Junk Food Advertising Moderates the Indirect Effect of Reward Sensitivity and Food Consumption via the Urge to Eat

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Abstract

The current study aimed to identify how underlying individual differences increases vulnerability to television food advertising. In particular, this study examined how reward sensitivity, a biologically-based predisposition to approach rewards (such as appetitive foods) in the environment, influenced participants' vulnerability to television food advertising and subsequent food consumption. Ninety-eight participants were randomly assigned to a cue condition (food cues versus non-food cues) and then viewed a 30 minute documentary interrupted by advertising featuring a mix of food and neutral advertising (food cue condition) or only neutral advertising (non-food cue condition). Participants' reward sensitivity, approach motivation measured as urge to eat, and food consumption were recorded. Moderated mediation regression analyses revealed the positive association between reward sensitivity and food consumption was mediated by an increase in urge to eat, but only when participants were exposed to food advertising. These findings suggest heightened reward sensitivity, exposure to appetitive food cues, and approach motivation are key interacting mechanisms that may lead to maladaptive eating behaviours.

Keywords: Television; Advertising; Reward; Food; Personality; Cue

1. Introduction

The World Health Organisation (WHO) has warned obesity levels are rapidly increasing worldwide and has become one of the top health problems in the world (WHO, 2016). Obesity is a major risk factor for cardiovascular diseases, diabetes, cancers, premature death (WHO, 2016), and poor mental health outcomes (Phillips et al., 2012). While several causes of increasing obesity levels have been proposed, including sedentary lifestyles (Martinez-Gonzalez, Martinez, Hu, Gibney, & Kearney, 1999) and easier access to cheaper, energy dense foods (i.e., foods with high fat, salt, and sugar content; Chandon & Wansink, 2012), the role of television food advertising has also been investigated. The current "obesogenic environment" includes extensive exposure to food advertising. However, despite this environment many individuals do not overeat and continue to maintain a healthy weight (Bellisari, 2008). Researchers have proposed that biologically-based individual differences in sensitivity to appetitive food cues, such as those used in television food advertising, may increase vulnerability to overeating and poor diet choices (Beaver et al., 2006; Davis et al., 2013; Loxton & Tipman, 2017; Maxwell, Loxton, & Hennegan, 2017). The current study aims to identify potential mechanisms underlying individual differences in sensitivity to appetitive food cues which may lead to maladaptive eating behaviours.

1.1. Reward Sensitivity

In recent years, researchers investigating maladaptive eating behaviours have begun examining the role of reward sensitivity. Reward sensitivity is a biologically-based predisposition to seek out rewarding substances and pursue situations and stimuli with high reward potential (Gray & McNaughton, 2000). A core theme of recent research has been the proposal that highly reward-sensitive individuals are more attuned to the rewarding properties of substances of abuse and energy dense foods (Dawe & Loxton, 2004; Hennegan, Loxton, & Mattar, 2013). Heightened reward sensitivity has been associated with a range of maladaptive

eating behaviours. Compared to control groups and individuals with restrictive-type eating disorders, individuals with bulimia nervosa and anorexia-nervosa (purging-type) scored significantly higher on self-report reward sensitivity measures (Beck, Smits, Claes, Vandereycken, & Bijttebier, 2009; Harrison, O'Brien, Lopez, & Treasure, 2010). In primarily female non-clinical and community populations, heightened reward sensitivity was associated with binging and purging behaviours (Eneva et al., 2017; Loxton & Dawe, 2001, 2006; Matton, Goossens, Braet, & Vervaet, 2013), dysfunctional eating attitudes (Haskings, 2006), overeating (Davis et al., 2007), and food addiction symptoms (Loxton & Tipman, 2016). Additionally, reward sensitivity has been linked with increased cravings and consumption of energy dense foods (Davis et al., 2007; Franken & Muris, 2005; Tapper, Baker, Jiga-Boy, Haddock, & Maio, 2015; Yen et al., 2010). While this research demonstrates a relationship between reward sensitivity and maladaptive eating behaviours, less is understood about the mechanisms by which this trait may lead to problematic overeating. Defining these mechanisms will extend the current literature and may inform the development of targeted interventions that aim to reduce unhealthy eating behaviours in highly reward-sensitive individuals. Previous research has implicated an approach-motivated state elicited by exposure to reward cues as a possible mechanism (e.g., Gullo et al. 2017).

1.2. Environmental Cues and Approach Motivation

Individuals with heightened reward sensitivity are more likely to notice rewarding stimuli in their environment and experience heightened anticipation about those rewards (Corr, 2009). Due to this heightened anticipation, these individuals are more motivated to approach and obtain a perceived reward (Gray & McNaughton, 2000). In line with this, research has demonstrated that individuals with greater levels of reward sensitivity exposed to rewarding cues (i.e., images of appetitive foods such as ice cream) show greater attentional bias towards food cues (Li et al., 2015) and a stronger approach-motivated state compared to

individuals with lower reward sensitivity (Hennegan et al., 2013; Loxton & Byrnes, 2012).

In particular, one study investigated the moderating effect of food cue exposure on the relationship between reward sensitivity and an approach-motivated state, measured as the urge to eat (Loxton & Byrnes, 2012). Participants were exposed to either junk food advertising, healthy food advertising, or non-food advertising while watching a non-food-related documentary. Participants were asked to rate their urge to eat before and after watching the documentary. Only participants with high reward sensitivity reported a significant increase in urge to eat following exposure to junk food advertising, but not after exposure to other advertising (Loxton & Byrnes, 2012). Providing further support, Hennegan et al. (2013) also demonstrated participants with high reward sensitivity reported an increase in urge to eat after exposure to still images of appetitive foods. Overall, these studies support the proposal that exposure to appetitive food cues such as those used in junk food advertising can elicit a stronger approach-motivated state in individuals with heightened reward sensitivity. However, findings from Loxton and Byrnes (2012) were limited by small samples in some conditions, and both studies failed to investigate if this increased approach-motivated state following food cue exposure led to an increase in subsequent food consumption. In addition, limited research has investigated how long an approach-motivated state (i.e., increased urge to eat) lasts following exposure to rewarding stimuli for individuals with heightened reward sensitivity.

1.3. The Current Study

The current study aimed to examine if an indirect effect of reward sensitivity on food consumption, via an increase in urge to eat was evident, following exposure to television food advertisements (Figure 1). Additionally, this study aimed to examine if an increase in urge to eat was still present following a brief non-food related task. This study will extend the findings of Loxton and Byrnes (2012) and Hennegan et al. (2013) by investigating the

mediating role of approach-motivation on the relationship between reward sensitivity and food consumption. It was hypothesised (1) that reward sensitivity would be positively associated with an increase in the urge to eat following exposure to appetitive food advertisements (but not following the exposure to non-food advertisements); and (2) that there would be a moderated indirect effect of reward sensitivity on food consumption via an increase in the urge to eat. This indirect effect would be moderated by cue condition; specifically, the indirect effect will only occur in the food cue condition, but not the non-food cue condition.

2. Materials and Methods

2.1. Participants

In total, 98 participants (35 males) were recruited to participate in this study. Participants were aged between 18 years and 53 years with a mean age of 25.58 years (*SD* = 8.41). Self-reported ethnicity included 71.4% Caucasian, 5.1% Indigenous Australian, 10.2% Asian, and 13.3% reported Other. Only 10.2% of participants identified as vegan, vegetarian, or pescatarian, and 16.3% reported food allergies. Body mass ranged from underweight to obese with a mean body mass index (BMI) of 24.77 (*SD* = 5.35).

2.2. Design

A 2 level between-subjects x 3 level within-subjects experimental design was employed. Participants were randomly assigned to a cue condition (food cue versus non-food cue) and urge to eat was measured three times: pre-cue exposure (Time 1), post-cue exposure (Time 2), and after a 10 minute non-food related filler task (Time 3).

2.3. Measures

2.3.1. Demographics Questionnaire

Information concerning participants' age, gender, ethnicity, height and weight were

collected. To control for diet, participants were asked if they were vegan, vegetarian, or pescatarian, how long ago they last ate (i.e., "In the last hour", "In the last two hours", "In the last three hours", or "More than three hours ago") and if they had any food allergies. The researcher also recorded the time of day participants completed the study.

2.3.2. Sensitivity to Reward Scale

The Sensitivity to Reward scale (SR) (Torrubia, Avila, Molto, & Caseras, 2001) was used to assess level of reward sensitivity and has been used in previous studies examining sensitivity to reward and eating behaviour (e.g., Loxton & Tipman, 2016; Maxwell et al., 2017). The self-report measure consists of 24 dichotomously scored items assessing participants' motivation to approach a reward (e.g., "Do you often take the opportunity to pick up people you find attractive?"). Individuals who agree with more items are higher in reward sensitivity. Internal consistency for this study was adequate ($\alpha = .74$) and similar to previous studies (e.g., Loxton & Tipman, 2016; Torrubia et al., 2001). In the current study, participants' total scores on this measure ranged between 3 and 22.

2.3.3. Urge to Eat Scale

The Urge to Eat scale includes an item asking "How do you rate your desire to eat at this moment in time?". Participants rated the extent of their desire along a 7-point Likert scale from 0 (*no desire*) to 6 (*very strong desire*). Higher scores indicate a greater urge to eat. This scale has been used in previous studies investigating reward sensitivity and eating behaviours (e.g., Maxwell et al., 2017). Four filler items, not related to food, were included to mask the true purpose of this measure (e.g., "How do you rate your desire to watch television at this time moment in time?"). In the current study, participants' urge to eat scores on this measure fell between 0 and 6 at each data collection time point.

2.3.4. Bogus Food Test

Similar to previous research (e.g., Nederkoorn, Van Eijs, & Jansen, 2004), participants were presented with a medium, white dessert bowl filled with mixed coloured M&M's^{TM} to snack on while completing the SR scale and demographics questionnaire (following cue exposure). M&M's were chosen as previous research has noted chocolate is one of the most commonly craved foods (e.g., Hill, Weaver, & Blundell, 1991; Parker, Parker, & Brotchie, 2006; Rodin, Mancuso, Granger, & Nelbach, 1991; Rozin, Levine, & Stoess, 1991). The contents of the bowl were weighed before participants arrived, with each participant receiving between 92 grams and 130.80 grams. The bowl was weighed again after participants finished the study. This data was recorded as the number of grams consumed by participants.

2.4. Procedure

Ethical clearance was granted by the University's Human Research Ethics Committee. Participants were tested individually in a dedicated research laboratory. After random allocation, all participants completed the first Urge to Eat scale to establish a baseline (Time 1). Participants then viewed a 30 minute segment adapted from the "March of the Penguins" documentary (Darondeau, Lioud, Priou, & Jacquet, 2005), interrupted by two advertising breaks at eight and 20 minutes lasting approximately 3 minutes each. This documentary is considered neutral in content and has been used in previous research for similar purposes (e.g., Anschutz, Engels, & Van Strien, 2010; Loxton & Byrnes, 2012). In total, participants were exposed to four advertisements promoting junk food (i.e., chocolate, ice cream, and two fast food restaurant menu options) and seven neutral advertisements in the food cue condition, and ten neutral advertisements in the non-food cue condition. Neutral advertisements included promotions of a university, pet food, cars, insurance, mobile phones, musicians, a department store, linen, and a home fitout service. These advertisements have been previously used in Loxton and Byrnes (2012). Each advertisement lasted between 20 to

45 seconds. The documentary was viewed in a room with no windows, on a 21-inch flat screen monitor. Participants were provided headphones to minimise outside distractions and instructed not to fast-forward. The experimenter remained in the room to ensure participants viewed the documentary and advertisements in their entirety. As a manipulation check and to test the first hypothesis, participants completed the Urge to Eat scale again immediately after viewing the documentary (Time 2).

Participants then completed a 10 minute filler task which consisted of a low stakes betting game and was completed by all participants.[1] After completing the filler task, participants completed the Urge to Eat scale (Time 3) again, the SR scale, and the demographics questionnaire. Once participants had completed the final Urge to Eat scale and before they completed the remaining measures, they were offered a previously weighed bowl of M&M's™ to snack on while they finished. At this stage, the experimenter left the room for 3 minutes to remove any influence from the experimenter's presence on food consumption. At the conclusion of the study participants were debriefed and informed that the quantity of food consumed was being measured. Permission to use this data was requested. All participants gave consent and the bowl was weighed again.

2.5. Data Analysis Plan

IBM SPSS Statistics version 22 was used to conduct the analyses. Descriptive statistics for key variables and demographics were calculated and bivariate correlations were performed to assess for relationships between key variables. Independent t-tests for continuous variables and chi square comparisons for categorical variables were conducted to

[1] The filler task was a low stakes betting game in which participants played 20 rounds. This task was included to investigate if urge to eat mediated the indirect relationship between reward sensitivity and food consumption after an extended period of time. Results indicated a significant positive correlation between reward sensitivity and the number of bets placed (r = .31, p = .002), however, this relationship was not moderated by cue condition, nor did the number of bets mediate the indirect relationship between reward sensitivity and food consumption.

assess random group allocation at baseline. A manipulation check using a one-way between subjects ANCOVA was conducted to assess the effect of cue condition on urge to eat following documentary viewing (Time 2), controlling for urge to eat at Time 1. To test the first hypothesis, if cue condition moderated the relationship between reward sensitivity and urge to eat at Time 2, a bootstrapped (n = 10,000) moderated regression was conducted using PROCESS Macro Model 1 version 2.16 (Hayes, 2013). SR was entered as the predictor variable, cue condition as the moderator (i.e., the direct effect of cue condition and the interaction between SR and cue condition), and urge to eat at Time 2 as the outcome variable. Baseline urge to eat, age, gender, and time since last meal were entered as a covariates. Finally, to test the second hypothesis, a moderated mediation model (Figure 1), PROCESS Macro Model 8 version 2.16 (Hayes, 2013) with bias corrected 95% confidence intervals (BC 95% CI; bootstrapped n = 10,000) was conducted. SR was entered as the predictor variable, cue condition as the moderator (i.e., the direct effect of cue condition and the interaction between SR and cue condition), urge to eat at Time 3 as the mediator, and amount of food consumed was entered as the outcome variable. Baseline urge to eat, gender, age, and time since last meal were entered as covariates on the moderator. This model tests the conditional (i.e., interaction between SR and cue condition) indirect effect of cue condition on the association between the predictor variable, SR, and the outcome variable, food consumed, via the potential mediator, urge to eat at Time 3 and the conditional direct effect of cue condition on the association between SR and food consumed. An index of moderated mediation was used to test the significance of the moderated mediation (i.e., the difference of the indirect effects between the food-cue and non-food cue conditions). This test supersedes the Baron and Kenny (1986) causal steps approach which required individual paths to be significant to imply mediation (Hayes & Rockwood, 2017). Instead, significant moderated mediation effects are supported by the absence of zero within the confidence intervals of the conditional

indirect effects (which account for the cross-products of predictor-mediator, and mediator-outcome paths at each level of the moderator) and do not require individual significant paths (Hayes, 2015).

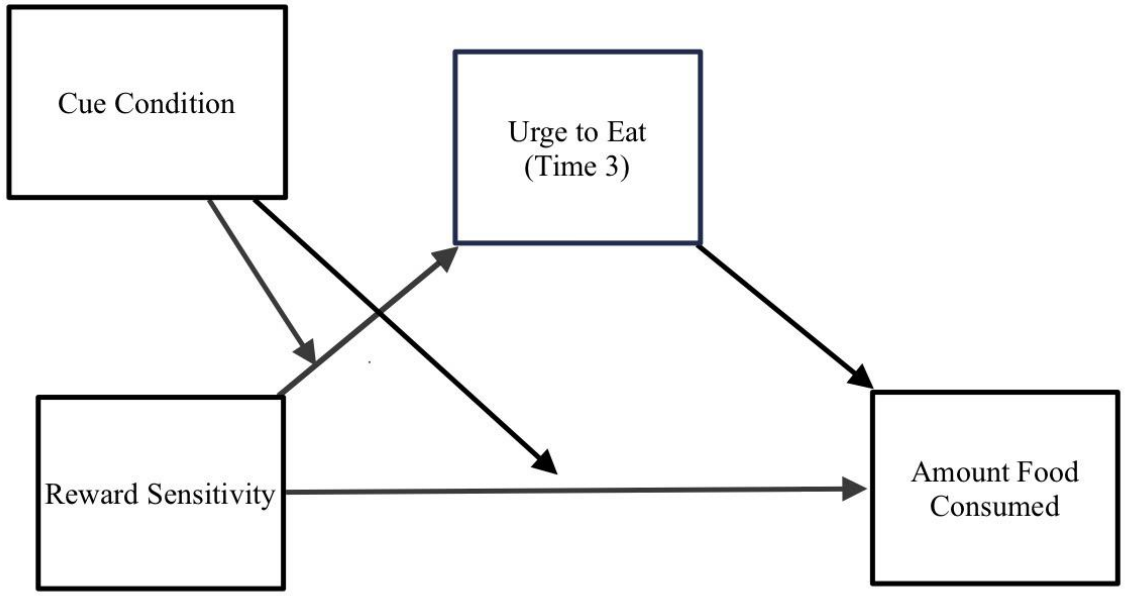

Figure 1. Proposed conditional indirect effects of reward sensitivity and food consumption via urge to eat and conditional direct effects of reward sensitivity and food consumption.

3. Results

3.1. Data Screening and Assumption Checking

Prior to running the analyses, the dataset was screened for missing data, normality and univariate and multivariate outliers. To identify any missing data patterns, a Missing Values Analysis was performed. The analysis revealed 1% of data was missing from the dataset. Little's Missing Completely at Random (MCAR) test was not significant ($\chi^2 = 84.56$, $p = .85$) indicating this data was MCAR, and it is appropriate to proceed with the analysis as planned

(Tabachnick & Fidell, 2013). As Hayes (2013) bootstrapping method accounts for significant skewness and kurtosis, no transformations were performed on variables that were significantly skewed (age, weight, and food consumption) or had significant kurtosis (weight and food consumption). One univariate outlier on the food consumed variable was identified and removed from further analyses involving this variable. Inspection of the standardised residual histogram and standardised residual-predicted value scatterplot indicated that all regression assumptions were met.

3.2. Randomisation Check

To confirm successful random allocation to cue condition, conditions were compared at baseline with independent *t*-tests for continuous variables and Pearson's chi-square tests for categorical variables (Table 1). No significant differences between conditions were observed for any variable except reward sensitivity. Participants in the food cue condition scored, on average, higher than those in the non-food cue condition. As participants were allocated to a cue condition using a coin toss, it is likely these groups differed by chance. Table 1 also displays comparisons between cue conditions on urge to eat at Times 2 and 3.

Table 1 *Independent t-tests and Pearson's Chi-Square Tests Between Cue Conditions on Baseline Scores, Demographic Variables, and Urge to Eat (n = 98)*

	Food Cue *n* = 52	Non-Food Cue *n* = 46		
Variable	*M (SD)/n (%)*	*M (SD)/n (%)*	t/χ^2	*p*
Age	24.90 (7.93)	26.35 (8.94)	0.85[a]	.399
Gender			1.05[b]	.305
Male	21 (40.4%)	14 (30.4%)		
Female	31 (59.6%)	32 (69.6%)		
Ethnicity			6.18[b]	.103

Caucasian	42 (80.8%)	28 (60.9%)		
Indigenous Australian	3 (5.8%)	2 (4.3%)		
Asian	3 (5.8%)	7 (15.2%)		
Other	4 (7.7%)	9 (19.6%)		
Food allergies			0.07[b]	.789
Yes	8 (15.4%)	8 (17.4%)		
No	44 (84.6%)	38 (82.6%)		
Vegetarian, Vegan, or Pescatarian			2.38[b]	.123
Yes	3 (5.8%)	7 (15.2%)		
No	49 (94.2%)	39 (84.8%)		
Last Meal			3.68[b]	.298
Last hour	12 (23.1%)	9 (19.6%)		
Two hours	5 (9.6%)	10 (21.7%)		
Three hours	9 (17.3%)	10 (21.7%)		
More than three hours	26 (50%)	17 (37.0%)		
RS	11.71 (4.16)	9.87 (3.89)	-2.26[a]	.026
BMI	24.10 (4.36)	25.55 (6.27)	1.33[a]	.185
UTE Time 1	2.58 (1.82)	2.48 (1.85)	-0.27[a]	.791
UTE Time 2	2.80 (1.77)	2.24 (19.56)	-1.49[a]	.139
UTE Time 3	2.79 (1.72)	2.39 (2.08)	-1.03[a]	.304

Note. [a]Independent *t*-test. [b]Pearson's chi square test. RS = Reward sensitivity. BMI = Body mass index. UTE = Urge to eat.

3.3. Manipulation Check

Controlling for baseline urge to eat, a one way between subjects ANCOVA revealed a

significant difference between cue conditions at Time 2, $F(1, 97) = 4.00$, $p = .048$, $\eta p^2 = .04$. Adjusted means for groups indicated participants in the food cue condition ($M = 2.76$, $SE = 0.17$) scored significantly higher on urge to eat at Time 2 compared to participants in the non-food cue condition ($M = 2.29$, $SE = 0.17$). Therefore, appetitive food advertisements embedded within the documentary were effective at eliciting a significant increase in urge to eat.

3.4. Descriptive Statistics

Descriptive statistics and correlations between demographics and key variables are provided in Table 2. Reward sensitivity and urge to eat mean scores were similar to those reported in previous literature (e.g., Hennegan et al., 2013; Maxwell et al., 2017). Significant positive relationships were observed between reward sensitivity and urge to eat at Time 2 and Time 3. Significant positive relationships were found between urge to eat scores at each time interval. A significant negative relationship was observed between reward sensitivity and gender, indicating males on average, scored higher on reward sensitivity than females. Age was significantly negatively correlated with urge to eat at each time interval. BMI was not significantly correlated with any key variables, however a significant positive relationship with age was found. Food consumption ranged from 0 grams to 44.80 grams and was significantly positively correlated to reward sensitivity, and urge to eat at Time 2 and Time 3. This suggests participants with higher reward sensitivity ate more than participants with lower reward sensitivity, and those who had a greater urge to eat, ate more than those with a lower urge. Time since last meal was significantly positively related with urge to eat at each time interval.

Table 2 *Means, Standard Deviations, and Bivariate Correlations Between Reward Sensitivity, Urge to Eat, Food Consumed, BMI, Age, Gender, and Time Since Last Meal was Consumed (n = 97)*

	M	*SD*	1	2	3	4	5	6	7	8	9
1. RS	10.85	4.12	-								
2. UTE Time 1	2.53	1.82	.18	-							
3. UTE Time 2	2.54	1.87	.27**	.77***	-						
4. UTE Time 3	2.60	1.90	.23*	.81***	.94***	-					
5. Food Consumed	6.18	8.38	.27**	.15	.26*	.26*	-				
6. BMI	24.77	5.35	-.17	-.12	-.14	.11	.06	-			
7. Age	25.58	8.41	-.40***	-.20*	-.22*	-.22*	-.08	.26*	-		
8. Gender[a]			-.23*	-.04	.03	.04	.06	.04	.16	-	
9. Last Meal			-.10	.22*	.21*	.20*	-.08	.07	.10	-.04	-

Note. RS = Reward Sensitivity; UTE = Urge to Eat; BMI = Body Mass Index; Last Meal = Time Since Last Meal.

[a]Gender has been dummy coded: Male = 0; Female = 1.

*$p < .05$. **$p < .01$. ***$p < .001$.

3.5. Moderation by Cue Condition on Reward Sensitivity and Urge to Eat at Time 2

The overall model was significant, $R^2 = .67$, $F(7, 89) = 25.56$, $p < .001$. The main effect of reward sensitivity on urge to eat at Time 2 (following cue exposure) was not significant ($b = -0.03$, $b_{se} = 0.05$, $p = .517$, BC 95% CI [-0.12, 0.06]). However, the main effect of cue condition ($b = -1.39$, $b_{se} = 0.66$, $p = .04$, BC 95% CI [-2.70, -0.07]), and the interaction between reward sensitivity and cue condition ($b = 0.17$, $b_{se} = 0.06$, $p = .005$, BC 95% CI [0.05, 0.28]) were both significant. Examination of the conditional effects (i.e., simple slopes analysis) at each level of the cue condition was conducted. This analysis revealed there was no significant association between reward sensitivity and urge to eat at Time 2 for participants exposed to the non-food cues ($b = -0.03$, $b_{se} = 0.05$, $t(89) = -0.65$, $p = .52$). However, there was a significant association between reward sensitivity and urge to eat for participants exposed to food cues, $b = 0.14$, $b_{se} = 0.04$, $t(89) = 3.34$, $p = .001$. These findings indicate participants with higher reward sensitivity reported a greater increase in urge to eat, but only following exposure to food cues.

3.6. Tests of Conditional Indirect and Direct Effects

The hypothesised moderated mediation model was tested using PROCESS Macro Model 8, which tests if cue condition moderated the indirect effect of urge to eat (Time 3) on the relationship between reward sensitivity and food consumption and the direct effect of reward sensitivity on food consumption (Figure 1; Hayes, 2013). Baseline urge to eat, gender, age, time since last meal were entered as covariates on the moderator. Table 3 displays the results of this analysis. The first section of the table represents reward sensitivity and cue condition regressing onto urge to eat at Time 3, and the interaction between reward sensitivity and cue condition. The model was significant, $R^2 = .70$, $F(5, 89) = 29.64$, $p < .001$. No significant main effects between reward sensitivity (path *a*) and cue condition on urge to eat at Time 3 were present, however a significant interaction between reward sensitivity and

cue condition was evident. This finding indicates significant moderation by cue condition on the relationship between reward sensitivity and urge to eat at Time 3. The second section represents reward sensitivity, cue condition, and urge to eat regressing onto food consumption, and the interaction between reward sensitivity and cue condition. This model was significant, $R^2 = .17$, $F(4, 92) = 4.63$, $p = .002$. No significant main effects between urge to eat (path *b*), reward sensitivity (path *c*'), and cue condition on food consumption were present, however, a significant interaction between reward sensitivity and cue condition was evident.

The overall moderated mediation model was supported with the index of moderated mediation = 0.09, 95% CI [0.003, 0.29]. As zero was not within the confidence intervals, this indicated a significant moderating effect of cue condition on the indirect effect of reward sensitivity and food consumption via urge to eat at Time 3 (Hayes, 2015). Examination of the conditional indirect effects revealed a significant indirect effect of reward sensitivity on food consumption via urge to eat in the food cue condition ($b = 0.07$, $b_{se} = 0.05$, BC 95% CI [0.0001, 0.202]) but not in the non-food condition ($b = -0.02$, $b_{se} = 0.03$, BC 95% CI [-0.120, 0.02]). This finding indicates food cue exposure moderated the indirect relationship between reward sensitivity and food consumption, via urge to eat at Time 3.

Table 3 *Results of Moderated Mediation Analysis Testing the Conditional Indirect Effects of Reward Sensitivity and Food Consumption, via Urge to Eat (n = 97)*

	Indirect Effect	
Variable	Bootstrap Estimate (*SE*)	BC 95% CI
UTE Time 3		
RS (Path *a*)	-0.03 (0.04)	-0.12, 0.05
Cue Condition	-1.22 (0.65)	-2.50, 0.07
RS x Cue Condition	0.13 (0.06)*	0.02, 0.25

Food Consumption		
UTE Time 3 (Path *b*)	0.69 (0.44)	-0.18, 1.57
RS (Path *c'*)	-0.07 (0.30)	-0.67, 0.52
Cue Condition	-7.93 (4.64)	-17.16, 1.29
RS x Cue Condition	0.90 (0.41)*	0.09, 1.71

Note. BC = Bias-Corrected; CI = Confidence Interval; RS = Reward Sensitivity; UTE = Urge to Eat.

Cue Condition: Food Cue = 1; Non-Food Cue = 0.

*$p < .05$.

Additionally, PROCESS Macro Model 8 tests the conditional direct effect of cue condition on the relationship between reward sensitivity and food consumption (Table 4). Findings indicated the conditional direct effect was significant but only for the food cue condition.

Table 4 *Conditional Direct Effects of Cue Condition on Relationship Between Reward Sensitivity and Food Consumption*

	Direct Effect	
Variable	Bootstrap Estimate (*SE*)	BC 95% CI
Non-Food Cue Condition	-0.07 (0.30)	-0.67, 0.52
Food Cue Condition	0.82 (0.28)**	0.28, 1.37

Note. BC = Bias-Corrected; CI = Confidence Interval.

**$p < .01$.

3.7. Summary of Results

The positive association between reward sensitivity and urge to eat at both Time 2 and Time 3 were moderated by exposure to appetitive food cues. This indicates, that when exposed to a food cue, participants with heightened reward sensitivity reported an increase in their urge to eat, and this effect held until after the 10 minute filler task. The conditional indirect effect of reward sensitivity on food consumption, via urge to eat at Time 3, was

significant, indicating an increase in urge to eat mediated this relationship, but only when exposed to food cues. Finally, a conditional direct effect of reward sensitivity on food consumption was significant for the food cue condition only, indicating participants with greater reward sensitivity and exposed to food cues consumed more food than participants with lower reward sensitivity and participants not exposed to food cues.

4. Discussion

The current study aimed to identify how underlying individual differences increases vulnerability to food cues used in television food advertising. In particular, the study examined how individual levels of reward sensitivity influenced participants' vulnerability to television food advertising and food consumption and the mediating role of approach motivation. The first hypothesis, that reward sensitivity would be positively associated with an increase in urge to eat following exposure to appetitive food advertisements, but not following non-food advertisements, was supported. Participants with heightened reward sensitivity experienced an increase in urge to eat, but only after exposure to food cues. In addition, the effect of exposure to food cues continued to moderate the relationship between reward sensitivity and urge to eat, even after participants completed a non-related task for ten minutes.

These findings were in line with previous research by Loxton and Byrnes (2012) and Hennegan et al. (2013) that demonstrated a moderating effect of appetitive food cues on the positive relationship between reward sensitivity and urge to eat. The findings also align with other research that suggest individuals with heightened reward sensitivity have a greater attentional bias toward appetitive food cues (e.g., images of ice cream, chocolate, fries; Li et al., 2015) and greater approach-motivated responses following exposure to appetitive cues (Bedi et al., 2011; Gullo et al. 2017; Witteman et al., 2015). These consistent findings support the proposal that individuals with heightened reward sensitivity may have an increased

vulnerability to food cues, which increases their desire to eat following exposure. In addition, the lack of increase in urge to eat in individuals with heightened reward sensitivity when not exposed to appetitive food cues, supports the notion that this trait is expressed as an approach motivated response only when exposed to the prospect of a reward (Corr, 2009).

The second hypothesis proposed an indirect effect of reward sensitivity on food consumption, via the urge to eat, would be moderated by cue condition. Specifically, that the indirect effect of reward sensitivity and consumption via the urge to eat would only occur in the food cue condition. The findings of this study supported this hypothesis, revealing that greater reward sensitivity was associated with an increased urge to eat which led to more food being consumed, however, this effect was only evident for participants who viewed the documentary embedded with food advertising. Although previous research has not investigated this conditional indirect effect, it was not unexpected. Previous findings had established a relationship between reward sensitivity and urge to eat after exposure to appetitive food cues (Loxton & Byrnes, 2012) and relationships between reward sensitivity and eating behaviours (Davis et al., 2007). The findings of this study indicate that exposure to television food advertising, heightened reward sensitivity, and approach motivation responses are key mechanisms that may lead to overeating.

While urge to eat accounts for part of the relationship between reward sensitivity and food consumption, a conditional direct relationship between reward sensitivity and food consumption was also evident. This suggests either reward sensitivity was directly influencing how much participants ate when cued, or other mediating mechanisms, not captured by this study, were exerting influence. For example, cue reward salience, an individual's perceived value of a cue, has been associated with reward sensitivity and an increase in urge to drink following alcohol cue exposure (Ivory, Kambouropoulos, & Staiger, 2014). However, research has not investigated if reward salience is a mediator of the

relationship between reward sensitivity and food consumption. Similarly, a recent study using an attentional bias task, found a greater attentional bias towards appetitive images (e.g., chocolate, fries, ice cream) mediated the association between reward sensitivity and ice-cream cravings (Li et al., 2015). Ice cream cravings was measured in a similar fashion (a visual analog scale) as the current study's "urge to eat". This supports the proposal that those high in reward sensitivity are more likely to notice appetitive food cues and experience greater cravings/urge to eat, which leads to greater consumption. Future research could identify complex mechanisms that involve cue-reward salience, attentional bias, and cravings/urge to eat in excess food consumption. The current research in the areas of cue-reward salience and attentional bias, in relation to reward sensitivity, has tended to investigate alcohol and other drugs. Given that reward sensitivity appears to be a common trait linked to both over-eating and substance misuse and dependence (e.g., Loxton & Dawe, 2001; 2006), future research could use the procedure utilised in the current study to assess additional factors that may drive a preference for appetitive food and/or alcohol and other drugs. This could be assessed by incorporating an additional condition with embedded alcohol advertisements.

4.1. Implications

This study extends the literature investigating the relationship between reward sensitivity and maladaptive eating behaviours. It has provided further evidence that individuals with heightened reward sensitivity are more likely to react to perceived rewards in their environment (Corr, 2009; Gray & McNaughton, 2000). Additionally, this is the first study to identify an interactive relationship between exposure to food cues, reward sensitivity, and approach motivation which resulted in food consumption. Furthermore, the results of this study demonstrated an effect of food cue exposure on food consumption. This effect was evident despite exposing participants to only four junk food advertisements during

50 minutes it took to complete the study. On average, viewers are exposed to five food and beverage advertisements per hour of television viewing (Harris, Bargh & Brownell, 2009). It is possible this amount of exposure has critical implications for viewers with heightened reward sensitivity, such as excess consumption of junk food. Advertising regulatory boards should consider these potential consequences when establishing guidelines for advertising practices.

In addition, the findings from this study have important clinical implications. As previous research has consistently demonstrated that heightened reward sensitivity is related to bulimia nervosa and anorexia-nervosa (purging-type; Beck et al., 2009; Harrison et al., 2010a) and a range of eating pathology behaviours (Davis et al., 2007; Eneva et al., 2017; Loxton & Dawe, 2001, 2006; Loxton & Tipman, 2016; Matton et al., 2013), urge to eat may be an important mechanism to target in clinical interventions. To inform these interventions, future research should extend upon the findings of this study by investigating if this approach-motivated state mediates the relationship between reward sensitivity and eating pathology behaviours in these vulnerable populations and determine if targeting it with existing cognitive behavioural and mindfulness techniques (e.g., urge surfing; Marlatt, 1994) reduces the occurrence of these behaviours.

4.2. Limitations

This study had a number of limitations that should be considered when interpreting the findings. Firstly, despite random group allocation, the groups differed at baseline with those in the food cue condition reporting significantly higher reward sensitivity than those in the non-food cue condition. This may have amplified the differences between conditions. As reward sensitivity was measured following exposure to food cues, it may be possible that exposure increased participants' scores in this condition. While reward sensitivity is considered a stable trait (Torrubia et al., 2001), future research should determine if levels of

self-reported reward sensitivity can be influenced by exposure to reward cues. Secondly, the Urge to Eat scale only consisted of one item measuring participants' general desire to eat, and was not specific to chocolate. The scale also fails to differentiate between homeostatic hunger and hedonic hunger, potentially reducing the reliability and validity of the scale. Development of a measure to assess approach motivation with multiple items, designed to delineate between desires for different foods and between hunger types could address these issues. Thirdly, this study only offered one snack option. While chocolate is one of the most commonly craved foods (Hill et al., 1991; Parker et al., 2006; Rodin et al., 1991; Rozin et al., 1991), it cannot be determined if offering other snack options (including other junk foods or healthy foods) would see a similar effect. Additionally, participants' perceived palatability of M&M's was not recorded and therefore, it could not be determined if this influenced their eating. Future studies seeking to replicate this study could expand to other food options and include a measure of palatability. Furthermore, while BMI was not significantly correlated with any key variables, participants' height and weight data was self-reported. Study participants often incorrectly report this information (e.g., Bowring et al., 2012; Elgar & Stewart, 2008) and this may have biased the findings of this study. Additionally, this study did not measure or control for eating pathology. The BMI range within this sample suggests eating pathology behaviours could be present, which may have confounded the findings. Future research should consider including objective measures of height and weight and including a measure of eating pathology.

5. Conclusion

The results of this study suggest individual differences in sensitivity to television food advertising can have detrimental consequences. Overall, this study found reward sensitivity was positively associated with food consumption, via an increase in urge to eat, but only for those exposed to food cues. The results of this study suggest that individuals with heightened

reward sensitivity appear more susceptible to the effects of junk food advertising and this may have dangerous implications for their health and wellbeing.

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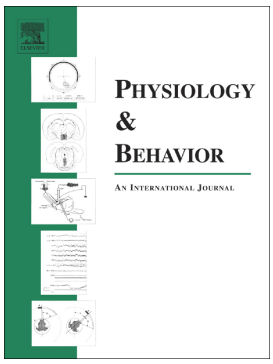
Title: Junk Food Advertising Moderates the Indirect Effect of Reward Sensitivity and Food Consumption via the Urge to Eat

Highlights:

- Exposure to food advertising alone does not increase food consumption.
- Heightened reward sensitivity increases vulnerability to food advertising.
- Interacting mechanisms following exposure to food cues influences food consumption.



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