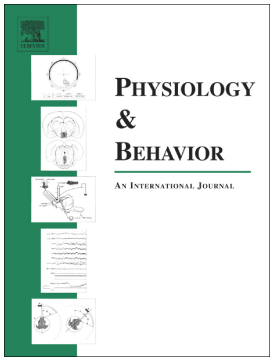

Reactivity to television food commercials in overweight and lean adults: Physiological, cognitive and behavioral responses

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Reactivity to television food commercials in overweight and lean adults: Physiological, cognitive and behavioral responses.

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Abbreviations used: BMI - Body Mass Index, CR = conditioned response.

Abstract

Recent evidence indicates that acute exposure to food advertising increases food intake. However, little research to date has explored the potential mechanisms underpinning this, such as the extent to which food commercials elicit conditioned physiological responses (e.g. increased salivation). The aim of the current study was to examine salivary, cognitive and consumptive responses to televised food commercials in overweight (N = 26) and lean (N = 29) adult females. Participants attended two laboratory sessions in a counterbalanced order; in one session they viewed a television show with embedded commercials for unhealthy foods, and in the other session they viewed the same show with non-food commercials. In both conditions, following viewing participants were exposed to an *in vivo* food cue (freshly cooked pizza) which they were then invited to eat *ad libitum*. Salivation was measured at baseline, during commercial exposure, and during *in vivo* exposure. Participants also self-reported components of appetite on visual analogue scales and completed a word stem task. Results indicated little evidence of increased salivary reactivity to the food commercials. In both conditions,

lean participants showed reliable salivary responses to the *in vivo* food cue. In contrast, overweight participants only showed increased salivation to the *in vivo* cue in the food commercials condition. Food commercial exposure did not increase the number of food-related cognitions or amount of food consumed, but did drive a greater increase in desire to eat prior to pizza consumption than exposure to the control commercials. Exposure to food advertising primes eating-related motivations, and while it may not be associated with increased intake or salivation *per se*, non-food commercials may attenuate subsequent physiological responses to actual food cues in overweight individuals.

Keywords: food advertising; commercials; food intake; salivation; cue reactivity; cephalic response.

1.0 Introduction

The obesogenic food environment has been strongly implicated as a causal factor contributing to the global obesity epidemic [1]. Globally 2.1 billion adults are overweight or obese [2], and this excess weight is contributing to increased incidence of non-communicable disease [3]. Poor diet is a greater risk factor for disease incidence than tobacco, alcohol and inactivity combined [4]. The persuasive and excessive marketing of energy-dense foods is a key component of the obesogenic environment, and in several countries restrictions have been placed on the marketing of such foods to children, either through Government intervention or industry self-regulation [5, 6]. This policy action reflects the large body of evidence demonstrating that food marketing influences children's eating behaviours including attitudes and preferences [7-9].

Far fewer studies have explored this phenomenon in adults. One systematic review explored the effects of food and non-alcoholic beverage advertising on food-related behaviour, attitudes and beliefs in adult populations, but the findings were inconclusive [10]. A subsequent review of reviews also noted the evident variability in findings across studies, but concluded that the majority reported a significant positive association between food advertising and food choice in adults [11]. A recent systematic review and meta-analysis of the impact of acute experimental exposure to food advertising (via television or the Internet) on food intake reported on just seven studies with adult participants [12]. Of these, three reported a significant main effect of food advertising condition on consumption. In Harris et al., [13] participants consumed an average of 6.5g more snack food following food commercials compared to after non-food commercials and Koordeman et al., [14] found that food advertising exposure significantly increased adults' soda intake. Furthermore, Wonderlich-Tierney et al., [15] found an interaction between food advertising condition and 'transportability' (defined as "a mechanism by which narratives influence individuals' beliefs and behaviours through their thoughts, emotional responses, and imagery of the events during the story", p58). In that study, those participants deemed 'high' in transportability ate more after exposure to food advertising than they did after neutral commercials or no commercials at all. However, in the overall meta-analysis there was no evidence of an effect of acute food advertising exposure on short-term food consumption in adults, which contrasts with the significant moderate sized effect observed across studies with children [12]. One possible explanation for this disparity is that adults are capable of resisting food advertising or altering their behaviour such that it overrides the influence of food advertising on food intake. This may be because of more advanced cognitive abilities that enable them to be critical

viewers of advertising and potentially to deploy cognitive defence mechanisms [16]. Another possibility is that research aims were insufficiently disguised in these studies, and thus the data were vulnerable to demand characteristics (participants believing themselves aware of the aims of the study and behaving in accordance with those beliefs). It may also be that adult participants were aware that their food intake was being monitored. Importantly this awareness has previously been associated with a weakening of the (usually robust) effect of portion size manipulations on intake in adults [17].

A small number of studies, in which outcome measures other than food intake were used, do suggest that food advertising exposure has an effect on eating-related behaviours in adults. For example, food commercials have been shown to prime food-related cognitions which are associated with self-reported desire to eat. Specifically, Kemps et al. showed that exposure to food commercials increased the number of food- and eating-related words that were produced in a word-stem completion task relative to a non-food commercial control condition. Food commercial exposure also increased self-reported desire to eat but only for overweight and obese participants [18].

This finding is consistent with the wider literature on learned associations and cue reactivity. Through a process of classical conditioning, external cues (e.g., the sight and smell of food) become conditioned stimuli for the rewarding consequences of eating. These conditioned cues acquire the ability to elicit conditioned responses (CRs) that influence eating initiation and meal size [19]. Accordingly, exposure to food cues has been shown to reliably elicit CRs such as changes in subjective state (increased hunger, desire to eat and craving), physiological readiness to eat (increased salivation and heart rate) and cognitive changes, such as food-related attentional bias [20-25]. Food cue exposure also increases the amount of food that is subsequently consumed, relative to no-cue exposure control conditions [21, 26, 27].

The extent to which television food commercials might function as conditioned cues for eating has received little empirical attention. Notably, a recent meta-analysis indicated that visual food cues (e.g., pictures and videos of food) are as powerful as real food exposure in terms of influencing subsequent eating behavior [26]. Another recent study found that televised commercials for energy-dense foods elicited greater skin conductivity than commercials for less energy dense foods [28]. These findings are important because when viewing food commercials the cued food is often not immediately available for consumption. Relatedly, it has been found that salivary responses to a real food cue were not influenced by perceived availability; that is, participants showed increased salivation to the food regardless of whether they perceived it as available or unavailable for consumption [29]. However, to the authors' knowledge, no studies have examined whether exposure to food cues via television commercials is sufficient to invoke an increased salivary response.

There is also evidence that differences in weight status and eating traits should be taken into account when exploring the impact of food commercials on eating behaviour in adults. Schacter's externality theory purports that obese individuals are particularly sensitive to external cues to consume [30]. With respect to food advertising exposure, this theory is supported by a previous study

with child participants in which normal weight children increased their intake by 89% following food commercials relative to non-food (toy) commercials, but overweight and obese children increased their intake by 101% and 150% respectively [31]. In adults, exposure to real food cues elicited a greater salivary response and desire to eat in overweight, compared to normal weight, individuals [22], and food commercial exposure increased self-reported desire to eat but, again, only for overweight and obese participants [18]. Relatedly, trait external eating refers to the general tendency to eat in response to external food-related cues. Previous research suggests that individuals who score highly on a trait measure of external eating may be particularly susceptible to the effects of food commercials on behaviour. Specifically, van Strien, Herman and Anschutz found that high external eaters consumed more food in response to food commercials compared to neutral commercials, whereas as low external eaters did not show this effect [32]. However, to our knowledge, no studies have explored the potential moderating role of trait external eating on physiological and cognitive responses to food commercials.

Based on the limited literature to date exploring the impact of food advertising exposure on consumptive responses in adults, and in order to address the paucity of research integrating physiological and cognitive responding, weight status and eating traits within this field, the following primary research questions were formulated: (i) does television food advertising exposure elicit increased salivation in adults relative to control (non-food) commercials?; (ii) does television food advertising exposure prime desire to eat and food-related cognitions?; (iii) is cognitive and salivary reactivity associated with the level of food intake after television advertising exposure?; and (iv) are weight status (lean versus overweight and obese) and eating trait (low versus high external eating) differences apparent in salivary, cognitive and consumptive responses to television food advertising exposure?

2.0 Methods

This study was approved by the University of Liverpool's Institute of Psychology, Health and Society's Research Ethics committee on June 12th 2015 and data were collected between late June and August 2015.

2.1 Participants

Fifty-five female participants [mean age 32.4 (range 20 - 62) years] were recruited from the staff and student population at the University of Liverpool, UK, and from the general population of the surrounding area of Merseyside. Only female participants were included in order to ensure large sex-related differences in intake did not obscure the anticipated more subtle effects of the experimental manipulation. Participants were screened to ensure they had no chronic illness, no known food allergies or intolerances, were not currently dieting, and were not taking any medication that might influence taste, salivation or appetite (excluding the contraceptive pill). Twenty-nine

participants were lean (i.e. body mass index [BMI; kg/m^2] <25) and 26 were overweight or obese (i.e. BMI >25; hereafter 'overweight'). Upon completion of the study, participants were reimbursed for their time and inconvenience with a £10 high street shopping voucher.

2.2 Advertising stimuli

Participants were exposed to 10 food commercials and 10 non-food commercials (embedded within two episodes of the same comedy programme, 'The IT Crowd') on two different occasions. Counterbalancing of condition order and programme episode (e.g. episode 1 with food commercials at first visit, episode 2 with non-food commercials at second visit) was conducted for each weight status group (lean and overweight) using www.randomizer.org. All commercials were obtained from contemporary UK television recordings held by the research group. The food commercials all promoted high calorie palatable meal items such as pizzas, burgers, fries and other convenience foods. The non-food commercials depicted motor insurance, toiletries, and other non-consumables. Participants viewed the stimuli using a laptop and an individual set of in-ear headphones.

2.3 Measures

2.3.1 Salivation

Salivation was measured using 3.5cm dental rolls placed horizontally under the tongue for periods of 30 seconds. The rolls were weighed before and after being in participants' mouths, and the difference in weight was recorded as the amount of salivation. This method is widely used in eating behavior research [20, 29]. It is non-invasive and is a sensitive measure of whole-mouth saliva volume.

2.3.2 Cognitions

Accessibility of food-related cognitions was assessed using a word stem completion task, previously shown to be sensitive to the manipulation of commercial exposure [18]. Participants were presented with 36 word stems (e.g. BRE-) and were instructed to complete each one with whichever word first came to mind. The dependent variable was the total number of food-related words that were generated.

2.3.3 Subjective appetite and trait eating behaviour

Subjective measures of hunger, fullness and desire to eat were obtained using 100mm visual analogue rating scales (VAS). These measures all followed the format of a question (e.g. "how hungry do you feel right now?") with the anchor points "not at all" and "extremely" to the left and right of the line, respectively. As participants were informed that the study was investigating the effects of television comedy programmes and food on mood (in order to disguise the true study aims), VAS

measures of a number of mood-related parameters were also taken to be consistent with this (e.g. rating stress, friendliness, lethargy). Participants also completed the Dutch Eating Behaviour Questionnaire (DEBQ) to measure dietary restraint, emotional eating and external eating [33].

2.3.4 Food consumption

Consumptive response to food advertising exposure was measured using a standard *ad-libitum* eating paradigm. Participants were individually served a large pre-weighed portion of freshly cooked pizza and were instructed that they could eat as much or as little as they wished. Two cheese and tomato pizzas (together comprising approximately 2056 kilocalories [kcal]), each cut into equal-sized square pieces, were given to each participant. This portion size and arrangement was used to minimise the likelihood of ceiling effects on intake or of participants being able to accurately monitor their own consumption. Remaining food was weighed to determine consumption in grams, and converted to kcal using nutritional information available on the product packaging (Goodfella's Stonebaked Thin Margherita Pizza 345 g, Green Isle Foods Ltd., Co Kildare, Ireland, 298 kcal/100 g). Pizza was selected as the test food as it is typically considered to be palatable and has previously been shown to elicit a robust salivary response in adults [20, 29].

2.4 Procedure (see Figure 1)

The experiment was conducted in the Human Ingestive Behaviour laboratory at the University of Liverpool, UK. The study used a within-participants design, in which the participants were required to visit the laboratory twice. A one-week washout period was observed between the two experimental sessions, and testing was conducted at the same time of day on each occasion [between 12pm - 4pm]. On test days, participants were instructed to eat their 'normal' breakfast but to then refrain from eating for at least 3 hours before attending the laboratory.

Following completion of informed consent procedures, participants were assigned to an individual testing booth and all procedures and measures were explained in full. As part of the cover story, participants were told that saliva measures were being taken in order to measure mood hormones. After this, the first salivation measure was taken; following which participants completed the appetite VAS. Participants then viewed the television show with embedded commercials (food or control, in accordance with randomisation schedule). At the end of the commercial break, the researcher paused the DVD and took another salivation measure before the participant resumed viewing. When the show ended, the participant completed the word stem task and further appetite VAS. Freshly cooked pizza was then placed in front of the participant and a final salivation measure was taken in response to the *in vivo* food cue. Participants were then told they could eat as much or as little of the pizza as they liked within 10 minutes. At the end of this time period, a third and final set of appetite VAS was completed. This signalled the end of study session one. Study session two followed the same format (although the participant viewed the other episode of the television show

and the other advertising content), but with the additional steps that after the final VAS questions were completed, participants were asked to complete the DEBQ and have their height and weight measurements taken. Participants were then asked to write down what they believed to be the aim of the study. They were then debriefed and given the voucher.

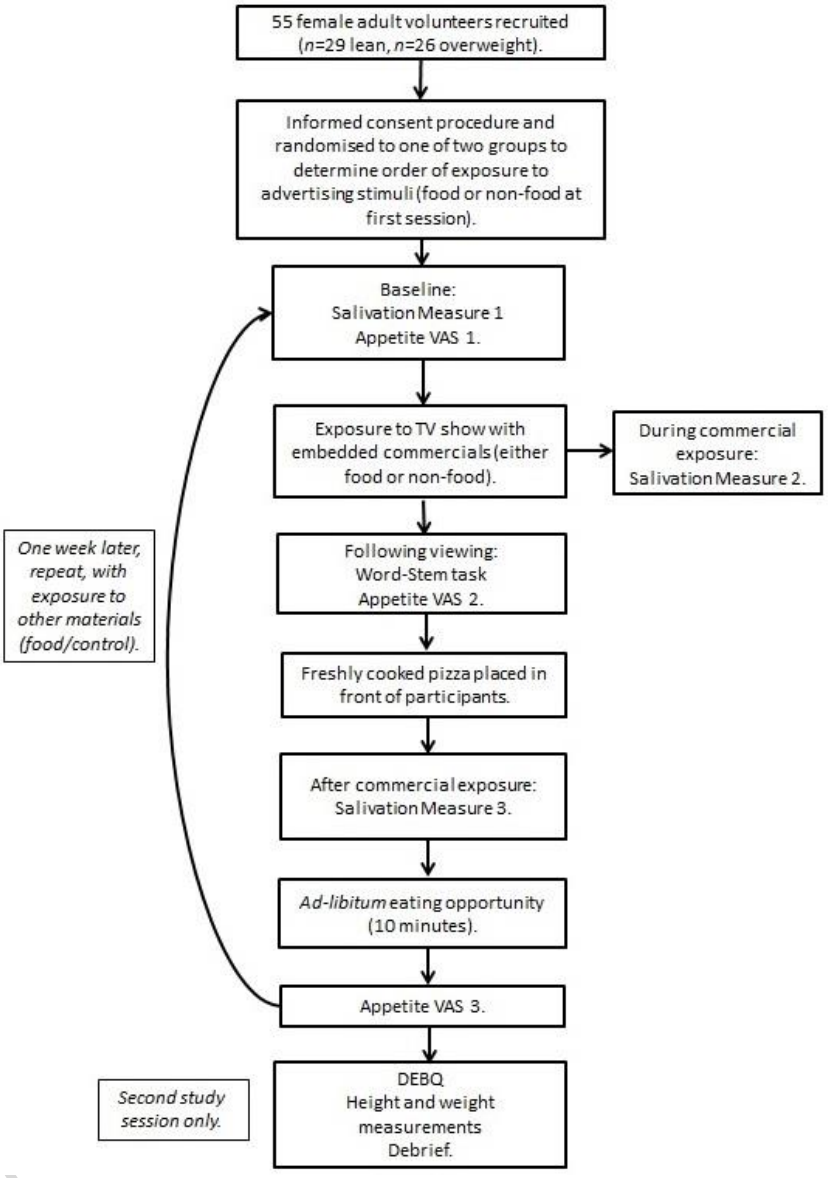

Figure 1: Procedure schematic

2.6 Data Analysis

To address research questions (i) and (iv), a 2 x 3 x 2 mixed ANOVA was conducted where the within-subjects factors were condition (food commercials, non-food commercials) and time (baseline, during commercial exposure, after commercial exposure). The between-subjects factor was weight status (lean, overweight). The dependent variable was salivary reactivity (in g). To investigate

the potential moderating role of trait external eating (research question (iv)), the sample was collapsed across weight status groups and participants were then assigned to high- and low-external eating groups based on a median split of the DEBQ scores (median = 3.4; *N* = 27 and *N* = 28, respectively). The analysis was then re-run with external eating group (high external eating, low external eating) as the between-subjects factor.

To address research questions (ii) and (iv), a 2 x 3 x 2 mixed ANOVA was conducted where the within-subjects factors were condition (food commercials, non-food commercials) and time (baseline, after commercial exposure, after pizza intake). The between-subjects factor was weight status (lean, overweight). The dependent variable was desire to eat VAS rating (in mm). To examine effects on food-related cognitions, a 2 x 2 mixed ANOVA was conducted, where the within-subjects factor was condition (food commercials, non-food commercials) and the between-subjects factor was weight status (lean, overweight). The dependent variable was the number of food-related words generated on the word stem completion task. Both analyses were then re-run with external eating group (high external eating, low external eating) as the between-subjects factor.

To address research questions (iii) and (iv), a 2 x 2 mixed ANOVA was conducted, where the within-subjects factor was condition (food commercials, non-food commercials) and the between-subjects factor was weight status (lean, overweight). The dependent variable was pizza intake (in kcal). The analysis was re-run with external eating group (high external eating, low external eating) as the between-subjects factor. Finally, correlation coefficients were computed to determine whether greater cognitive and salivary reactivity was associated with increased food intake in the food commercial condition.

3.0 Results

3.1 Participant characteristics

Descriptive characteristics of the full sample and the lean and overweight groups separately, are shown in Table 1. The overweight group had significantly higher BMI and levels of external eating relative to the lean group.

Table 1. Sample characteristics. Values are means with standard deviations (*SD*s) in parentheses.

	Full sample	Lean	Overweight
N	55	29	26
Age (y)	32.4 (9.8)	30.1 (8.0)	34.9 (11.1)
BMI (kg/m^2)	25.0 (4.7)	21.7 (2.0)	28.8 (3.9)*
DEBQ-Restraint	2.7 (0.8)	2.6 (0.9)	2.8 (0.6)
DEBQ-Emotional	2.6 (0.8)	2.5 (1.0)	2.8 (0.7)
DEBQ-External	3.4 (0.6)	3.2 (0.6)	3.6 (0.5)*

* Significant difference between lean and overweight, $p < .05$

3.2 Does television food advertising exposure elicit increased salivation in adults relative to control (non-food) commercials?

There was a significant main effect of time ($F(2,106) = 3.6$, $p = .03$), but no significant effect of condition ($F(1,53) = 2.8$, $p = .1$). The three-way interaction between condition, time and weight status was of borderline significance ($F(2,106) = 2.9$, $p = .06$). There were no other significant main effects or interactions. To further investigate the three-way interaction, a series of *post hoc* paired *t*-tests were conducted to examine changes over time in each condition within each weight status group separately.

In the lean group, in the food commercials condition, there was no significant difference in salivation between baseline and during commercial exposure ($t(28) = -1.3$, $p = .2$). However, salivation after commercial exposure (i.e., in response to *in vivo* pizza exposure) was significantly greater relative to baseline ($t(28) = -2.4$, $p = .02$). A similar pattern of results of results was observed in the non-food commercials condition. There was no significant difference in salivation between baseline and during commercial exposure ($t(28) = -1.1$, $p = .29$). However, salivation after commercial exposure (in response to *in vivo* pizza exposure) was significantly greater relative to baseline ($t(28) = -2.1$, $p = .049$; Figure 2, left panel).

In the overweight group, in the food commercials condition, there was no significant difference in salivation between baseline and during commercial exposure ($t(25) = -1.5$, $p = .16$). Salivation after commercial exposure (in response to *in vivo* pizza exposure) was significantly greater relative to baseline ($t(25) = -2.6$, $p = .015$). In the non-food commercials condition, there was no significant difference in salivation between baseline and during commercial exposure ($t(25) = 0.5$, $p = .59$). However, in contrast to the food commercial condition, there was no significant difference in salivation between baseline and after commercial exposure (i.e. *in vivo* pizza exposure) in this condition ($t(25) = 0.8$, $p = .41$; Figure 2, right panel).

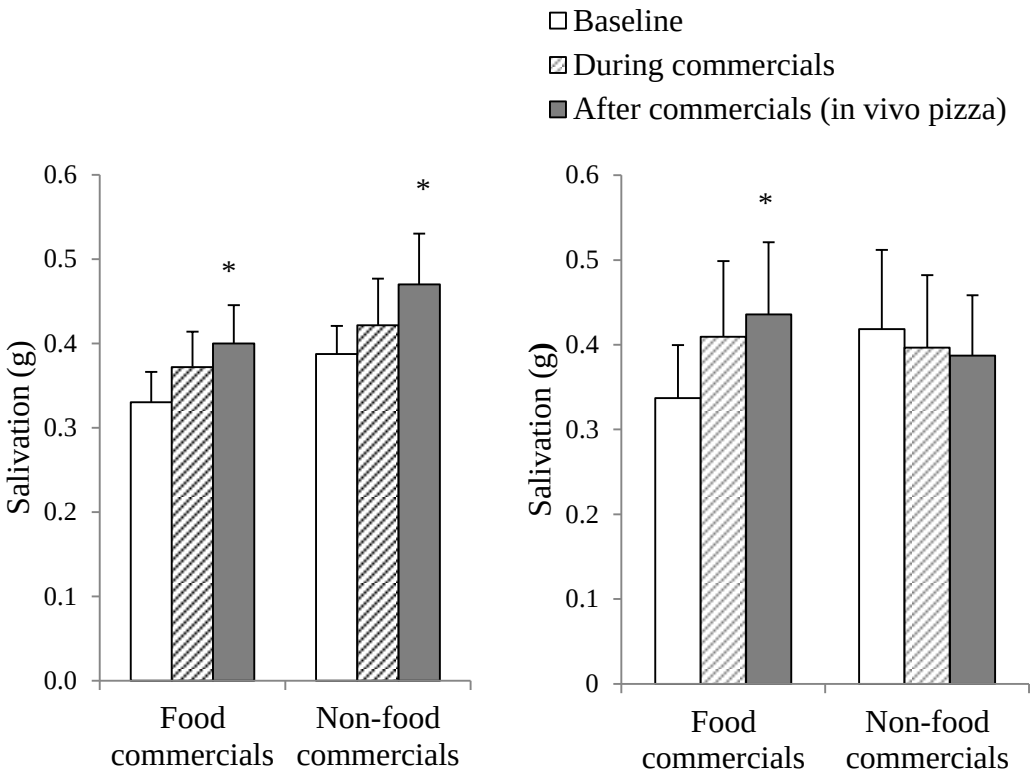

Figure 2. Salivation by condition and time in lean group (left panel) and overweight group (right panel). Error bars represent +1 standard error (*SE*) of the mean,
* significant difference from baseline within-condition, $p<.05$.

The above 2 x 3 x 2 mixed ANOVA was then re-run with external eating group (high external eating, low external eating) as the between-subjects factor. Notably, in this analysis the three-way interaction between condition, time and external eating group was not significant ($F(2,106) = 0.9$, $p = .393$). There was also no main effect of external eating ($F(1,53) = 0.7$, $p = .407$).

3.3 Does television food advertising exposure prime desire to eat and food-related cognitions?

3.3.1 Desire to eat

There were significant main effects of condition ($F(1,53) = 6.4$, $p = .014$) and time ($F(2,106) = 279.4$, $p < .001$), but not weight status ($F(1,53) = 0.5$, $p = .501$), on desire to eat. The main effect of condition indicated higher levels of desire overall in the non-food commercials condition relative to the food commercials condition (Means (*SD*) = 59.5 (16.3) mm vs. 54.6 (17.1) mm, respectively). However, this main effect was subsumed by the two-way interaction between condition and time which was borderline significant ($F(2,106) = 2.7$, $p = .07$). The three-way interaction between condition, time and weight status was not significant ($F(2,106) = 0.27$, $p = .76$).

To further investigate the condition by time interaction, a series of *post hoc* paired *t* tests were conducted to examine changes over time in each condition collapsed across weight status groups. In the food commercials condition, desire to eat was significantly higher after commercial exposure relative to baseline ($t(54) = -3.3$, $p = .002$). Desire to eat then declined significantly after pizza intake relative to baseline ($t(54) = 12.6$, $p < .001$). A different pattern of results was observed in the non-food commercials condition. Here, there was no significant difference in desire to eat from baseline to after commercial exposure; $t(54) = -1.2$, $p = .249$). Desire to eat then declined significantly post-pizza intake, relative to baseline ($t(54) = 15.7$, $p < .001$) (Figure 3).

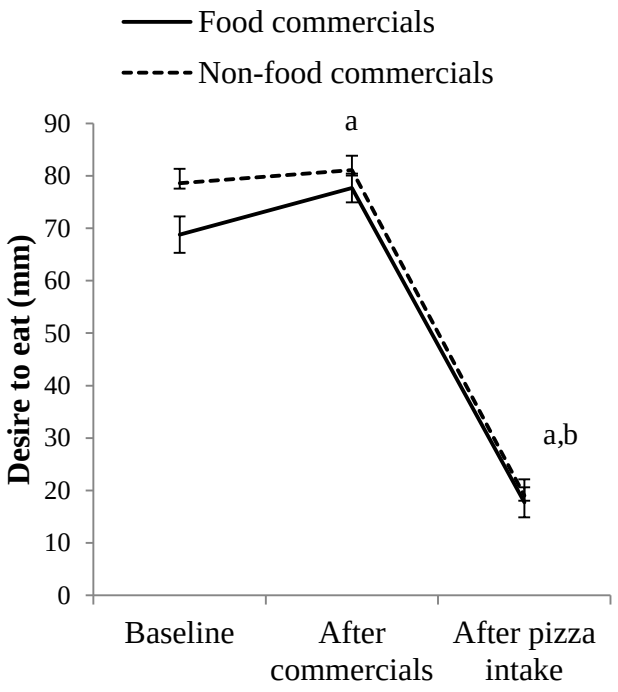

Figure 3. Desire to eat ratings (100-mm VAS) by condition and time collapsed across weight status groups. Error bars represent +1 standard error (*SE*) of the mean. [a] significantly different from baseline, food commercials condition $p \leq .002$. [b] significantly different from baseline, non-food commercials condition $p < .001$.

The above 2 x 3 x 2 mixed ANOVA was then re-run with external eating group (high external eating, low external eating) as the between-subjects factor. Notably, in this analysis the three-way interaction between condition, time and external eating group was not significant ($F(2,106) = 0.6$, $p = .535$). The main effect of external eating was borderline significant ($F(1,53) = 3.6$ $p = .06$), which indicated higher levels of overall desire-to-eat in high external eaters relative to low external eaters (means (*SE*) = 60.9 (2.79) *vs.* 53.5 (2.74) mm, respectively).

Additional analyses conducted on the VAS hunger and fullness ratings may be found in the supplementary materials.

3.3.2 Food-related cognitions

There was no main effect of condition or weight status on the mean number of food-related words generated, and the condition by weight status interaction was also non-significant (*p* values > .66). The mean (*SD*) number of food-related words generated by condition and group were as follows; overweight group, food commercials = 6.2 (3.1) and non-food commercials = 6.3 (3.1); lean group, food commercials = 6.6 (3.6) and non-food commercials = 6.6 (3.3).

There was no main effect of external eating on the mean number of food-related words generated ($F(1,53) = 0.7$, $p = .404$). Conversely, this analysis revealed a significant condition by external eating interaction ($F(1,53) = 5.5$, $p = .02$). However, this was not in the expected direction. There was a trend for high external eaters to generate more food words in the non-food commercials condition (mean (*SD*) = 7.2 (2.8)) relative to the food commercials condition (6.3 (3.5); $t(26) = -1.8$, $p = .09$). There was also a trend for high external eaters to generate more food words than low external eaters only in the non-food commercials condition (7.2 (2.8) vs. 5.7 (3.3), respectively; $t(53) = -1.8$, $p = .07$). None of the other contrasts approached statistical significance.

3.4 Is cognitive and salivary reactivity associated with the level of food intake after television food advertising exposure?

Pizza intake in the food commercials condition was not significantly correlated with salivation (during commercial exposure and after commercial exposure), desire (after commercial exposure) or number of food-related words generated. Correlation coefficients between all variables are shown in the supplementary materials (Table S1).

3.5 Are weight status (lean versus overweight) and eating trait (low versus high external eating) differences apparent in salivary, cognitive and consumptive responses to television food advertising exposure?

There was no main effect of condition or weight status on pizza intake (kcal), and the condition by weight status interaction was also non-significant (*p* values > .28). Mean (*SD*) pizza intake in each condition and weight status group was as follows; overweight group, food commercials = 858 (267) kcal and non-food commercials = 832 (245) kcal; lean group, food commercials = 829 (294) kcal and non-food commercials = 801 (288) kcal. When external eating group was entered as the between-subjects factor instead of weight status, there was no main effect of external eating and the condition by external eating interaction was also non-significant (*p* values > .62). For salivary and cognitive responses, see the results described in sections *3.2* and *3.3*.

3.6 Demand awareness

On the basis of their free text responses to the demand awareness question, participants were categorized as "aware", "partially aware" or "unaware" (participants were classified as "partially aware" if they mentioned that the commercials were different in the two conditions but had not explicitly linked this to the true aims of the study). These data indicate that 53% of participants were unaware of the study aims, 13% were partially aware, and 34% became aware of the study's aims.

4.0 Discussion

This study examined consumptive, cognitive and physiological responding to television food advertising in adults. The results revealed that exposure to television food commercials did not drive increased food intake or greater food-related cognitions, compared to non-food commercial exposure. However, desire to eat increased significantly after commercial exposure (relative to baseline) in the food commercials condition only. Television food advertising exposure did not elicit increased salivation relative to baseline, but exposure to the non-food commercials did appear to attenuate *in vivo* cue-induced salivation in overweight participants. When external eating was entered as an independent variable in the analysis, this latter effect was no longer significant, and this suggests that the different pattern of results in the overweight participants relative to the lean participants is not explained by differences in trait external eating.

The lack of an effect of food advertising on consumption is broadly consistent with previous studies in this area, including a recent meta-analysis [12] and a narrative review [10]. Although a small number of studies have reported greater intake in adults following food commercial exposure relative to control, this has either been an increase of a very small magnitude (6.5g; [13]), an increase in soda consumption rather than food [14], or only found in a subset of participants with particular characteristics that were not measured in the current study [15].

That exposure to food commercials did generate greater desire to eat compared to baseline (an effect not found in the non-food commercial condition) demonstrates that the advertising did have an effect on eating motivation, but this was not then evident in the quantity of food subsequently consumed. Given that studies with children show moderate sized effects of food advertising exposure on food intake [12], the results presented here could be interpreted as adding weight to the cognitive defence model which posits that adults are capable of being critical viewers of advertising and deploying the necessary cognitive defences to avoid responding to the cue to consume [16]. However, there was an overall difference between the conditions on desire to eat, whereby desire to eat was higher in the non-food commercial condition compared to the food commercial condition and this was most evident at baseline. This effect was also found for the hunger ratings (i.e. higher overall hunger in the non-food commercial condition relative to the food commercial condition, see supplementary materials). The reason for this difference is not clear as the order of conditions was counterbalanced, the two test sessions were conducted at the same time of day, and the instructions to participants (i.e., eat breakfast but then refrain from eating for at least 3 hours) were kept consistent. Nevertheless, it is

plausible that a potential effect of the food commercials on intake may have been obscured by the higher overall levels of desire to eat and hunger in the non-food commercials condition. We note, however, that neither desire to eat nor hunger correlated significantly with intake (see supplementary materials) which would suggest that differences in these variables do not explain our findings, In future studies, it will be important to ensure that baseline ratings of appetite are well-matched across the different experimental conditions.

The finding that desire to eat was raised from baseline following food commercial exposure but not non-food commercial exposure is consistent with previous findings from food cue studies [21, 26], although unlike Kemps et al., [18], in the current study this effect was found across all participants, not only those who were overweight. However, the absence of an impact of exposure to food commercials on food-related cognitions differs from the finding of Kemps et al. [18]. An explanation for this disparity is not immediately obvious. Both studies included only female participants, of whom some were undergraduate students and others were drawn from the wider community, and the same word stem task was used. Although the sample size was much smaller in the current study compared to the two studies in Kemps et al., [18] (n = 55 here versus n = 160 and n = 124), there is nothing to suggest that the lack of a finding in the present study is due to a power issue. Means were almost identical across conditions, and when external eating was included in the ANOVA model the trends were in the opposite direction - that is for a greater number of food words to be generated in the non-food condition relative to the food commercial condition in those with high external eating. However, our study did use a within-subjects design, whereas Kemps et al., [18] used a between-subjects design, so it may be that this influenced the findings. Whilst related studies of the impact of food advertising on food intake in children have typically produced larger effect sizes when within-subjects designs were used [12], with adults, there is increased likelihood of demand characteristics interfering with participants' responding. It is possible that our cover story was insufficiently robust. Indeed, the responses collected at the end of study indicated that a number of participants had guessed or partially guessed the true aims of the study and this may have led them to adjust their behavior accordingly.

The above mentioned phenomena of cognitive defences and demand characteristics contributed to our interest in studying adults' physiological responsivity to food commercial exposure, that is - to examine a response which may be less influenced by conscious control. Here there was no interaction between condition and time, so participants did not salivate more as a result of exposure to television food commercials than they did following non-food commercials. This, and the lack of an effect of food cue exposure on consumption, is inconsistent with other studies exploring conditioned responses to food cue exposure [20-27]. Another physiological response, greater skin conductivity, was found in a previous study to be elicited by exposure to food commercials for energy-dense foods particularly [28]. Interestingly, a recent study indicated that salivary responses to food cues were greater when participants were instructed to simulate consumption of the food relative to a mere

exposure control condition [34]. In the present study, participants were not instructed to imagine or simulate eating the advertised foods and this could potentially explain the lack of effect on salivation. The impact of eating simulations in the context of televised food advertisements thus merits attention in future studies.

In the present study, the lean participants reliably responded to the presence of the *in vivo* food cue by increasing salivation relative to baseline in both conditions (i.e. regardless of the nature of the commercials they had previously been exposed to). Whilst the overweight participants displayed a similar response in the food commercials condition, the measure of salivation taken in the presence of the *in vivo* food cue in the non-food commercials condition showed no such increase from baseline. This unexpected finding could be due to the trend for baseline salivation to be higher in the non-food commercials condition relative to the food commercials condition (Figure 2) which could have created a ceiling effect. However, while research generally reports that overweight adults show greater salivary responses to food cues than lean adults [e.g. 22], other studies have reported *lower* salivary responses to food exposure in obese binge eaters [35] and bulimics [36]. One possibility is that certain individuals, such as restrained eaters, may use cognitive suppression to block physiological responding as a strategy to control their food intake [37]. Relatedly, there is evidence that chronic dieters have difficulty downregulating subsequent hedonic responses when they are put into a "hot" state via pre-exposure to palatable food cues [38]. In the current study, it is possible that overweight participants were able to suppress their salivary response to the *in vivo* food cue in the non-food commercials condition due to their being in a "cold" state. However, priming participants with palatable food cues via the food commercials may have induced a "hot" state meaning that overweight participants were less able to suppress subsequent salivary responses to the *in vivo* food cue. This interpretation is speculative at present and it will be important for future studies to replicate this finding and identify the underpinning mechanism.

4.1 Limitations

The sample size of this study was relatively small. The use of a robust within-subjects design ensured that the study was sufficiently powered to address the main study aims, but this design also left the data vulnerable to demand characteristics. Indeed, our results indicate that a number of participants in our study became demand-aware. Future studies of this type should consider a between-subjects design with a larger sample size, in order to examine the reliability of these findings in the absence of the possibility of participants' behaving in accordance with perceived study aims. Only female participants took part in the current study, so conclusions cannot be drawn about males' consumptive, cognitive and physiological responsivity to television food advertising exposure.

4.2 Conclusions

This is the first study to empirically explore consumptive, cognitive and physiological responses to television food advertising exposure in adults. The strengths of the study include the examination of a number of behavioural, psychological and physiological outcomes using objective measures. The effects suggest that food commercials drive desire to eat in adults, but that this does not necessarily translate into greater food-related cognitions or increased short-term food intake even when palatable food is immediately available. Overweight participants appeared able to suppress their appetitive response (salivation) when in the presence of actual food cues following non-food commercials, but were unable to do so after exposure to food commercials. Although the importance of eating traits in this effect should not be overlooked, these findings may have implications for weight management programmes, given the omnipresence of food cues, including pervasive food marketing, in the western 'obesogenic' environment.

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Highlights

- Food commercials did not increase food-related cognitions, intake or salivation.
- Exposure to food advertising did prime eating-related motivations in adults.
- Non-food commercials may attenuate physiological responding to food cues.
- This attenuation appears to occur in overweight individuals only.