The role of implicit wanting in relation to explicit liking and wanting for food: implications for appetite control.

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Abstract

Considering the psychological mechanisms that influence eating, we assume that both implicit and explicit processes will operate. This distinction informs the liking vs. wanting issue of food reward. We investigated the effect of meal-induced satiation on implicit and explicit processes of liking (L) and wanting (W) by developing a computer-based procedure to measure L and W in hungry and satiated states. Explicit measures were derived from analogue ratings whilst an implicit W measure was derived from RT in a forced-choice procedure, which also measured food preference. Subjects completed the computer-task before and immediately following consumption of a savoury test meal. Satiation caused explicit ratings of L and W to decrease in all food categories; with a greater decrease for savoury foods compared with sweet foods. Implicit W was increased for sweet foods, but not for savoury. Implicit and explicit measures of L&W independently correlated with preference for sweet foods. Adjustments in hunger were linked to changes in explicit L&W in a manner consistent with sensory-specific-satiety, while a relationship between hunger and implicit W was absent. We suggest that implicit W is not systematically downregulated by the physiological consequences of food consumption in the same way as hunger and therefore may be largely independent of homeostatic processes influencing intake.

Key words: Implicit; Liking; Wanting; Preference; Food reward; Hedonic; Homeostatic; Appetite control.

Introduction

Traditionally homeostatic and hedonic influences over eating have been treated separately both through experimentation and theory development. However, recent considerations of homeostatic and non-homeostatic determinants of eating (Blundell and Finlayson, 2004; Berthoud, 2004; 2006) imply that such systems interact in the overall expression of appetite. Since eating is a behavioural act carried out through the voluntary skeletal musculature, it is often believed that eating is invariably under voluntary conscious control. Despite the fact that eating is an action open to awareness by the individual, it cannot be claimed that processes that control the expression of eating habits are necessarily explicit. An individual may have awareness of the act of eating per se whilst remaining unaware of the processes that determine the expression of appetite and the pattern of eating. It is, of course, obvious that a person cannot be aware of the (implicit) changes in neuropeptides, hormones or other physiological processes that help to determine the initiation, termination and topography of eating. Moreover, in considering just the psychological mechanisms that influence eating, we assume that both implicit and explicit processes will operate. Verplanken (Verplanken & Aarts 1999; Verplanken 2006) argued that the formation of habits should be constructed as a psychological process with automatic (implicit) features that operate somewhat independently to the explicit experience of a repeated behaviour. Using a 12-item measure derived from the conception of habit as an implicit process (Self-report habit index; Verplanken & Orbell, 2003), Verplanken (2006) demonstrated that the consumption of unhealthy snack food during a week was better accounted for by their measure of habit than by behavioural frequency of snack consumption during the previous week.

Indeed, since its renaissance in early memory research, implicit cognition is increasingly recognised as an important factor in understanding many aspects of human behaviour. This has led to the development of numerous experimental methodologies to operationalise implicit processes by observing their impact on measurable events. The Implicit Attitutdes Test (IAT; Greenwald et al. 1998) for example, is a computer-based category sorting task that uses response reaction time to uncover implicit attitudinal bias toward the association of a dichotomous target concept (e.g. photographs of faces altered to look fat or thin) with positively or negatively valenced words. If, over a number of repeated trials, stimuli belonging to one category of the target concept are responded to faster when paired with positive attributes compared with negative attributes relative to the alternative category, this is interpreted as a positive implicit bias towards that concept category. Maison et al. (2004) used the IAT to demonstrate an implicit attitudinal bias toward preferred brands of fast food restaurant, yoghurt and soft drink that accounted for more of the variance in product usage than explicit attitudes (e.g. frequency of consumption, reported liking and preference) alone.

Recently, implicit and explicit processes of reward and their involvement in the regulation of feeding behaviour have been examined in more detail. Through the examination of specific neural substrates in the brain, Berridge and colleagues argue that distinct processes of affective ‘liking’ and motivational ‘wanting’ for food can influence behaviour without explicit awareness of their underlying cause i.e. changes in hedonic feelings (explicit liking) or the intent or desire to consume a specific food (explicit wanting) (Berridge & Robinson, 2003). To test the influence of implicit processes on measurable aspects of feeding behaviour, Winkielman et al. (2005) subliminally presented subjects with emotionally valenced picture stimuli (16 ms exposure to positive or negative facial expressions) which were subsequently masked with neutral faces (400 ms exposure). Interestingly, this implicit affective priming technique had no effect on the subject's explicit affect ratings recorded online, but interacted with thirst levels such that positive facial expressions increased the serving size and consumption of a beverage in thirsty subjects, while negative facial expressions inhibited drinking, relative to neutral primes.

In a recent review, Mela (2006) explored the liking/wanting distinction of food reward in human appetite and suggested that implicit measures of wanting (e.g. behavioural tasks, physiological correlates, etc.) are more valuable assays of obese/lean differences in food reward and food preferences than explicit hedonic responses. For example, Saelens & Epstein (1996) assessed the reinforcing value of food using a slot-machine-like progressive ratio computer task. In this paradigm, subjects' commitment to the task was rewarded with points that could be exchanged for palatable snacks or allotments of time that could be spent playing a fun computer game. The reinforcing value of the palatable food was calibrated as the willingness to work for amounts of the food relative to the time playing the game. In a study comparing obese and lean subjects, the authors found that subjective ratings of (explicit) liking for snack food items – including the most preferred item used in the progressive ratio task – did not differ; however, the obese subjects were found to work harder for food relative to playing the game, and this corresponded to the amount subsequently consumed. These findings may also demonstrate important differences in implicit and explicit processes as mediating variables in food consumption. Although explicit liking for foods as they are ingested may be involved in establishing their reinforcing value, it is possible for implicit processes (i.e. wanting) to play a more significant role in maintaining consumption (e.g. Robinson & Berridge, 1993) and could promote overconsumption in people at risk of weight gain.

To further examine the significance of dual liking and wanting components of food reward to appetite control, we previously reported the development of a novel computer-based procedure to allow the separate and concurrent assessments of liking and wanting for the same target stimuli while preventing cross-contamination of these measures (Finlayson et al. 2007). This was achieved by using an implicit 'forced choice' behavioural measure of wanting in addition to explicit subjective measures of liking and wanting for photographic food stimuli varying in fat content and taste. Over a series of randomised trials, the forced choice task required subjects to physically select one food from a pair of stimuli presented on 17" flat screen monitor (150×100 mm^2). Subsequently, the frequency of selections made in each of four distinct stimuli categories (high fat savoury, low fat savoury, high fat sweet and low fat sweet foods) provided an indication of the implicit wanting for that category relative to the other categories. However, in the validation of this procedure we observed some limitations to this operation of implicit wanting. For example, in certain cases, the subject may have no wanting for either stimulus in a pair trial and therefore each trial can reveal a preference, but it may not reflect greater wanting for one stimulus. Furthermore, it did not provide a measure of intensity of wanting. With this procedure it was not always possible to determine whether relative differences were caused by artefacts of a reduction in wanting for one stimulus or an increase in wanting for the other stimulus. Therefore, frequency of selection could not easily discern the difference between approach and avoidance.

The present study reports a key modification to our previous operation of implicit wanting to address the limitations outlined above. In line with other laboratories successful use of reaction time as an indicator of implicit processes (Greenwald et al. 1998), implicit wanting was operationalised as the reaction time of each pair trial decision. Thus, the speed with which one stimulus is chosen in preference to its alternative provides a quantifiable measure related to the wanting for that food item. This new output can convey information about the degree (on a continuous, scaled unit of measurement) to which the chosen stimuli is wanted relative to its alternative. Furthermore, mean reaction time for each food category can give an indication of whether motivation is generally increasing or decreasing independent of the other categories.

The aim of this study was to extend our previous investigation into the effect of manipulating hunger state – by meal-induced satiation – on implicit and explicit processes of liking and wanting. By measuring liking and wanting for a range of food stimuli in hungry and satiated states, changes in these processes were assessed and compared.

Methods

Subjects

Subjects were recruited from the staff and student population of the University of Leeds using posters, email and a database of previous study volunteers. 30 males and 40 females aged 18-45 years (mean = 21.8, ± 0.85) were included after an initial screening process to exclude those who were taking medication, actively losing weight, or reported a history of eating or psychological disorders. Subjects were familiarised with the study procedures, and told that they would be participating in a study to investigate mechanisms of human appetite, before giving their written consent. Of the 70 participants tested, data from 7 were not included in the final analysis because experimental procedures were not adhered to correctly. Data are presented for the remaining 63 subjects (25 male and 38 female) who completed all parts of the study. Based on reported height and weight, subjects' BMI ranged from underweight to obese (mean = 22.2 kg/m^2, ± 0.51; range = 14.8-39.6 kg/m^2). All subjects were instructed about the procedures before giving their written consent.

Measures

Explicit subjective sensations

Subjective appetite sensations and hedonic ratings of explicit liking and wanting were recorded throughout the test day using 100mm visual analogue scales (VAS) anchored at each end with the statements "extremely" and "not at all". Subjects were required to rate their subjective sensations on three scales combined with the questions: How hungry do you feel now?; How full do you feel now?; and How much food could you eat now? Two scales corresponding to the explicit measures used in the liking &

wanting computer task (see below) were used to assess the test meal after an initial taste, and again when the subject had eaten to fullness.

Test meal

The meal consisted of a commercial brand of cheese and tomato pizza (Goodfella's Delicia Margherita; Green Isle foods Ltd., UK) and water, supplied ad libitum. Other than its palatable and distinct sensory properties, no particular criteria were applied to the selection of this meal since the manipulation was designed primarily to facilitate the transition from a hungry to a satiated state. Energy intake was calculated by weighing the food before and after consumption (to the nearest 0.1g) and with reference to the manufacturer's energy values (see table 1).

Liking & wanting computer task

The original liking & wanting task (Finlayson et al. 2007) comprised two programs designed to assess explicit liking and wanting, followed immediately by implicit wanting for the same target stimuli. Subsequently, an important development to this procedure was to integrate the separate task elements in order to fully randomise explicit and implicit trials. Experiment generator software (E-prime v1.1.4) was used to integrate the single stimulus trials for the liking task with the paired stimuli trials for the wanting task. The integrated software was also programmed to centre the cursor between each trial to produce more consistent response times, and different question prompts were presented in contrasting colours to encourage discrimination.

Food stimuli presented in the task were selected based on two key dimensions associated with loss of appetite control and overconsumption: the fat content and taste properties of foods. Stimuli were presented on a 17” flat screen monitor and measured 150×100 mm^2. The food items were selected from a database of photographic stimuli and sorted according to their fat content and taste properties into one of four separate categories: high fat savoury (HFSA); low fat savoury (LFSA); high fat sweet (HFSW); and low fat sweet (LFSW). Each category was represented by five different foods; hence a total of 20 different food stimuli were presented in the procedure.

Explicit liking and wanting trials

The aim of the explicit task was to obtain an introspective hedonic measure for the same stimuli used in the implicit wanting task. Therefore, each food stimulus was assessed independently using VAS. The explicit computer task trials consisted of twenty food stimuli presented one at a time and rated according to a 100-mm VAS anchored at each end by the statements “not at all” and “extremely”. Subjects were prompted with the statements “How pleasant would it be to experience a mouthful of this food now?” and “How much do you want some of this food now?”. The VAS was presented on-screen beneath each food stimulus and subjects used the mouse to move a centred cursor along the line to indicate their response. When a rating was made, the program automatically cycled to the next stimulus trial. Responses on the software were recorded online and mean ratings for each food category (HFSA, LFSA, etc.) were automatically computed.

Implicit wanting trials

Implicit wanting was measured by a behavioural ‘forced choice’ methodology. In this task, a food stimulus from one of the four food categories was paired with one stimulus from the remaining categories to form a series of 150 trials in which the subjects were given the standardised instruction to select the food they 'most want to eat now'. In addition to recording the frequency of selections made in each category (with a possible range of 0-75) which may reveal a preference, reaction time (in ms) of each choice was also measured. By recording reaction time subjects remained unaware of implicit changes in their behaviour on the task, while remaining free to determine the direction of their choices. In this measure, the motivated behavioural response independent of the explicit awareness of its incentive value was the key variable. Data from the forced choice task – including frequency of category choice and reaction time of choice – were recorded online for later calculation of the means.

Procedure

The study conformed to a simple repeated measures design, with explicit and implicit measures for each food category compared immediately before and after the test meal intervention. Subjects attended the research unit for one lunchtime visit commencing at approximately 12.30 pm, having not consumed any food for at least 3 hours. Upon arrival, subjects were made comfortable in an experimental cubicle and asked to verify when they last ate and complete some general health, mood and demographic questions presented on the computer. The liking & wanting task was then completed. Subjects were navigated through the procedure at all times by written instructions presented on-screen. After the pre-meal measures were completed (in a hungry state), subjects completed the subjective state VAS before receiving the ad libitum meal. All subjects were given the instruction to eat until they were "comfortably full" to ensure that the measures were carried out in two quite different states: a state of strong hunger then a state of satiety. Subjects rated the pleasantness of the meal using VAS presented in the computer task; initially immediately after the first mouthful and again when they had finished eating. The post-meal task immediately followed consumption of the meal (sated state), after which more subjective state measures were taken. Subjects received written and verbal debriefing before leaving the unit.

Data analyses

Data were analysed using SPSS 14.0 for Windows. Data from the liking & wanting task collected using E-Prime (v.1.1.4.4.) were exported to MS Excel via E-DataAid. MS Excel was used to calculate the variables for export to SPSS. Satiety was treated as a within subjects factor with two levels (pre-meal/hungry state – post-meal/satiated state). Subjective sensation VAS were analysed by paired samples t-test. Data from the liking & wanting task were analysed by 2*2*4 repeated measures ANOVA with satiety (hungry, satiated), task (liking, wanting) and food stimuli category (HFSA, LFSA, HFSW, LFSW) as factors.

Results

Subjective sensations and test meal intervention

Males consumed on average 1439.2 kcal (± 80.3) compared to 942.4 kcal (± 45.9) in females [$t(61) = 5.76$, $p<0.01$]. As anticipated, the test meal caused a significant decrease in hunger (mean ± SEM: -72.3 ± 2.2mm) and prospective consumption (-64.8 ± 2.2mm) and an increase in fullness (70.5 ± 2.6mm) [$t(62) = 33.2$, $p<0.01$; $t(62) = -27.3$, $p<0.01$; and $t(62) = 29.9$, $p<0.01$ respectively]. Hedonic ratings of the test meal at the first mouthful and at the end of the meal revealed significant reductions in explicit liking (-59.1 ± 3.1mm) [$t(62) = 19.22$, $p<0.01$] and explicit wanting (-73.7 ± 2.4mm) [t(62) = 31.21, p<0.01]. Explicit ratings of liking and wanting were significantly correlated at both time points [t1: r(63) = 0.60, p<0.01; t2: r(63) = 0.40, p<0.01] and the magnitude of change in these variables was correlated [t1-t2: r(63) = 0.38, p<0.01].

Liking & wanting computer task

Data from the computer task were used to calculate mean ratings of explicit liking, explicit wanting, choice reaction time (implicit wanting), and frequency of choice for each food category (shown in table 2).

Explicit liking

As shown in table 2, ratings of explicit liking declined for all food categories over time [F(1,62) = 179.27, p<0.01]. A time*category interaction was also apparent [F(3,186) = 48.43, p<0.01] with a greater reduction in liking for savoury stimuli relative to sweet stimuli.

Explicit wanting

Ratings of explicit wanting were very similar to the liking data. Hence, main effects of time [F(1,62) = 188.11, p<0.01] and time*category [F(3,186) = 51.93, p<0.01] were observed. Mean scores for explicit wanting were highly correlated to explicit liking in terms of change across the meal (see table 3).

Implicit wanting (choice reaction time)

Mean choice RT decreased (became faster) in all food categories. However, the decrease in RT for savoury foods was smaller compared to the decrease in RT for sweet foods. There was a main effect of time [F(1,62) = 21.09, p<0.01] and a time*category interaction [F(3,186) = 16.53, p<0.01]; suggesting that sweet foods were being selected faster than savoury foods following the meal.

Frequency of choice

The mean frequency of choice in each category indicated that choices in the savoury categories were decreasing with a corresponding increase in choices for sweet foods. There also appeared to be a slight decrease in choices for high fat category foods after the meal relative to a small increase in choices for low fat foods.

Comparison of liking & wanting task outputs (mean Δ)

Mean change in each output of the computer task was calculated by subtracting scores at time 1 from scores at time 2. Using these delta scores, the software outputs were correlated for each food category (see table 3). For the sweet categories, it was observed that the explicit measures correlated positively [r(63) = 0.50-0.92, p<0.01] and in turn were correlated with frequency of choice [r(63) = 0.40-0.56, p<0.01]. Implicit wanting was inversely correlated with the frequency of choice [r(63) = -0.31, p<0.05] indicating that a faster response time was associated with an increase in the number of times those categories were selected. A more complex relationship emerged from outputs for the savoury categories. For the HFSA category, explicit liking correlated with explicit wanting [r(63) = 0.83, p<0.01] and explicit wanting correlated with frequency of choice [r(63) = 0.27, p<0.05]. However, implicit wanting did not correlate with any other output. The relationship between outputs for the LFSA category was similar to HFSA in that explicit liking correlated with explicit wanting [r(63) = 0.86,

$p<0.01$] and explicit wanting correlated with frequency of choice [$r(63) = 0.32$, $p<0.05$]. In this category however, explicit liking also correlated with frequency of choice [$r(63) = -0.33$, $p<0.01$].

The differences between outputs of the computer task are summarised in figure 1. Ratings of explicit liking and wanting decreased for savoury categories relative to sweet after the meal. Frequency of choice decreased for savoury categories and increased for sweet, and implicit wanting increased (became faster) for sweet categories relative to savoury.

Discussion

The aim of this study was to manipulate hunger state to examine its effect on explicit and implicit processes of liking and wanting measured using a novel computer task. In addition to causing a considerable reduction in hunger and increase in fullness, the test meal manipulation was likely to have induced specific satiety (e.g. Rolls et al. 1986) or habituation (e.g. Epstein et al. 1991) to its sensory properties as a function of unvaried, uniform sensory composition. Indeed, satiety induced by eating the savoury test meal caused explicit ratings of liking and wanting to decrease in all food categories; but with a more marked decrease for savoury foods compared with sweet foods. Implicit wanting was increased for sweet categories, but not for savoury categories as demonstrated by a decrease in choice RT for sweet stimuli. Frequency of choice decreased in savoury and increased in sweet categories.

Mean change in explicit liking and wanting were highly correlated for all categories of food stimuli. One interpretation is that explicit liking and wanting were affected similarly by the test meal manipulation. However, introspective ratings are vulnerable to cross-contamination where distinct sets of underlying processes may be interpreted as a single – more general – variable which is only subsequently partitioned cognitively into the required domains (Booth, 1987). Therefore it is also possible that the subjective reporting of explicit processes may have been derived from a single evaluatory process, or that subjects found it difficult to make this distinction explicitly. This uncertainty makes the interpretation of multiple explicit measures of subjective sensations problematic. The inclusion of an implicit, instrumental measure in the liking & wanting computer task to assess the same food stimuli was therefore an important development to prevent cross-contamination issues in the measurement of underlying processes.

Mean change in the frequency of choice was found to correlate with explicit wanting for all food categories, and with explicit liking for sweet categories. Frequency of choice was also negatively associated with implicit wanting for all categories except HFSA. It is interesting that frequency of choice was largely associated with both explicit and implicit measures, but that no direct relationship existed between implicit wanting and explicit liking or wanting. This outcome may suggest that the explicit measures were tapping a different process to implicit wanting, but – importantly – frequency of choice (for sweet categories of food) shared elements of both these distinct processes (for example see figure 2).

Implicit wanting did not correlate with any of the explicit ratings, but was negatively correlated to frequency of choice. This suggests that when a category was selected more frequently, it was also chosen more rapidly, but independent to any change in subjective evaluation of the stimuli. These preliminary findings provide support for the conceptualisation of preference (seen here as a behavioural outcome) as containing implicit and explicit elements of liking and wanting.

In the present study, explicit liking and wanting for an array of food stimuli decreased following ad libitum consumption of a savoury test meal. This effect was observed regardless of the sensory or macronutrient properties of the stimuli, and would suggest that the foods became less pleasurable as a consequence of them becoming less useful (i.e. the presence of an alliesthesia-like effect; Cabanac, 1989). These data also contribute to the literature documenting sensory specific satiety (e.g. Rolls, 1999). The test meal had savoury and fatty taste properties and prolonged exposure to these gustatory elements can be linked to greater decrease in liking for savoury stimuli relative to sweet. Interestingly, the test meal produced a cross-modal effect on subjective liking, as none of the food stimuli were tasted and the test meal food did not feature as one of the 20 food stimuli presented in the L&W computer task. Therefore, exposure to the specific properties of a given food is not required to observe a sensory specific decrease in liking for that food.

The implicit wanting output of the liking & wanting computer task revealed faster reaction times for sweet foods following the test meal, whereas for savoury foods, no significant change was observed. Using reaction time as an index of wanting for a category of food stimuli relative to its alternatives, these findings suggest that sweet foods (and not savoury foods) were wanted more following the test meal. In other words, subjects responded faster to stimuli with novel taste properties but no change in response occurred for stimuli with the same generic taste properties. These data may reveal more about the sensory specific satiety phenomenon and its role in appetite. It is thought that novel stimuli can delay the development of sensory specific satiety causing food to elicit more pleasure and therefore be consumed for longer (Hetherington et al. 2006). An alternative mechanism for this effect is (dis)habituation caused by exposure to salient and discriminable stimuli that can reinstate both responding and hedonic evaluation of a food that has become monotonous (Epstein et al. 1991; Temple et al. 2006). However, neither of these explanations can sufficiently account for the reaction time outcome in the present study. Rather, it is possible that during food consumption, two processes were in operation. The first component reflected the pleasure elicited by the test meal which declined after the subject habituated to its stimulatory properties. The second component tracked the motivational significance of contrasting (discriminable) stimuli which increased after the pleasure of the given stimulus had declined. This demonstrates that implicit wanting can be dissociated from explicit liking and wanting, and that implicit and explicit processes appear to have separate intervening roles in the expression of food preference.

Implications for appetite control

The explicit measurement of liking and wanting are subject to cross-contamination, however this confound can be circumvented by measuring one – and ideally both – processes implicitly. The dissociation between implicit wanting and explicit liking and wanting demonstrated in the present study suggests that two (at least partially) independent processes were being measured. By measuring changes in implicit wanting and explicit liking associated with the consumption of a test meal, an interesting difference in the relationship between these processes with hunger was apparent. Adjustments in hunger were linked to changes in explicit liking and wanting in a manner consistent with alliesthesia and/or sensory specific satiety, while a relationship between hunger and implicit wanting was absent. This may seem counterintuitive since it may be supposed that hunger and wanting could share a common motivating capacity. However, we have demonstrated that implicit wanting can be unaltered or even enhanced for specific foods while hunger and explicit liking and wanting are observed to decrease. Thus it is suggested that implicit wanting is not systematically downregulated by the physiological consequences of food consumption in the same way as hunger and therefore implicit wanting may be largely independent of homeostatic processes influencing intake. Because of this, implicit wanting could be considered as an independent risk factor for overconsumption – one that is not normally tapped into by the usual methodologies used to study appetite control. Certainly, it can be expected that processes of wanting would act in concert with liking and with hunger to contribute to consumption above physiological need. For example, recent research is exploring the concept of "hedonic hunger" as a mediating state between perceived deprivation of pleasure and non-homeostatic consumption (Lowe & Levine, 2005; Markowitz et al.[1]). Therefore implicit wanting may be viewed as a more free-running process to explicit liking and wanting, consistent with a neuro-chemical substrate that is insensitive to homeostatic changes in appetite while reactive to environmental triggers.

Conclusion

This study provides support that implicit and explicit processes of food reward can be simultaneously measured and dissociated using a test meal. The study engineered the opportunity to observe an uncoupling in implicit and explicit processes by observing them across a meal. Explicit liking and wanting were found to decrease for all food stimuli, and more so for foods with similar taste properties to the food consumed. Implicit wanting was found to increase for food stimuli with novel taste properties. These data indicate that the refined liking & wanting computer task has tapped two separate psychological processes that contribute independently to food preference, with implications for appetite control.

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