice (20 g alcohol) or 200 mL orange juice with 31 g maltodextrin (Nutricia Fantomalt, Nutricia Cuick, Cuijk, The Netherlands) which they had to consume within 5 min. The beverages were matched for calories by adding maltodextrin, a nonsweet carbohydrate, to the orange juice beverage (Table 1). The dosage of 20 g alcohol was considered to be moderate for men (Kalant & Poikolainen, 1999).

Participants were blinded to the alcohol intervention. Beverages were served in a closed cup and at a serving temperature of ca. 5 °C. In addition, a little sterilium (an alcohol based disinfection lotion) was placed at the opposite side of the drinking opening of the lid on only the alcohol-free beverage to make it smell like alcohol.