EMOTIONAL RESPONSES (VERBAL AND PSYCHO-PHYSIOLOGICAL) TO PICTURES OF FOOD STIMULI

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Abstract: Emotional processing of food-related pictures was studied in four experiments, comparing participants who revealed unhealthy attitudes toward food, dieting and body shape with control groups. All subjects were female and responses to pictures of low and of high calorie foods were compared to responses to other emotional stimuli. The first three experiments measured verbal and autonomic responses and Experiment 4 was a classical conditioning study. In Experiments 2-4, pictures were presented backward masked in order to observe automatic, non-conscious responses. The results showed that, in general, food pictures were processed in the same way as other emotional material, both verbally and psychophysiologically. Although there were some results indicating a difference between groups, the general pattern was that participants selected for being more worried about food and dieting did not show higher reactivity to food cues.

Keywords: food stimuli, psychophysiology, emotions, skin conductance

Respostas emocionais (verbais e psicofisiológicas) perante imagens de estímulos alimentares (resumo): O processamento emocional de imagens com estímulos alimentares foi estudado em quatro experiências, comparando participantes que revelaram ter atitudes pouco saudáveis face à alimentação, dieta e forma do corpo, com grupos de controlo. Todos os participantes eram do sexo feminino e as respostas a imagens de alimentos de baixo e elevado teor calórico foram comparadas

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às respostas a outros estímulos emocionais. Nas primeiras três experiências foram medidas as respostas verbais e autonómicas; a Experiência 4 foi um estudo de condicionamento clássico. Nas experiências 2-4 foi usado um procedimento *backward masking* de apresentação de imagens com o intuito de observar respostas automáticas, não-conscientes. Os resultados mostraram, no geral, que as imagens de alimentos foram processadas de modo semelhante a outro material emocional, a nível verbal e fisiológico. Embora alguns resultados indicassem diferenças entre grupos, o padrão geral foi o de que as participantes com maiores preocupações com a alimentação e dieta mostraram maior reactividade a estímulos alimentares.

Palavras-chave: Estímulos alimentares, psicofisiologia, emoções, condutância dérmica da pele

One strategy used to investigate emotional phenomena is to induce emotions in controlled settings and measure the modifications caused by that manipulation. Since the classic *Velten Mood Induction Procedure* (Lopes & Garcia-Marques, 2003; Velten, 1968), in which participants were asked to read emotionally coloured statements to induce a particular mood (*e.g.*, happy or sad), several methods have been used. Some are straightforward, other are more sophisticated, such as asking participants to make different facial expressions (*e.g.*, Laird & Strout, 2007), using hypnosis (*e.g.*, Bower, 1981; Maccallum, McConkey, Bryant, & Barnier, 2000), or exposure to different kinds of emotional material, such as films (Arriaga & Almeida, 2000; Rottenberg, Ray, & Gross, 2007), odours (Villemure, Slotnick, & Bushnell, 2003), music (Arriaga, Franco, & Campos, 2010; Koelsch, Fritz, Von Cramon, Muller, & Friederici, 2006), or pictures (Bradley & Lang, 2007; Bradley, Cuthbert, & Lang, 1991).

Probably because it is easy to implement and because it allows a good control of the independent variables, the use of pictures, presented either on a wall screen or on the computer monitor, is the most used method for studying emotional reactions. Pictures are used that are either usually emotionally arousing to most adult human beings (*e.g.*, nudes, mutilated bodies) or that have some kind of relevance to the participant (*e.g.*, a picture of a snake presented to a person with snake phobia). Another method that has been used is the induction of affective relevance by means of classical conditioning. Presenting an emotionally neutral picture together with an aversive unconditioned stimulus in order to get a laboratory-analogue fear response is a strategy that has been used with success in the study of fears and phobic reactions (Öhman, 1986, 2000).

One central issue in the study of induced fears in the laboratory is the distinction between stimuli with phylogenetic relevance (for example, animals that were dangerous to our ancestors, like reptiles) and those that are associated with fear in our society, like guns. Thirty years of classic conditioning experiments conducted by Öhman and colleagues (see Öhman, 2000, for a review) and by other research groups (*e.g.*, Schell, Dawson, & Marinkovic, 1991) have supported the existence of an evolutionary basis for fear learning and for the activation of defensive fear responses. Using pictures of small animals like snakes and spiders as fear-relevant stimuli and flowers and mushrooms as fear-irrelevant stimuli, participants were conditioned to either a fear-relevant or a fear-irrelevant picture. Although other dependent variables were used in some experiments (*e.g.*, heart rate changes), in most studies skin conductance responses (SCRs) were measured. The general pattern of results showed that, after a conditioning procedure in which an aversive unconditioned stimulus was paired with one picture, having another picture as the control stimulus, the difficulty of extinguishing the conditioned response was enhanced when the conditioned stimulus was a fear-relevant picture (Hugdahl & Öhman, 1977; Öhman, Fredrikson, & Hugdahl, 1978). A similar result has been observed using pictures of faces showing different emotional expressions. Extinction of a conditioned response was more difficult when an angry expression was used as the conditioned stimulus than when, for example, a happy face was used (Dimberg, 1987; Öhman & Dimberg, 1978). On the other hand, when ontogenetically fear-relevant stimuli (*e.g.*, electrical outlets, guns) were used as the conditioned stimulus, the pattern of resistance to extinction was reduced (Cook, Hodes, & Lang, 1986; Hugdahl & Kãrker, 1981).

Food stimuli can also be interesting for at least two important reasons. First, as stimuli that have existed in human life since the very beginning, they have a clear phylogenetic relevance. Second, the clinical relevance of eating disorders is reflected in the growth of this research field (Preti *et al.,* 2009), especially because it is associated with increased mortality (*e.g.*, Crow *et al.,* 2009). It is relevant, both from an evolutionary theoretical point of view and from a clinical perspective, to investigate people's reactions to food stimuli and to understand the mechanisms of information processing of food cues. In fact, from the classic Pavlovian experiment to the taste aversion studies conducted by Garcia and co-workers (see Garcia, 1989, for a review), food has been used to elicit bodily responses and to study learning processes. A distinction should, however, be made between "real food", with the important taste and smell components, and pictures of food, like the ones used in the series of experiments to be described below. Considering the phylogenetic/ontogenetic distinction, the sight of a running wild boar was certainly a relevant food stimulus to our ancestors, eliciting not only action readiness that characterizes emotions (Frijda, 1986), but also, if possible, real hunting behaviour. With the exception of some existing hunting people, the association between a picture of a running wild boar and food has, however, become less evident. Nowadays, to most young people over the world (with the exception of some Obelix fans), the picture of the McDonald's symbol would most probably be a more relevant food cue (Gillen, 1998). Thus, despite the evolutionary relevance of food stimuli, the learning history of each individual, within a cultural and social context, makes the presentation of food-related pictures more similar to ontogenetic-relevant stimuli.

Eating disorders have become an important concern in our society, both with regard to theoretical issues like aetiology and to the development of clinical intervention methods (see Striegel-Moore & Smolak, 2001; Treasure, van Furth, & Schmidt, 2003, for reviews). In recent years there has been an increased interest in cognitive aspects, and some cognitive models of anorexia nervosa and bulimia nervosa have been proposed (*e.g*., Greben & Kaplan, 1995; Spangler, 2002; see also Treasure, *et al.,* 2003). In general, these models emphasized the importance of information processing mechanisms, for example, the way attention is drawn to specific stimuli. It could be suggested that, in a similar way to what has been observed in different anxiety disorders (see Williams, Watts, MacLeod, & Mathews, 1997, for a review), selective attention toward stimuli relevant to the patients' concerns could be a factor contributing to the maintenance of different eating problems.

Using the modified Stroop colour naming task, Cooper and Fairburn (1992) found that selective attention to information related to eating, weight, and shape occurred in anorexia and bulimic patients. Perpiñá, Leonard, Treasure, Bond, and Baños (1998) also found that patients with eating disorders were slower than controls in the colour-naming task with food words, and that this effect was larger with anorectic patients. Furthermore, this interference pattern was also found in participants without clinical diagnosis, but with a history of dieting and other disorder-related behaviours (Cooper & Fairburn, 1992). Perpiñá, Hemsley, Treasure, and Desilva (1993) also identified attentional biases in non-clinical restrained eaters who presented strong concerns about their thinness.

The study of emotional reactions to food-related stimuli increases our understanding of the underlying mechanisms of these psychopathologies. The present series of studies was designed to investigate emotional responses (both psychological, through self-reported measures, and psychophysiological) to visually presented food stimuli. Furthermore, special emphasis was placed on automatic reactions: While Experiment 1 exposed pictures for four seconds, Experiments 2, 3 and 4 used backward masked stimuli, presented beyond participants' consciousness. Experiments 2 and 3 analyzed autonomic responses and cognitive appraisal, and Experiment 4 was a classical conditioning study with food slides as conditioned stimuli. As eating disorders are much more frequently diagnosed among women (about 90 % of the patients are female, Smolak & Muenen, 2001), only female subjects participated in the studies. Although no clinical sample was used, subjects were selected on the basis of a self-report questionnaire about eating attitudes, in order to compare participants worried about eating and dieting with participants without any sign of these problems.

Experiment 1

The aim of the first study was to investigate the way subjects automatically responded to pictures of food, by measuring skin conductance responses (SCRs). Thus a group of female participants who showed worries with food and eating behaviour was compared with a control group. SCRs were recorded throughout the presentation of the pictures. After exposure to each slide, participants had to rate their affective response (i.e., pleasure--displeasure).

Method

Participants. From a sample of 198 female university students, a group of thirty-one volunteers (M_{age} = 20.1) were selected by means of the *Eating Attitudes Test* (Garner & Garfinkel, 1979): Fifteen had higher scores indicating a worried attitude toward food and eating habits, and the sixteen with lower scores were selected to be a control group because they reported a carefree attitude toward food and eating.

Measures. The Eating Attitudes Test (*EAT*; Garner & Garfinkel, 1979; Portuguese translation by Santos, Cruz, Costa, & Baptista, 1998) was used to select the participants. EAT is a self-rating scale with 40 items (*e.g*., “I eat diet food”, “I feel guilty after eating”), developed to assess symptoms associated with *Anorexia Nervosa*. Participants had to rate the frequency with which each item applied to them on a 6-point rating scale, ranging from 1 (“never”) to 6 (“always”).

The *Body Shape Questionnaire* (BSQ; Cooper, Taylor, Cooper, & Fairburn, 1987; Portuguese translation by Santos, Cruz, Costa & Baptista, 1997) was also applied. It is a self-rating scale with 34 questions about how the individual has felt about her own body during the past month (*e.g*., “Have you been ashamed of your body?”; “Do you avoid running because you are afraid your body will shake?”). The answers are given on a 6-point frequency rating scale, ranging from 1 (“never”) to 6 (“always”).

Skin conductance responses (SCRs) were measured through silver/silver-chloride electrodes, 6 mm diameter, filled with NaCl electrode paste. A Biopac hardware (MP100 TEL) and software system (Acknowledge) was used to continuously record SCRs.

The pictures were 34 slides chosen from the *International Affective Picture System* (*IAPS*; Lang, Bradley, & Cuthbert, 1997), distributed across six categories: high calorie food, low calorie food, nudes, sports, neutral, and unpleasant pictures. The slides were projected with a Kodak EktaPro 9020 slide projector from outside the experimental chamber onto a milk-glass screen window.

Affective valence of the slides was rated using the *Self Assessment Manikin* (*SAM*; Bradley & Lang, 1994). SAM, a pictorial rating scale, measures three dimensions: valence, arousal, and dominance. Only the valence scale was used in the present experiment. This scale is composed of five pictures, each depicting a human figure, that define a 9-point scale, ranging from very happy and smiling, to sad and negative.

Procedure. In a pre-experimental phase, first-year university students filled in the EAT questionnaire. Once informed about the confidentiality of the data, students were encouraged to leave their telephone numbers in order to participate in a psychophysiology experiment. Only participants with either high or low values in the EAT were selected. Each participant was tested individually. After arrival at the psychology laboratory, each participant was seated on a chair and skin conductance electrodes were fastened with Velcro-straps to the palmar side of the second phalanx of the first and second fingers of the participant's non-dominant hand (Dawson, Schell, & Filion, 2000). Participants were informed that they were going to see a series of slides presented on a screen 1 meter from them. Each slide was exposed for four seconds, and after the presentation they were asked to rate their affective valence by using the SAM scale, that is, rate how they felt after exposure to each image by selecting the SAM figure that best matched their feelings or putting an X between two mannequins, making it a 9-point scale. After the exposure to the slide series, participants were asked to fill in the BSQ and their participation was acknowledged.

Data scoring. Phasic SCRs were scores as the maximal deflection, starting in the interval between 1 and 4 seconds after picture onset. The minimal response criterion was .1 microsiemens. Both amplitude and frequency (number of responses within each category) were analyzed.

Results

The results of the BSQ showed a general high correlation with the EAT data (r= .87). Two subgroups within the High EAT-group could, however, be differentiated: one with high scores on the BSQ and another with low scores. Data analyses were therefore done comparing three groups: a group with high scores on both the EAT and the BSQ (*n*=8), a group with high EATs but low BSQ (*n*=7), and a group with low scores on both scales (*n*=16).

Skin conductance responses. To correct for the general individual variation observed, a range correction transformation was done by dividing each response by the largest response of the participant (Lykken & Venables, 1971). Range and frequency were analyzed separately. Analyses of Variance (ANOVAs) were run, with Group (high EAT/BSQ, high-EAT/lowBSQ, and low EAT/BSQ) as a between-participants variable, and Picture Category (high calorie food, low calorie food, nudes, sports, neutral and unpleasant pictures) as a repeated measure. The 3x6 ANOVA on SCRs amplitude showed a main effect of Category, F (5, 140) = 5.87, p<.001, but no reliable effect of Group and no interaction effect were found. A post-hoc Tukey HSD test indicated that SCRs to low calorie food were not significantly different from responses to high calorie food, but significantly smaller than SCRs to the other four categories. The difference between high calorie food and negative pictures was also significant (see Figure 1, left panel). As we were interested in the comparison between the three groups on reactions to the food slides, a 2x3 ANOVA was performed with Food slides (high calorie and low calorie) as repeated measures and Group as a between--subjects factor. There was a main effect of Category, F(1, 28) = 4.23, p<.05, corresponding to smaller responses to low calorie food compared with high calorie food, and a marginally reliable difference between groups, F(2, 28) = 3.07, p=.06. Participants in the group with high scores on both the EAT and the BSQ showed a tendency to larger SCRs to food slides than the other two groups. The comparison between the groups on reactions to the other slides did not show significant differences.

Frequency data were analyzed in the same way. The 3x6 ANOVA again showed a reliable main effect of Category, F(5, 140) = 2.75, p<.05, with responses to low calorie food being less frequent compared with negative pictures and bodies. The separate analysis of food stimuli, similar to the one carried out with amplitude data, showed no significant effects.

Affective valence. SAM ratings on the affective valence of the different images were also analyzed by a 3x6 ANOVA. As expected, there was a clear main effect of Category, F(5, 140) = 70.10, p<.001. A Tukey post-hoc test showed that almost all categories differed statistically from one another. The only exceptions were the high calorie food slides being rated equal to sport and neutral pictures, and naked bodies to neutral pictures (see Figure 1, right panel).

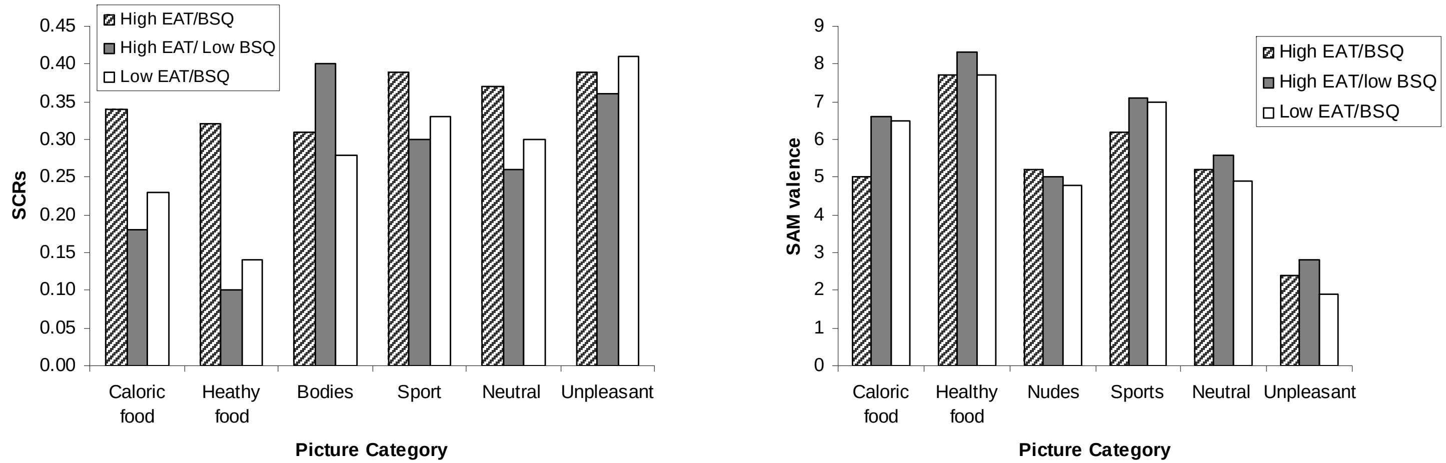

Figure 1. Skin Conductance Responses (left panel) and valence ratings (right panel) as a function of group and picture category (Experiment 1).

Discussion

Although the effects were not statistically significant, a tendency was observed for a difference between the group with high scores on both the EAT and the BSQ and the other two groups. The group that reported more worries about food, dieting and body shape on the self-evaluation scales had a tendency to show larger skin conductance responses to food pictures than the other two groups as well as to rate food slides as less positive than the other participants.

In this experiment participants were aware of the stimuli, and although SCRs reflect an immediate emotional response, it is a reaction mediated by a conscious appraisal of the stimuli and by expectancies within a specific “artificial” context. Thus, if more automatic responses are to be studied, a subliminal presentation (under the threshold for conscious awareness) should be used.

Within information processing research, a distinction is usually made between two modes of processing. One is automatic, involuntary, and pre-attentive, and the other is voluntarily-controlled and accessible to consciousness (Shiffrin & Schneider, 1977). Although there are several studies about cognitive biases in eating disorders (*e.g.*, Cooper, Anastasiades, & Fairburn, 1992), almost all use methods that allow a conscious perception of the stimuli used. Exceptions are the studies done by Waller and collaborators that investigated processing of threat cues presented subliminally. Using a measure of the amount eaten after exposure, they found that non-clinical women with unhealthy eating attitudes ate more after a subliminally presented threat (Waller & Mijatovich, 1998). This result was replicated by Meyer and Waller (1999), who showed that an anger cue elicited a greater amount to be eaten than in a neutral condition.

Using a backward masking procedure, Experiment 2 was designed to allow the study of autonomic responses to food stimuli presented outside of consciousness.

Experiment 2

To investigate the possibility of non-conscious activation of emotional reactions to food-related stimuli, Experiment 2 included a subliminal condition. In Experiment 2 the series of exposures of emotional stimuli could thus be separated into two parts. In the first part, using a backward masking procedure, participants were exposed to a very brief presentation of the emotional pictures masked with another, neutral, irrelevant picture. The mask prevented conscious awareness of the relevant target stimulus. The second part of the exposure series was a replication of Experiment 1, with a series of the same emotional pictures, but presented on a supraliminal level. As in Experiment 1, a pre-selection was done in order to compare women worried about food and dieting with a control group.

Method

Participants. Thirty female participants were selected from a sample of 165 volunteers according to the *Eating Attitudes Test* (EAT) and the *Body Shape Questionnaire* (BSQ) scores. Fifteen had high scores on both questionnaires, revealing worries about food, dieting, and body shape; the control group (n = 15) had low scores. Mean age of the participants was 23 years. Due to problems during the psychophysiological data collection, four participants had to be discarded from data analysis.

Material. Twenty four pictures from the same categories used in Experiment 1 were selected from the *International Affective Picture System (IAPS*). To mask these pictures in subliminal trials, eight pictures were processed to become abstract colour patterns. These pictures were tested previously in order to assure their masking effect. *Testes Cognitivos* (TEC, 1.4.1) software was used to control for the images presentation, the subliminal exposure, the time of exposure, and the inter-stimulus interval. Together with the affective valence, participants rated their excitement on the arousal scale of SAM.

Procedure. The general procedure was similar to Experiment 1. The main differences were the fact that participants had to look at a computer screen instead of the window used in Experiment 1, and that they had to rate each picture both on the affective valence and on the arousal scales of SAM. The exposure series was divided into two parts, one subliminal, in which the emotional pictures were presented for 20 ms, followed by a mask for four seconds; and one supraliminal, with the same pictures presented for four seconds without masks. After exposure to each picture, participants rated how they felt on SAM scales. Ratings were also collected during the subliminal part of the exposure series. Thus, without consciously perceiving the target pictures, participants rated the abstract masks, which were counterbalanced between different picture categories.

Results

Data scoring and individual range transformation was done as in Experiment 1. Amplitude of the SCRs was analyzed separately for the subliminal and the supraliminal data by means of 2x6 ANOVAs. Thus, the six categories (high calorie food, low calorie food, bodies, sports, neutral and negative pictures) were repeated measures, and the Group (high EAT/BSQ and low EAT/BSQ), was a between-participant factor.

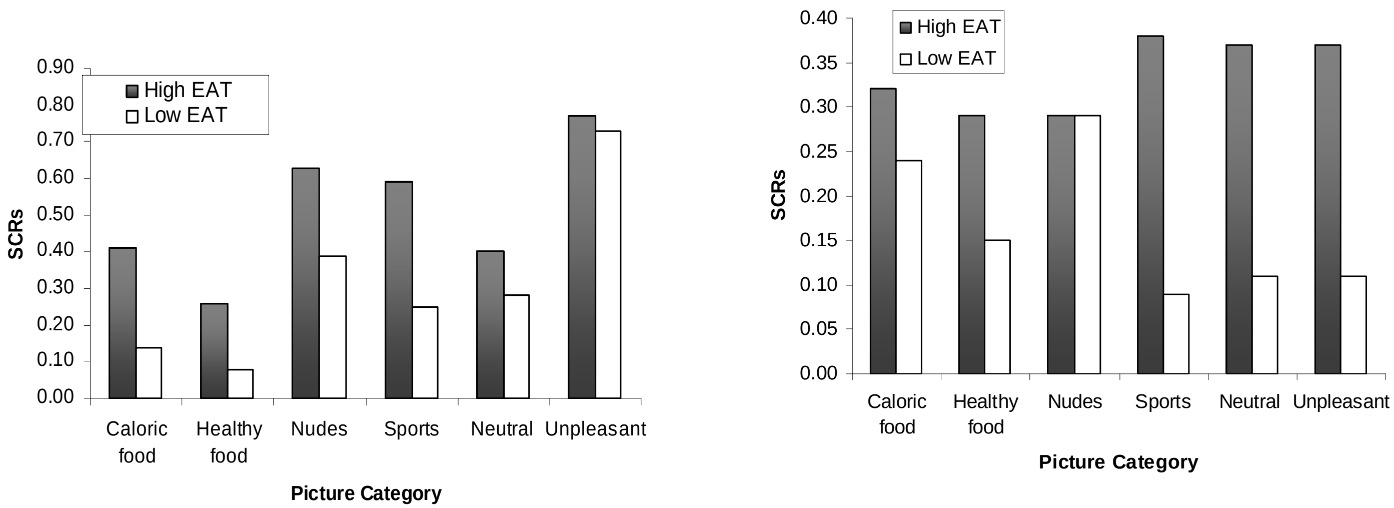

Figure 2. Skin Conductance Responses in supraliminal trials (left panel) and in subliminal trials (right panel) as a function of group and picture category (Experiment 2).

Skin conductance responses. The analysis of the supraliminal data showed that the group scoring high on worries with food and body shape had, in general, significantly larger SCRs than the control group, $F(1, 24) = 18.94$, $p<.001$. A reliable main effect of Category was also obtained, $F\ (5, 120) = 15.47$, $p<.001$, with negative pictures eliciting larger SCRs and low calorie food as the less arousing stimuli (see Figure 2, left panel).

Data from subliminal trials showed that the group scoring high on worries had a general pattern of significantly larger SCRs compared with the control group, $F\ (1, 24) =7.38$, $p<.05$; no statistically significant differences were, however, obtained for the different picture categories (see Figure 2, right panel).

Affective ratings. SAM-ratings data were analyzed separately for affective valence and arousal, both for the supraliminal trials and for the subliminal exposures. Again, 2x6 ANOVAs were run. It should be noted that in subliminal trials participants were only aware of the masking picture. Data analyses were, however, done with the category of the target pictures as a factor.

Affective valence ratings for the supraliminal pictures showed a pattern of results similar to those obtained in Experiment 1, with a main effect of Category, $F\ (5, 120) = 92.35$, $p<.001$, and a clear distinction between pleasant stimulus categories and negative pictures. Data from the subliminarily presented trials showed reliable main effects for both Group, $F\ (1, 24) = 7.85$, $p<.01$, and Category, $F\ (5, 120) = 2.75$, $p<.05$. In general, participants in the control group felt less pleasure when exposed to the masked pictures than the High EAT/BSQ group.

Arousal ratings of the supraliminal data also showed a Category main effect, $F\ (5, 120) = 41.35$, $p<.001$, but no reliable effect of Group. A post--hoc Tukey test showed that negative pictures were considered more arousing than all other categories, and the neutral ones were the least arousing (significantly different from the other categories, except from low calorie food) (see Figure 3). Arousal ratings of the subliminal trials showed a general pattern of low values ($M = 3.4$), with no significant differences across conditions.

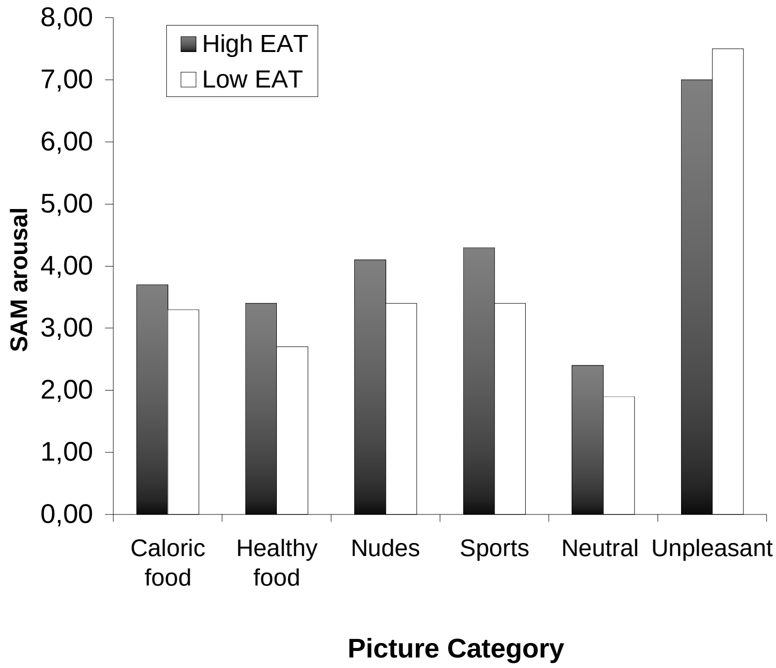

Figure 3. Arousal ratings in supraliminal trials as a function of group and picture category (Experiment 2).

Discussion

The skin conductance data showed a general difference between groups. Participants from the group worried about food and body shape had larger responses than the control group. Interestingly, this pattern (which could be due to a sensitization effect) was also observed during the first part of the experiment – the subliminal phase, when participants did not know to what kind of stimuli they were being exposed. On the other hand, the expected difference between groups in terms of reactions to food stimuli was not observed. That is, there was a general differentiation, with the control group showing smaller responses, but this effect was not specific to food pictures, as was observed in Experiment 1. One possible explanation could be that this group was more anxious than the control group.

The general absence of differences in SAM ratings to the subliminal exposure may be considered indirect evidence that participants were not aware of stimuli content. On the other hand, the supraliminal data replicated the affective ratings of Experiment 1, and the arousal ratings also showed a clear difference between stimuli categories.

To sum up, there was no evidence for a preferential processing of food stimuli in the group that revealed food and body shape worries. Skin conductance responses were, in general, larger in this group, but the effect was not specific to food stimuli. Verbal ratings also did not show this difference. In order to again test the emotional reactions to subliminally presented food cues, a third experiment was run with a larger sample.

Experiment 3

Experiment 3 was designed to replicate Experiment 2, with some improvements. The sample was increased, a self-rating scale on anxiety was introduced, heart rate was also monitored, and participants were tested with a behavioural task after exposure to the picture series. In fact, emotional reactions can be measured in three different response systems: verbal, psychophysiological, and behavioural (Lang, 1993). In Experiments 1 and 2 only psychophysiological and verbal responses were measured. In Experiment 3 a behavioural measure was introduced at the end of the experiment.

Method

Participants. Sixty female participants (M_{age} = 20.9 years) were selected from a sample of 417 university students who filled in the EAT-26 (Garner & Garfinkel, 1979). Sixty participants were selected (30 with high EAT-26 scores; the other 30 with low scores).

Material. In general, the instruments used were similar to those of Experiment 2. The *State-Trait Anxiety Inventory-State* (*STAI-S*; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was added. The STAI-S is a self-rating questionnaire that measures the state of anxiety at the present moment. Confronted with statements like “I am happy”, participants have to choose, from four levels, from “nothing” to “very much”, the one that best corresponds to how they feel at that moment. A shorter version of the EAT was also used (EAT-26), because it is easier to fill in and the correlation between the 40-item original and this version is very high (.98) (Garner & Garfinkel, 1979).

Twenty five images were selected from the IAPS (Lang, *et al.,* 1997), with five images from each of the following categories: high calorie food, low calorie food, sports/physical appearance, pleasant, and unpleasant images. Thus, compared with Experiments 1 and 2, neutral images were replaced by pleasant ones, and sport and body images were grouped together. We also chose clear body images when selecting the sport pictures.

Heart rate was also monitored during the exposure using the Biopac MP100 system. Disposable pre-gelled electrodes (41mm diameter) were used.

Procedure. The general procedure was similar to Experiment 2. ECG electrodes were fastened to both wrists and to the left ankle of the participant. After the exposure to the stimulus series, participants were left alone in the experimental room and were instructed to fill in the STAI-State questionnaire. A bowl with peanuts was left on the table, and participants were told they could take some if they wanted.

Results

The procedures for data analysis, scoring and data transformations were the same as those in Experiments 1 and 2. Heart rate was analyzed by comparing changes from baseline (before the images exposure) in the different conditions.

Psychophysiological data. Analysis of the supraliminal data showed, once again, a reliable main effect of Category, $F\ (4, 128) = 2.56$, $p<.05$. Nevertheless, a post-hoc Tukey test did not give any significant differences between the categories. Data from subliminal trials showed no significant effects, all $Fs < 1.9$, $p>.10$.

There were no significant changes in heart rate during the supraliminal trials. A 2x5 ANOVA on subliminal data also showed no significant effects. In order to analyze if there were, however, any differences in reactions to the specific food pictures, a 2x2 ANOVA was conducted, comparing food related pictures with other emotional images as a repeated measure, and Group as a between-subjects factor. A tendency for a significant interaction was observed, $F\ (1, 32) = 3.36$, $p=.076$, with participants in the high EAT group showing a higher score in heart rate to food pictures, while the control group did not show this pattern (see Figure 4).

Affective ratings. The analysis of subliminal data showed no significant effects on SAM ratings. As in the previous experiments, however, there was a clear difference between categories in valence ratings in supraliminal trials, $F\ (4, 248) = 284.78$, $p<.001$, and also for arousal, $F\ (4, 248) = 111.05$, $p<.001$. In general, unpleasant stimuli were considered more arousing and less pleasant than stimuli from the other categories.

Behavioural test. No reliable differences between groups were found for the amount of peanuts the participants ate after the exposure, $t\ (56) = .68$, $p=.50$.

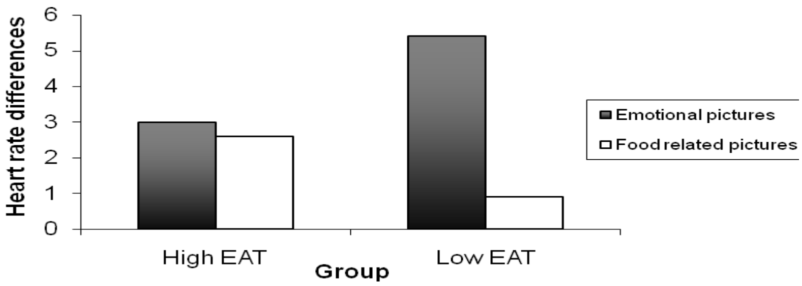

Figure 4. Heart rate differences from Baseline on subliminal trials, for emotional and food pictures, as a function of group (Experiment 3).

Discussion

In general, the results of Experiment 3 replicated the main effects of Experiments 1 and 2. No discrimination of verbal data in the subliminal condition indicated that participants were not aware of the target stimulus and that ratings of the mask pictures were not affected by the preceding targets. In fact, the significant effects observed in valence ratings in Experiment 2 were not replicated. On the other hand, ratings of emotions while pictures were presented subliminally indicated that participants clearly discriminated pleasant from unpleasant images, food stimuli being, in general, perceived as pleasant; nevertheless, no group effects were observed. Independently of group conditions, participants rated their emotions toward pictures in a rather expected way (Lang, Bradley, & Cuthbert, 1997).

The skin conductance data did not confirm a difference between groups in their responses to food-related pictures. The heart rate acceleration tendency during the subliminal exposure to food pictures was, however, an interesting result. Heart rate acceleration is considered a measure of a defensive reaction, usually observed in phobic patients when visualizing their feared stimuli (Globish, Hamm, Esteves, & Öhman, 1997). Thus, although the effects were not clear-cut, it seems that food pictures might have some preferred processing in people worried about food, dieting and body shape. One possible way to test this preferred processing is to use a classical conditioning trial, using food stimuli as the conditioned stimulus. This was the main aim of the last experiment.

Experiment 4

In 1970, Seligman suggested that evolution has prepared humans and other organisms to associate specific conditional stimuli with, for example, dangerous situations. This proposal, the "preparedness" hypothesis, has since been invoked to account for some characteristics of simple phobias (*e.g.*, Marks, 1977). Using a differential classical conditioning paradigm, Öhman and colleagues have conducted several series of experiments to test the preferred association between aversive unconditioned stimuli and different fear--relevant categories (see Öhman & Mineka, 2001, for a review). Several studies have also tested the possibility of unconscious activation of conditioned responses. For example, using a backward masking procedure to prevent the participant becoming aware of the pictures presented, this non-conscious activation of fear responses has been shown using small animals, like spiders and snakes (Öhman, 1986, 2000), and angry faces (Esteves, Dimberg, & Öhman, 1994). Furthermore, the possibility of unconscious associative learning, using a similar procedure, has also been tested, and the results showed that participants could learn fear responses to pictures of small animals (Öhman & Soares, 1998) and to angry facial expressions (Esteves, Parra, Dimberg, & Öhman, 1994) previously associated with an aversive contingency.

One major issue is, however, that these unconsciously learned responses were only observed with stimuli that had some kind of fear--relevance from a biological point of view (i.e., stimuli that our ancestors would have considered dangerous). That is, emotional stimuli that were relevant for the participant (or became relevant by means of classical conditioning), and that were important from a phylogenetic point of view. One interpretation of these results is that fear-relevant stimuli get some kind of preferred cognitive processing and automatically activate fear responses (Öhman & Mineka, 2001).

An extension of these studies is to test if it is possible to observe a similar pattern with food stimuli. More specifically, if participants who are worried about food and dieting will process food-related pictures in a similar way to which phobic individuals process phobic images (Öhman & Soares, 1994). It will be of great interest to analyze if it could be easier to associate pictures of food than a control picture with an aversive unconditioned stimulus. Experiment 4 seeks to investigate if conditioning to backward masked food pictures is possible, especially for participants anxious about food and dieting.

Method

Participants. Eighty university female students were randomly assigned to one of four groups. Half of the participants were conditioned to a food-related picture (*e.g.*, ice-cream), with a neutral picture (*e.g.*, a basket) as the control stimulus (CS-). The other half were conditioned to the neutral stimulus and a food image was used as the CS-. Within both conditions, one group had high scores on the EAT-26 and the other group had low scores.

Apparatus. Five different food pictures and four neutral ones, selected from the IAPS, were used as the conditioned stimulus (CS+) and/or the control stimulus (CS-). Each participant was only exposed to one pair of images, and each combination CS+/CS- was only used once within each group. Two masking pictures, selected from the ones presented before, were used.

The unconditioned stimulus (UCS) was an aversive broad band noise, presented in both ears through headphones. Skin conductance responses (SCRs) were recorded using the same method and apparatus as in Experiments 1-3.

Procedure. After entering the laboratory, participants were asked to sit down in an arm-chair. Electrodermal electrodes were applied, and headphones were put on. Participants were instructed to sit quietly during the experiment and to watch the images. They were informed that during the exposure to the picture series a noise would be presented via headphones several times.

The experiment consisted of three phases. A Habituation phase, with two presentations of the to-become CS+ and two presentations of the to-become CS-. These exposures were very brief (20 ms) and were masked by an abstract picture that was exposed during four seconds. After that, the Acquisition phase consisted of a series of 24 pictures, twelve presentations of the CS+, immediately followed by the white noise (UCS), and 12 exposures of the CS- (without UCS presentation). This phase was also masked, using the same stimuli and exposure time as in the Habituation phase. Finally, the Extinction phase, with sixteen trials, eight of each stimulus. During this phase no noise was delivered and CS+ and CS- were presented unmasked, for four seconds. From the participants' point of view, the three phases were not separated, although participants might have noticed that pictures in the beginning were abstract and without a specific theme, while in the last part of the series they could recognize a couple of objects.

Results

ANOVAs were conducted separately for the Habituation phase and for the Extinction phase. The habituation data analysis was conducted to verify whether there were any differences before conditioning. The extinction data analysis was done to analyse whether there were differences between groups in terms of resistance to extinction. ANOVAs were done with two between-subjects factors, the EAT category (high or low) and the CS+ (food or neutral), and two repeated measures, CS (CS+ or CS-) and Trial.

The analysis of the Habituation phase showed a main effect of Trial, F (1, 75) = 14.36, p<.001. Participants reacted more in the first trial than in the second one. No other significant effects were obtained. A 2x2x2x8 ANOVA was run for the extinction data. Only a significant effect of Trial was obtained, F (7, 525) = 31.58, p<.001, showing an expected decrease in the magnitude of the SCRs during the extinction phase. No differences between groups or between the reinforced CS+ and the control CS- were obtained.

Discussion

Non-conscious associative learning has been observed in several experiments with biologically fear-relevant stimuli (Öhman & Mineka, 2001). In the present experiment, the hypothesis that this effect could be observed with food stimuli on "food-worried" participants was tested. The results did not, however, show the expected learning effects. Thus, independently of the conditioned stimulus (a food picture or a neutral picture), and independently of their food anxieties, there were no differences in the autonomic responses, measured by skin conductance, during the extinction phase. Although it is not possible to prove the null hypothesis, the results are more similar to the data on fear-irrelevant stimuli than the data on fear-relevant stimuli (Esteves, Parra, *et al.,* 1994) and suggest that food stimuli do not have preferential cognitive processing and do not activate a fear response.

General discussion

The general aim of this series of experiments was to investigate emotional reactions to food-related stimuli, both when the pictures were presented with a duration that allowed a complete conscious perception, and when awareness of stimulus content was prevented by means of backward masking.

The pattern of results of the four experiments showed that with conscious presentations, food stimuli are processed in a similar way to other emotional visual material. Thus, verbal ratings showed that food pictures can be considered, in general, pleasant stimuli that are not especially arousing. With the masked presentation, there was a tendency for a difference between groups that could indicate that heart rate changes could be modulated by the participants' attitudes toward food and body shape. The general pattern is, however, an absence of subliminal effects. Comparing these results with the conditioning literature, it thus seems that there is no parallel with fear--relevant stimuli and the preferred processing observed there (Öhman, 2000;

Öhman & Mineka, 2001). As has been referred to before, non-aware associative learning has only been observed with stimuli that were biologically fear--relevant. The use of ontogenetically fear-relevant stimuli (*e.g.*, guns or electrical outlets) has failed to produce this effect (Cook *et al.,* 1986). It could thus be concluded from our results that food stimuli presented as pictures are not processed as fear-relevant material. While food pictures have no negative associations for most individuals, we selected as participants young women who reported unhealthy attitudes toward food and dieting. Thus, in accordance with the studies of Cooper and Fairburn (1992) and Perpiñá and colleagues (1997), a difference in stimulus processing could be expected between participants showing behaviours and attitudes similar to those that characterise eating disorders and participants without that kind of problems. Although the pattern was not clear-cut, some differences were observed. In Experiment 1, for example, there was a tendency in the "worried" group to larger skin conductance responses to food images. This result may reflect some kind of automatic reaction to food stimuli that could be associated with a specific sensitivity to food cues in these participants. The global pattern of results does not, however, confirm this hypothesis. It should nevertheless be noted that our participants were not a clinical sample. From the clinical point of view it would be interesting to further investigate this possible sensitivity. The potential use in detecting risk-groups and evaluating treatment effects would certainly be a valuable help. The study of information processing of food cues in participants with eating disorders, and not only of "worried" people, such as those who participated in our studies, could thus be valuable.

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