Abstract

The Three Factors Eating Questionnaire's measure of disinhibited eating is a robust predictor of long- term weight gain. This experiment explored if disinhibited eaters display attentional bias to food cues. Participants (N=45) completed a visual dot probe task which measured responses to food (energy dense and low energy foods) and neutral cues. Picture pairs were displayed either for a 100 ms or 2000 ms duration. All participants displayed attentional bias for energy dense food items. Indices of attentional bias were largest in disinhibited eaters. Attentional bias in disinhibited eaters appeared to be underpinned by facilitated attention.

Key Words: Attentional Bias, Food, Orientation, Visual Dot Probe, Disinhibition

Introduction

Drug cues acquire higher motivational value through the process of dopaminergic conditioning (Berridge & Robinson, 1997). This associative learning leads to the reward system becoming hypersensitive to drugs and their associated cues (Robinson & Berridge, 2001). A frequently used behavioural measure of neural sensitivity to drug cues is attentional bias. Attentional bias occurs when an individual is quicker at processing personally relevant information compared to neutral information (Macloed, Matthews & Tata, 1986). Attentional bias for drug cues has been consistently documented in smokers, frequent caffeine consumers, drug users and alcoholics (For a review see Field and Cox, 2008). It is thought that attentional bias serves a functional role in maintaining addictive behaviour. Selective attention to drug cues has been shown to underpin approach behaviour and craving (Cox, Klinger & Fadardi, 2016). It is also a robust predictor of relapse (Franken, 2003).

Overeating provides an interesting parallel to addictive behaviour. Much like habitual drug users, obese individuals commonly report experiencing craving and a preoccupation with food (Herman and Polivy, 2008; Jastreboff, Sinha, Lacadie, Small, Sherwin & Potenza, 2013). The influence that food relevant cues (e.g. sight, smell, taste) have on food intake has also been well documented (for review see Herman & Polivy, 2008). It is plausible that dopaminergic conditioning occurs in individuals who habitually overeat. Attempts to establish if attentional bias for food cues can be a useful predictor of obesity risk has had mixed success. However, there is a growing body of research that demonstrated that obese individuals allocate greater attentional resources to food stimuli compared to their lean counterparts. (Castellanos et al. 2009; Nijs, Franken & Muris, 2010, Yokum, & Stice, 2011; Braet & Crombez, 2003; Graham, Hoover, Ceballos & Komogrotsev, 2011; Kemps, Tiggemann & Hollitt, 2014; Long, Hinton & Gillespie, 1994; Nijs, Muris, Euser & Franken, 2010; Werthmann et al., 2011).

A recent review of this literature by Doolan, Breslin, Hanna & Gallagher (2015) proposes that attentional bias to food cues is influenced more by an individual's eating traits than body weight. Research suggests that biased processing of food cues may increase obesity risk. This explanation has been used to explain the paradoxical relationship that exists between body weight and restrained eating patterns. Repeated attempts by restrained eaters to limit their food intake to control body weight, seemingly increases the likelihood that they will become obese (Herman & Polivy, 1980).A number of studies have demonstrated that restrained eaters have high indices of attentional bias to food cues (Hollitt, et al. 2007; Tapper, Pothos, Fadardi & Ziori, 2008). It can be proposed that attempts to restrict calorie intake made by restrained eaters are thwarted by biased processing of food cues. Higher indices of food processing bias have been linked to other eating patterns that are associated with obesity risk; these include external eaters (Brignell, Griffiths, Bradley, & Mogg, 2009; Newman, O'Connor & Conner, 2008) and high chocolate cravers (Smeets, Roefs, & Jansen, 2009).

To date, there has been no published attempt to document attentional bias in individuals who experience disinhibited eating. This oversight limits the existing literature as the Three Factors Eating Questionnaire's measure of disinhibited eating (TFEQ_D, Stunkard & Messick, 1985) is viewed as one of the most robust predictors of long- term weight gain (Hays & Roberts, 2008). Conceptually the term disinhibition refers to a variety of eating behaviours that can be characterised by a lack of self-regulation (e.g. binge eating, unhealthy food choices, low awareness of satiety) (Lattimore & Malinowski, 2008). Research has shown that individuals who score high on measures of trait disinhibition consistently have higher body weights (Boschi et al 2001; Provencher et al. 2003), make unhealthy food choices (Contento, Zybert, & Williams, 2005; Lahteenmaki & Tuorila, 1995), are more impulsive (Yeomans, Leitch, & Mobini, 2008) and experience reduced success from weight loss interventions (Bryant, Caudwell, Hopkins, King & Blundell 2012). This paper aims to examine if the opportunistic eating pattern displayed by disinhibited eaters is indicative of increased attentional bias to food cues.

The present research examined if individuals who have high levels of disinhibited eating (as measured by the TFEQ, Stunkard & Messick, 1985) paid increased attention to food cues during a visual dot probe task. Two visual stimuli were briefly presented side by side, followed by a dot (probe) where one of the stimuli had been. Some trials involved a food picture and a neutral picture, and others contained two neutral pictures. Participants had to press a button on the side of the display to indicate where the probe had appeared. Response time (RT) was used to calculate attentional bias. Faster RTs on trials where the probe followed in the location of a food picture, compared with trials when it followed one of two neutral stimuli was indicative of increased attention to food stimuli. To explore the impact of motivational value on attentional bias the food pictures consisted of both energy dense and low energy food items (Tapper, Pothos & Lawrence, 2010). It was predicted that attentional bias would increase for all participants when responding to trials containing foods which are energy dense (due to the cues higher motivational value). However, it is anticipated that this effect will be exacerbated in disinhibited eaters who are typically more responsive to the presence of hedonic food cues (Tapper et al. 2010).

During the visual dot probe task, picture pairs were displayed for either 100ms or 2000ms exposures. A matched neutral design was used to allow the reaction time data to be analysed in a way that provides both a traditional measure of attentional bias, but also establishes whether bias reflects facilitated attention to food cues or delayed disengagement (Tapper et al 2010; Koster , Crombez, Verschuere & Houwer, 2004). If attentional bias for food cues is driven by facilitated attention participants will make quicker responses when the probe replaces a congruent stimulus (probe position replacing food item). Whereas delayed disengagement of attention would result in slower reaction times to incongruent stimuli (probe position replacing neutral items).

Method

The sample comprised of forty-five participants who were recruited from the undergraduate population of the University of Swansea. The mean age of participants was 20.5±1. 8 years. The sample's mean BMI was within the normal range (23.6±4.8kg/m2). Disinhibition was measured using the disinhibition subscale of the Three Factor Eating Questionnaire (Stunkard and Melleck, 1985). This measure explores an individual's level of uncontrolled eating using 9 items. All potential participants were asked to complete the TFEQ_D; those whose scores placed them in the bottom or top 40% of the sample were invited to complete the visual dot probe task. Participants were grouped in terms of high and low disinhibited eating based on their TFEQ_D scores Recruitment adhered to the following selection criteria; all participants were non-vegan or vegetarian, self-reported that had no history of disordered eating and were not dieting.

Laboratory sessions were scheduled so that they occurred after meal times, all participants ate their habitual breakfast or lunch prior to attendance. This was to ensure that any behavioural differences in task performance were not caused by hunger. On arrival, participants were required to rate their hunger measured using a general mood questionnaire (VAS 0-100) which contained 10 items. Participants were asked to rate their mood (e.g. on a scale of 0-100 how happy are you feeling?) Included in these ratings were questions on hunger and thirst). Participants were then introduced to the visual dot probe task and were informed that they would be required to attend and respond to stimuli in the form of pictures. The test stimuli consisted of 64 pairs of colour pictures. Sixteen pairs were an energy dense food and a household item; sixteen were a low energy food and a household item, and 32 were two household items. All stimuli used in this task had been previously rated in a pilot study as being representative of each of the two categories (Tapper et al. 2008) and none of the household items selected altered the context of the food stimuli (e.g. related to food preparation, cleaning). In addition 10 animal items were used to create practice trials.

Picture pairs were presented for 100 ms and 2000ms duration across two blocks of 258 trials (128 critical trials, 128 matched neutral trials). Each block contained 4 presentations of each of the experimental or matched neutral picture pairs (e.g. experimental stimulus shown on left, followed by a probe on the left; experimental stimulus on left, followed by a probe on the right; experimental stimulus shown on the right, followed by a probe on the right and experimental stimulus show on right followed by a probe on the left). These presentations were randomised. The probe used in this task was a dot and was displayed until the participant made a response. Participants responded to the probe by identifying which side of the screen the probe had appeared. This was done by pressing one of two response buttons. Reaction time (RT) was measured in Milliseconds (ms). At the end of the computer task, participants were asked again to rate current mood and hunger. Finally, participant's height (cm) and weight (kg) were recorded. An average laboratory session lasted 45 minutes.
All trials with incorrect responses were excluded from the data analysis. RT for correct choices that were > 200 ms and < 2000 ms and < two SD longer than the participant's mean RT was analysed. Attentional bias scores were calculated for each participant and picture duration by subtracting the mean RT for probes replacing food items from the mean RT for probes replacing neutral items. Thus positive values would reflect a bias favouring a food stimulus relative to a neutral stimulus.

Data Analysis

Task Accuracy was compared across the two groups using an x 2 (Stimulus Duration) x 2 (Stimuli Set) X 2 (TFEQ_D) ANOVA. Attentional bias was compared across the two groups using a 2 (Food Type) x 2 (Stimulus Duration) x 2 (TFEQ_D group) ANOVA was conducted. Effect sizes for both ANOVA's were reported are Cohen's d (*d*).The significant interaction between disinhibition group and food type was explored using four planned comparisons of the mean attentional bias for energy dense and low energy foods (within and between each disinhibition group). A significant interaction was also found between stimulus duration and food type. Four planned comparisons were conducted, these compared stimulus duration (energy dense 100ms vs. 2000ms; low energy 100ms vs. 2000ms) and food type (energy dense 100ms vs. low energy 100ms; energy dense 2000ms vs. low energy, 20000ms). Bonferroni's correction was used to find the true critical p value for these eight planned comparisons. This critical p value was $p<0.006$. The extent to which attentional bias for food cues reflected increased facilitated attention or delayed disengagement was explored using an approach set out by Koster et al (2004).

Results

The demographics of the two groups are shown in Table 1. As expected, the groups differed significantly in terms of their TFEQ_D scores [$p<0.01$] and although the high disinhibition group had higher BMI this was not significantly higher [$p=0.51$]. There were no significant between group differences in baseline hunger [$p>0.05$]. Rated hunger did not change significantly in either group between the start (time point one) and end of the study (time point two) [$p > 0.05$]

Accuracy was significantly improved for trials which displayed stimuli pairs for 2000ms compared to 100ms (Mean 99.6% compared to 96.5%) [$F (1, 42) =240.71$ $p<0.01$]. However the type of stimulus which the probe followed (food or household item) had no significant impact on detection accuracy [$F (1, 42) =0.51$ $p =0.47$]. The groups did not differ in terms of task accuracy [$F (1, 42) = 0.06$ $p=0.80$].

A 2 (Food Type) x 2 (Stimulus Duration) x 2 (TFEQ_D group) ANOVA was conducted (For F values, effect size and mean bias scores for each group refer to Table 2). Analysis revealed that both groups displayed attentional bias for food cues on trials where picture pairs contained energy dense food items. There was no evidence of attentional bias for low energy foods. There was an interaction found between disinhibition group and food type. Planned comparisons indicated that both groups had a significantly higher attentional bias for trials where picture pairs contained an energy dense stimulus compared to a low energy stimulus (Low TFEQ_D; $t (22) =3.69$ $p<0.001$; High TFEQ_D $t (21) =8.11$ $p<0.001$). Although mean attentional bias for energy dense foods was highest in the high TFEQ_D group planned comparisons indicated no significant between group differences in attentional bias scores based on either food type (Energy Dense $t (43)0.55$ $p=0.58$; Low Energy $t (43) =1.11$ $p=0.27$).

An interaction was also found between stimulus duration and food type. Planned contrasts conducted across the two time durations indicate that there were no significant differences in bias scores when trials contained energy dense picture pairs [$p> 0.05$]. At the 100ms duration, attentional bias was significantly higher for energy dense foods compared to low energy foods ($t (44) =3.66$ $p<0.001$). The same pattern was found when comparing the two food types across 2000 ms trials ($t (44) =7.03$ $p <0.001$).

The extent to which attentional bias scores reflected facilitated attention to food cues or delayed disengagement from food cues was explored using an approach set out by Koster et al (2004). RTs (ms) for congruent and incongruent trials were compared to mean RTs from neutral trials to indicate whether FPB reflected orientation or disengagement. If attentional bias reflected facilitated attention to food cues this shown in quicker responses on congruent trials (compared to neutral and congruent matched neutral). Whereas difficulty disengaging from food cues would result in slower responses on incongruent trials (compared to neutral and matched neutral). Evidence of facilitated attention was found only for energy-dense foods in the high TFEQ_D group. Here participants were significantly faster at identifying probes replacing congruent food items compared to neutral items [t (21) =-2.289 $p<0.05$]. There was no evidence of delayed disengagement in either group [$p>0.05$].

Discussion

The present study is the first to examine if disinhibited eaters pay more attention to food cues. The results suggested that trait disinhibition (as measured by the TFEQ_D subscale) is associated with increased attentional bias for energy dense food cues. Although both groups were significantly quicker at identifying probes replacing energy dense food cues compared to neutral cues); mean attentional bias was highest in disinhibited eaters. The mean difference in attentional bias scores between the high and low disinhibition group was 12.7 ms. Though this difference is small it does support the prediction that disinhibited eaters opportunistic eating pattern is associated with heightened attention to food cues. The visual dot probe data documented attentional bias only on trials where the picture pairs contained energy dense foods. This finding is consistent with previous research that also identified attention bias only for palatable food items (Hepworth et al. 2010; Tapper et al. 2010). Disparity in task performance on energy dense and low-energy trials was largest for the high disinhibition group. This group typically displayed attentional bias for energy dense foods and directed attention away from low-energy foods. This pattern of avoiding low energy foods and while having biased processing of high energy foods is most commonly documented in patients with disordered eating (Shafran, Lee, Cooper, Palmer & Fairburn (2007).

From a methodological standpoint the findings from this study may be a consequence of the type of stimuli chosen to represent ‘low energy foods’. Many of these items were foods which would not typically be consumed immediately or by themselves (i.e. shredded wheat biscuit, plain rice). The energy dense stimuli set contained foods which were more representative of foods that can be eaten “at that moment” (i.e. burgers, chips, crisps and sweets). This is a limitation of classifying food into energy dense and low-energy groups, as it is likely that the energy-dense foods are those which are easily obtainable and can be consumed then and there. These foods may also be viewed as ‘forbidden’ by individuals who are aware that they have difficulty regulating their eating behaviour These are all features that are likely to have high salience for individuals whose appetite control is disinhibited by the availability of palatable foods. In light of these comments, this interaction suggests that opportunistic eaters allocate more attentional resources to cues that signal the availability of ‘forbidden’ or ‘hedonic’ foods.

In this study the visual dot probe task measured two components of attentional bias, facilitated attention and delayed disengagement from cues. Evidence of facilitated attention was only found for energy dense food cues in the high disinhibition group. There was no evidence of delayed disengagement. As facilitated attention is likely to act as a reminder of the presence of food in the environment, this together with the elevated biases displayed by the high TFEQ_D group suggests albeit tentatively that individuals with this eating trait are more responsive to food cues. This data adds further support to the prediction that overeating is driven by an individual’s sensitivity to food cues. It can be inferred that the opportunistic eating patterns of individuals who with high TFEQ_D scores places them at increased risk of long-term weight gain. It is important to acknowledge that the BMI range in this sample was restricted due to the sample size. There was also limited variation in the mean age of participants; the majority of participants were in their early twenties and it is likely that if the high TFEQ_D group exhibit a phenotype associated with weight gain, this may not be expressed as obesity until later life. With this in mind it would be valuable to replicate this experiment using an older sample with the inclusion of a follow up at 12 months; this would allow us to ascertain if the higher biases seen in the disinhibited eaters are indeed reflected in long-term weight gain.

To summarise this study is the first to illustrate that disinhibited eaters have a higher attentional enhanced attention to food cues in the environment may underpin overeating. This data suggests that disinhibited eaters are at increased risk of developing obesity, as disinhib bias for energy dense food cues. This work further substantiates the proposition that paying ition is associated with opportunistic eating patterns but also increased attentional bias to food cues. This interaction needs to be considered when developing successful interventions for weight management. There remains scope to explore if attentional retraining can lead to a reduction in responsivity to food cues in this non-clinical population.

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Tables

Table 1: Demographics of the TFEQ_D Groups (Mean±SD)

	Low TFEQ_D	High TFEQ_D	*t*

	(n=23)	(n=224)	
Age	20.6(2.3)	20.3(0.9)	0.71
BMI	22.2(4.5)	25.0(4.7)	2.01
TFEQ_D	4.2(1.4)	9.4(2.5)	-8.55**
TFEQ_R	*3.87(3.6)*	6.1(3.8)	2.00
Hunger Time 1	52.6(1.09)	55.5(1.1)	0.87
Hunger Time 2	55.0(1.1)	53.9(1.2)	0.39

*$p<0.05$ **$p<0.01$

Table 2: F value and effect size (Cohen's d)

	F	*p*	Effect size (*d*)
Food Type	70.71	0.00**	0.78
Stimulus Duration	1.63	0.21	
TFEQ_D	0.11	0.73	
TFEQ_D*Food Type	10.89	0.002**	0.44
Stimulus Duration* Food Type	7.13	0.01**	0.38

*$p<0.05$ **$p<0.01$

Table 3: Mean±SD Bias Scores (ms) based on stimuli exposure and food type

Group	Stimulus Duration	Energy Dense	Low Energy	t
Low TFEQ_D	100ms 2000ms	17.88±11.9 8.206±15.7	9.01±12.1 -20.08±15.9	1.12 4.59**
High TFEQ_D	100ms 2000ms	19.80±8.7 20.95±15.7	-10.99±10.45 -33.42±16.3	4.78** 5.80**

*$p<0.05$ **$p<0.01$