# Is contextual-potentiated eating dependent on caloric density of food?

Joan Sansa*, Isabel Krug**, Victoria D. Chamizo* & Fernando Fernández-Aranda**

*\*Universitat de Barcelona;  \*\*Hospital Universitari de Bellvitge and Instituto Salud Carlos III, Spain*

One experiment tested whether a specific context could elicit eating in rats as a result of Pavlovian conditioning and whether this effect depended on the caloric density of food. Thirty two deprived rats experienced two contexts. They had access to food in context A, but no food was available in context B. During conditioning, half of the animals received high density caloric food (HD groups) whereas the other half, low density caloric food (LD groups). Then, half of the rats in each type of food group was tested in context A and the other half in context B. The results demonstrated an effect of context conditioning only in HD groups. These findings suggest the relevance of both contextual conditioning and caloric density of food in eating behaviour. Implications for the aetiology of binge eating will be discussed.

Eating is controlled by both physiological mechanisms and a number of learned cues (Woods, 2005). Weingarten (1983) found that an auditory stimulus (CS) presented systematically paired with 8 ml. of milk (US) elicited feeding on test days even though rats were tested while satiated. Working with Preschool children, Birch, McPhee, Sullivan, and Johnson (1989) found that when the children were in a room previously associated with food and eating, they initiated a meal quicker, and had a larger meal, than when they were in a different room that had never been related to food

and eating. During testing the children were satiated. In a recent and related experiment, with rats, Petrovich, Ross, Gallagher, and Holland (2007) have reported that a contextual conditioned stimulus (CS), which was paired with consumption of food pellets, enhanced consumption in animals that were not food-deprived on test. Moreover, these authors found that this cue-potentiated eating, as they call this enhanced eating, was observed only when the food presented during the test was the same as that used in the training phase. These authors have suggested that the mechanism that mediates cue-enhanced eating does not involve induction of general motivation to eat, but rather the selective enhancement of consumption of the food US.

The aim of the present study is to replicate the contextual cue-potentiated eating effect and to extend its analysis to the role that caloric density of food could play in this conditioning.

Flavour-nutrient associations have been extensively studied (see Capaldi, 1996, for a review). For instance, Ramirez (1994) reported that rats given access to a saccharin solution paired with intra-gastric (IG) carbohydrate infusions drank 70% more saccharin than did rats given the saccharin solution paired with IG water. On the other hand, evidence for learned preferences based on nutrient concentration is provided by studies in which rats were trained to consume, on alternate days, a flavoured nutritive source and a differently flavoured and less concentrated source. On subsequent choice tests with the two flavours presented in otherwise identical sources, rats usually preferred the flavour previously paired with the higher nutrient concentration (e.g., Ackroff, and Sclafani, 2006; Arbour, and Wilkie, 1988; Bolles, Hayward, and Crandall, 1981; Hayward, 1983; Warwick, Synowski, Coons, and Hendrickson, 1999, but see Van Vort, and Smith, 1983; Sclafani, Nissenbaum, and Ackroff, 1994; Lucas, Azzara and Sclafani, 1998, for the opposite results).

In the studies cited above the rats were given fixed amounts of fluids, each one with a different concentration of nutrients. With this procedure the rats are given different concentrations and different amounts of nutrients. Any resulting flavour preference could be explained by the number of calories paired with each flavour as well as the differential density of fluids. Nevertheless, Bolles, *et al.* (1981) showed that caloric density was more important than the number of calories in developing a preference for a given flavour. Preference was greater for a flavour associated with 2 g of a 4-calorie food than for a flavour associated with 4 g of a 2-calorie food.

In addition to flavours, context can also be associated with postingestive effects of food. Agmo, and Marroquin, (1997) found that a

sweet and nutritive solution was more effective in producing a place preference than a plain sweet solution. However, as far as we know, no study has assessed whether caloric density plays a role in cue-potentiated eating.

In the experiment reported here, one group of rats always had access to high density food (HD-diet) in a specific context A, while they did not have access to food in a second context B. An additional group had the same experience except that they received a low density food (LD-diet) instead of the HD-diet. Following conditioning, fifty per cent of the rats in each diet condition was tested in the conditioned context A (groups HD-Paired and LD-Paired), and the other fifty percent in the non-conditioned context B (groups HD-Unpaired and LD-Unpaired). Contextual conditioning will be evident if animals eat more in the conditioned context than in the non-conditioned context. Furthermore, if the context paired with HD-diet is able to develop a stronger association with this type of food in comparison with a second context paired with LD-diet, then the former context must elicit a more vigorous CR (greater intake) than the latter context during testing.

# METHOD

**Subjects.** The subjects were thirty-two naïve female hooded Long Evans rats reared in the Animal Laboratory at the University of Barcelona. At the start of the experiment they were approximately 90 days old and weighing between 223 and 270 g. They were housed in pairs in home cages made of semitransparent white plastic, 50x25x15 cm. The colony room had a temperature and humidity-controlled environment, and a 12:12 light/dark cycle. Throughout the experiment, water was freely available, but food was restricted as detailed below. The University of Barcelona Animal Care and Use Committee approved all procedures.

**Apparatus**. Two sets of cages, both distinctively different from the home cages and located in different rooms, served as the experimental contexts. The walls and floors of all these cages were made of plastic and the roofs of wire mesh (i.e., with room for both solid food as well as bottles -when they were available). The first set of cages was placed in a room highly illuminated by two fluorescent lamps. These cages measured 40x25x18 cm; their walls and floors were transparent. The floor was covered with commercial cat litter with lavender essence. This context will be referred to as "light context" hereafter. The second set of cages were

smaller, in a room which was maintained in semidarkness, illuminated only by a single infra-red ray bulb located in a corner far away from the cages. The floors of the cages were covered with wood shavings. This second context will be referred to as "dark context" hereafter. Animals in this phase (and also during testing) were run individually.

The HD-diet was commercial laboratory rodent chow diet (maintenance A-04, Panlab, S.A.; nutritive quality: 15.4% protein, 2.9% fat, 60.5% carbohydrate, 12% moisture, and 9.2% fibres and minerals; 3.17 kcal/g). The LD-diet was an especially prepared diet consisting of 200 ml semi-skimmed milk; 200 ml water; 50 g baby food and 15 g powder milk (nutritive quality: 3.2% protein, 0.8% fat, 13,1% carbohydrate, 82.5% moisture, and 0.4% fibres and minerals; 0.72 kcal/g). The LD-diet was designed so that it maintained the same proportions of nutrients as the HD-diet (commercial laboratory rodent chow diet), but with a lower caloric-density. The LD-diet was administered to the animals via a drinking bottle, which was placed on the wire mesh roof.

**Procedure**. During the whole experiment rats were weighed every day at 8:00 am. The body weight of the animals was controlled in order to prevent a weight fall below 80% of their initial body weight. During the experimental sessions, the rats were always run individually.

Baseline Phase: During the first four days, before starting the deprivation schedule, a weight baseline was established.

Deprivation Phase: Over the next seven days, rats received a food deprivation schedule in their home cages. Food was taken away at about 5:00 p.m. on the last day of the baseline phase and then was administered at 8:30 am every day. On the first day, animals had access to food for 6 hours. On the following days, this duration was gradually lowered, so that on the last day of deprivation, access to food was limited to 1 hour only. On the last three days of the deprivation phase, all rats were introduced to the new LD-diet in order to reduce any novelty effects of this kind of food. Thus, during the feeding period, animals had access to both, HD- and LD- diets. At the end of this deprivation phase, rats were assigned to each group in such a way that the LD-diet consumption in the LD- groups (Paired and Unpaired) equated the HD-diet consumption in the HD- groups (Paired and Unpaired). In order to make consumptions of both kinds of food comparable, intake was measured in kcal. Also animals were weight matched into LD- groups and HD- groups (n=8 in each group: HD-Paired, HD-Unpaired, LD-Paired, and LD-Unpaired). By the last day of this deprivation phase the animals' body weight ranged from 195 to 241 g.

Conditioning phase: Following the deprivation phase, all rats began the conditioning phase, which lasted 10 consecutive days. Animals received 2 daily sessions, each of them 1 hour long. The first daily session always took place at 9:00 am and the second daily session was carried out at 15:00 pm. Contexts (Light vs. Dark) were counter-balanced across groups. That is, during the first session half of the animals in each group were placed in the Light context and the other half in the Dark context. During the first daily session food was administered to all animals. Rats in the HD-groups had access to the HD-diet, and animals in the LD-groups had access to the LD-diet. Consumption was recorded by weighing the food, any diet, to the nearest tenth of a gram on an electronic scale before and after the 1-hour eating period. The difference indicated the amount of food the rats had consumed during each session. During the second daily session, animals were placed in the alternative contexts, but this time no food was presented to them. The rats had free access to water during the two daily sessions. After each session rats were immediately transported back to their home cages, where they remained until the next session. Since by day 5 of the conditioning phase the body weight of some rats had fallen below 80% of their baseline weight, all animals had access to a 30 min period of supplementary food at 19:00 pm in their home cages and until the end of the conditioning phase. For HD-groups, the supplementary food was LD-diet while for the LD-groups, HD-diet. The alternative diets were used as maintenance food in order to keep the contingency between each context and the experimental diet. On the last day of this phase the body weight of groups LD ranged from 189 to 234 g., whereas that of groups HD varied from 198 to 237 g.

Test Phase: After the conditioning phase the test phase lasted for six days. This phase had two test days which were intermixed with four refeeding days. Test days were conducted on days 3 and 6 of this phase, while refeeding days on days 1, 2, 4, and 5. On refeeding days all rats had "ad libitum" access to the supplementary food (i.e., animals in groups HD received LD-diet, and rats in groups LD received HD-diet) in the home-cages. On test days animals had access to the conditioned diet (i.e., animals in groups HD received HD-diet, and rats in groups LD received LD-diet). One group of each diet was tested in the conditioned context (i.e., groups HD-Paired and LD-Paired), while the remaining groups were tested in the non-conditioned context (i.e., groups HD-Unpaired and LD-Unpaired). The body weight ranges for each group, averaging the two test days, were: 224-247 g; 215-263 g; 229-255 g; and 222-255 g, respectively. On the first test session, food was removed three hours before testing (Hungry test); while

on the second test session, food was maintained until testing (Satiated test). Each test session started at 12:00 noon and lasted for one hour.

**Statistical Analyses.** Prior to any analysis, all data from the two test sessions were explored with a box-and-whisker plot (Tukey, 1977) in order to identify any outlier values. Then, multivariate analyses of variance (MANOVA) were carried out, followed by simple effects analysis if an interaction was significant. Throughout this article, a significance level of $p < 0.05$ was adopted for all statistical analyses.

## RESULTS

Three animals were excluded from the analysis because a box-and-whisker plot identified their food consumption as outlier values during testing. One animal of the LD-Unpaired group ate 1.47 kcal while the consumption of the rest of the animals in this group ranged between 10.99 and 18.89 kcal. Another rat of the HD-Unpaired group ate 35.58 kcal while the rest of the animals ranged between 5.27 and 18.33 kcal. The third rat, of group HD-Paired, ate 3.78 kcal while the rest of animals in this group ranged between 13.24 and 24.08 kcal. Finally, all groups had 7 animals except group LD-Paired, which had 8.

The consumption of each diet throughout the last three days of the deprivation phase was similar. Although the proportion of HD-diet intake for all animals was 0.51, there were some individual differences. Therefore, rats were assigned to each diet condition according to their preferences. The proportion of HD-diet intake during the baseline phase in groups which had access to this diet during conditioning was 0.59 and the proportion of LD-diet intake in groups which had access to LD-diet during conditioning was 0.58. An ANOVA confirmed that the consumption of the selected experimental diet did not differ between groups (Highest $F$=0.06).

The rats' body weight fell throughout the deprivation and conditioning phases but it was recuperated on the second test session. A MANOVA with diet (HD-diet vs. LD-diet) and conditioning (Paired vs. Unpaired contexts) as between factors and sessions as a within factor was conducted. For the analysis of the rats´ weight, the weight of the last session of phases baseline, deprivation and conditioning was considered; as well as the weights of the two test sessions. This analysis revealed a significant main effect of sessions, F(4,100)=385.3, $p$<0.001; and the conditioning x sessions interaction was also significant, F(4,100)=3.3, $p$=0.015. No other factor or interaction was significant (highest $F$=2.6). In order to analyse the

interaction conditioning x sessions, univariate ANOVAs were conducted session by session. The factor of conditioning did not differ in any session (all $F$s<1). On the other hand, all sessions differed among each other at both levels of conditioning factor (Bonferroni contrasts, $p<0.05$), except the comparison between baseline and the second test session in the Unpaired groups.

All groups increased the number of kcal ingested throughout the conditioning phase. However, HD- groups consumed more than LD-groups. A MANOVA with diet (HD-diet vs. LD-diet), conditioning (Paired vs. Unpaired contexts) and context (Light vs. Dark) as between factors and sessions as a within factor confirmed these observations. This analysis revealed that the main factors diet, context and sessions were significant, F(1,21)=6.3, $p=0.020$, F(1,21)=5.3, $p=0.032$ and F(9,189)=17.8, p<0.001, respectively. The interactions diet x context and sessions x diet x context were also significant, F(1,21)=5.1, $p=0.035$ and F(9,189)=2.0, $p=0.040$, respectively. No other factor or interaction was significant (highest $F$=2.0). In order to analyse the interaction diet x context, univariate ANOVAs were conducted at each level of both factors. The factor context at HD-diet and the factor diet at light context were significant, F(1,12)=5.4, $p=0.038$ and F(1,12)=12.1, $p=0.004$, respectively. In particular, rats ate more kcals when the diet was HD-diet and they had access to it in the light context. No other comparison was significant (all Fs<1). Univariate ANOVAs were also conducted session by session in order to analyze the significant third interaction diet x context x sessions. While on sessions 1 and 6 the interaction diet x context was significant, F(1,25)=10.6, $p=0.003$ and F(1,25)=7.0, $p=0.014$, respectively; it was very close to significance on sessions 3 and 4, F(1,25)=4.2, $p=0.051$ and F(1,25)=4.1, $p=0.053$, respectively. On the remaining sessions the interaction diet x context was not significant (highest $F$=2.0). Besides, the main factor context was significant on sessions 2 and 6, F(1,25)=6.2, $p=0.020$ and F(1,25)=8.1, $p=0.009$, respectively; as well as diet on sessions 5 and 6, F(1,25)=12.5, $p=0.002$ and F(1,25)=9.5, $p=0.005$, respectively. None of the two factors was significant in the remaining sessions (highest $F$=3,3), although context was very close to significance on session 8, F(1,25)=4.1, $p=0.053$.

Figure 1 shows the food intake (shown in kcal) during the two test sessions of the four groups (i.e., left-hand side: HD-Paired and HD-Unpaired groups; right-hand side: LD-Paired and LD-Unpaired groups). The HD-Paired group ate more than the other three groups and the HD-Unpaired group ate less than the other groups in both test sessions (after 3 hours of food deprivation and after no deprivation, respectively). A MANOVA with diet, (HD-diet vs. LD-diet), conditioning (Paired vs.

Unpaired contexts) and context (Light vs. Dark) as between factors and test as a within factor, showed that the main factors conditioning and test were significant, $F(1,21)=4.4$, $p=0.049$, and $F(1,21)=10.8$, $p=0.003$, respectively; as well as the interaction diet x conditioning, $F(1,21)=8.4$, $p=0.009$. But neither the main factors diet and context, nor the remaining interactions were statistically significant (highest Fs=3.3). Further analysis of the interaction diet x conditioning revealed that the factor conditioning differed in the HD-diet, $F(1,12)=8.9$ ($p=0.012$), but did not differ in the LD-diet, $F<1$. On the other hand, the two diets differed in the Paired groups, $F(1,13)=6.6$ ($p=0,024$), but did not differ in the Unpaired groups, $F(1,12)=4.1$ ($p=0.065$).



**Figure 1. Groups mean intake (±SEs) in kcal for High-density caloric groups (on the left) and Low-density caloric groups (on the right) during hungry and satiated tests. Paired = groups tested in the conditioned context; Unpaired = groups tested in the non conditioned context.**

# GENERAL DISCUSSION

The present study had two main aims: firstly, to replicate the findings reported by Petrovich *et al.* (2007) in which contextual cues related to food intake elicited higher consumption than an alternative context which had never been paired with food; secondly, to examine whether the caloric density of food had an effect on the cue-potentiated eating.

The present results clearly show that contextual cues can serve as conditioned cues to stimulate eating when HD-diet was used as a US but, surprisingly, they fail to show such an effect when LD-diet was presented as a US. In fact, the results observed in the HD- groups replicate those reported by Petrovich *et al.* (2007). In a related study, Weingarten (1983) found that a tone paired with milk potentiated eating. Similarly, working with children, cue-potentiated eating mediated by context has also been reported by Birch, *et al.* (1989).

The null result observed in LD- groups could be interpreted in several ways. Firstly, it is reasonable to assume that HD-diet is more effective as a US than LD-diet. Supporting this argument, a large number of studies have reported that a flavoured-cue paired with nutrient can allow a flavour-nutrient association, and that this association depends on the caloric density of food (e.g., Ackroff, and Sclafani, 2006; Arbour, and Wilkie, 1988; Azzara and Sclafani, 1998; Warwick, *et al.*, 1999). However, it is worth mentioning that in all these experiments nutritive density of food covaried with the net amount of consumed nutrients. Such a fact allows an alternative explanation because the observed flavour preferences could be explained both by the density of the food as well as by the absolute number of calories consumed. Although in the current experiment the rats of HD- groups ingested more kcal than the rats in LD- groups during the conditioning phase, these differences disappeared throughout the last four sessions of conditioning, where groups HD- and LD- differed in terms of food-density rather than ingested kcal. In this sense, our results seem to agree with those reported by Bolles *et al*. (1981) who gave rats 2 g of a 4-calorie food or 4 g of a 2-calorie food. In this way, they ensured that the amount of nutrients was identical in both conditions, HD and LD, although the two conditions differed in density. Their results showed a greater preference for a flavour paired with more dense food.

Another possibility in order to explain the differences observed between diets is based on anticipatory negative contrast (Flaherty and Checke, 1982). The effectiveness of a reinforcer is reduced if it is closely accompanied by a second preferred reinforcer (see, Mackintosh, 1974). Flaherty and Checke (1982) showed that consumption of saccharine was reduced if saccharine was followed by more preferred sucrose. Note that, in the experiment reported here, animals in the LD- groups received HD-diet in the evening, and thus they could learn to anticipate a more reinforcing food when they were moved to the experimental contexts. However, the 2.5-hours delay from the end of the last experimental session until the beginning of access to HD-diet in their home-cages could be long enough to prevent any association between the last experimental session and HD-diet

and, therefore, the anticipatory contrast effect. In fact, Flaherty and Checke (1982) found that delayed sucrose delivery reduced saccharine consumption only when it was delivered within 30 min.

A third possibility is based on Treit and Spetch's (1986) proposal that rat's caloric intake is controlled by two factors: under certain conditions control is by caloric learning, and under other conditions by a caloric metering mechanism. The metering mechanism refers to the ability of rats to precisely calculate the caloric density of foods. Thus, it could be argued that the rats of groups, HD- and LD-, had metered the density of HD-diet and LD-diet, and therefore that, throughout the conditioning phase, they could have learned to adjust their consumptions in order to obtain the needed nutrients of both types of food. Effectively, rats in the LD- groups ate a large amount of LD-diet; enough to provide them with a very similar quantity of nutrients as those consumed by HD- rats during the conditioning phase. This was confirmed in a thorough inspection of the daily consumption during the last four days of this phase, which showed that HD-rats ate an average of 6.15 g., while LD- animals ate an average of 23.82 g.; and this distribution provided approximately the same amount of kcal for each source of food. It is also reasonable to argue that some characteristics of LD-diet, like its smell, taste, etc., could have been associated with the low density diet and, as a consequence, they could have activated a greater consumption regardless of the context where that kind of food was found. Therefore, it is possible that on the test sessions the ingestion size might be controlled by different cues: by some food features in the presence of LD-diet, and by contextual cues with HD-diet. If this line of reasoning is correct, differences could be expected to be found between the Paired and Unpaired groups on tests with HD-diet, and that these differences will disappear with LD-diet.

Another interesting detail from the interaction between diets and conditioning (see Figure 1) is the fact that both Paired groups differed between each other, and that the difference between the Unpaired groups was close to significance. It is important to realize that the procedure used in this experiment is similar to the "differential procedure", which is used to study inhibitory conditioning. In this procedure, one stimulus (a CS+) is paired with the US, and a second stimulus (a CS-) is presented alone (i.e., is followed by the absence of the US). Often inhibitory conditioning is behaviourally silent and therefore additional tests are necessary to measure it, like summation and retardation tests. In the summation or compound stimulus test (Rescorla, 1969; Pavlov, 1927), the effects of a supposedly inhibitory stimulus (CS-) presented in compound with an excitatory

stimulus (CS+) are observed. In the retardation of the acquisition test (Rescorla, 1969), a supposedly inhibitory stimulus (CS-) is expected to cause a retardation when learning an excitatory conditioning in comparison with a neutral stimulus. For example, Maes and Vossen (1995) found a differential inhibition effect using contextual stimuli. In their experiment rats received an electric footshock during training, which was consistently delivered in one context, but not in a second context. Subsequent summation and retardation tests showed that the second context had acquired inhibitory properties. Having in mind this procedure, it is possible that whereas the paired context acted as an excitatory CS+ eliciting eating, the unpaired context (i.e., the context that systematically signalled the absence of food) could have acquired inhibitory properties and could thus have acted as an inhibitory CS–, which in turn could have reduced the food ingestion. Accordingly, in the present study, this interpretation could account for differences in the food consumption between the unpaired groups. The explicit unpaired presentations of the non-conditioned context and the food could have allowed the animals to learn a negative relation between the cues and could therefore have produced an inhibitory conditioning effect. Unfortunately, there is not an appropriate control condition to state that the unpaired context acquired inhibitory properties. Further research is certainly needed to address all these questions.

### Implications for bingeing behaviour.

The fact that a context-nutrient association can potentiate eating behaviour has important implications. It means that this kind of association does not only affect food selection via enhancing a flavour or a context preference, but also that it can produce overeating. Furthermore, if context-nutrient association was selective for HD-diet then any learning model of binge eating, must consider this fact.

Although we are conscious of the limitations of this study, the results of the present experiment could suggest the existence of interesting variables which could take part in the aetiology of binge eating.

The term bingeing behaviour refers to the consumption of a large amount of food in a discrete period of time during which loss of control is experienced (APA, 1994). Even though up to this date substantial research has been carried out on this behaviour, knowledge of its aetiology remains unclear (Crowther, Sanftner, Bonifazi & Shepherd, 2001; Grilo, Masheb & Wilson, 2001; Vanderlinden, Dalle Grave, Fernandez, Vandereycken, Pieters & Noorduin, 2004). One of the models proposed to account for

bingeing behaviour is Jansen's (1998) theory of cue reactivity based on classical conditioning.

Jansen's (1998) cue reactivity theory states that after systematic associations of cues (the conditioned stimulus, CS) with food (the unconditioned stimulus, US), the CS cues will reliably signal food. When these cues are good predictors of food, they acquire the ability to elicit adaptive physiological responses for digestion, such as salivation and insulin release. These classical conditioned responses (CRs) are supposed to be experienced as appetite, or even craving, and therefore increase the likelihood of food intake. The predictive cues are often directly related to food (such as the smell, the sight and the taste of food), but they might also be contextual cues (e.g., being at home, being alone) or interoceptive cues (e.g., specific feelings or cognitions) (Carter & Bulik, 1994; Carter, Bulik, McIntosh and Joyce, 2002; Jansen, 1998).

The context-potentiated eating effect reported here and in Petrovich *et al.* (2007) agrees with Jansen's model. People who restrain food consumption can eat in a specific context (e.g., at home) and after several pairings, the context can elicit overeating.

Furthermore, according to the present results, high density caloric food rather than low density caloric food, might promote a stronger context-nutrients association which then could lead to overeating. On the other hand, Petrovich *et al.* (2007) have suggested that the context-nutrients association elicits cravings for food paired with the context rather than a more general motivation to eat.

These results, taken together, suggest that those cues paired with high density caloric food could become effective CSs, which will elicit a craving for the specific high density caloric food. According to this idea, Alpers & Tuschen-Caffier (2004) found that individuals who exhibit binge eating behaviour tend to eat high density caloric food during their binges, whereas during non-binge meals they generally consume fewer calories than healthy controls.

The present study should be evaluated within the context of learning processes. Our results point out the relevance of both contextual conditioning and caloric density of food to explain binge behaviour in rats. Nevertheless, it remains unclear to which extent other biological factors are also implicated in binge eating.

# RESUMEN

**¿Es la potenciación contextual de la conducta de comer dependiente de la densidad calórica del alimento?.** Se puso a prueba en un experimento con ratas si un contexto específico podría provocar la conducta de comer como resultado del condicionamiento Pavloviano, y si este efecto dependía de la densidad calórica del alimento. Treinta y dos ratas privadas de comida experimentaron dos contextos. Los animales tenían acceso al alimento en el contexto A, pero nunca encontraron alimento en el contexto B. La mitad de los animales recibió un alimento de alta densidad calórica (grupos HD) mientras que la otra mitad recibió un alimento de baja densidad calórica (grupos LD) durante las sesiones de condicionamiento. Posteriormente, la mitad de los animales en cada tipo de alimento se puso a prueba en el contexto A y la otra mitad en el contexto B. Los resultados mostraron un efecto de condicionamiento contextual solamente en los grupos HD. Estos resultados sugieren la importancia del condicionamiento del contexto y de la densidad calórica del alimento en la conducta de comer. Se discuten las implicaciones que estos hallazgos pueden tener en la etiología de la conducta de atracón.

# REFERENCES

Ackroff, K., & Sclafani, A. (2006). Energy density and macronutrient composition determine flavor preference conditioned by intragastric infusions of mixed diets. *Physiology & behavior, 89*, 250-260

Ågmo, A. & Marroquin, E. (1997). Role of gustatory and postingestive actions of sweeteners in the generation of positive affect as evaluated by place preference conditioning. *Appetite, 29*, 269-289.

Alpers, G.W., & Tuschen-Caffier, B. (2004). Energy and macronutrient intake in bulimia nervosa. *Eating Behaviours, 5*, 241-249.

American Psychiatric Association (APA) (1994). *Diagnostic and statistical manual of mental disorders,* 4th edn. Pp. 539-550. Washington: American Psychiatric Association.

Arbour, K.J., & Wilkie, D.M. (1988). Rodents' (Rattus, Mesocricetus, and Meriones) use of learned caloric information in diet selection. *Journal Of Comparative Psychology, 102*, 177-181.

Azzara, A.V. & Sclafani, A. (1998). Flavor preferences conditioned by intragastric sugar infusions in rats: maltose is more reinforcing than sucrose. *Physiology and Behavior, 64*, 535–541.

Birch, L.L., McPhee, L., Sullivan, S., & Johnson, S. (1989). Conditioned meal initiation in young children. *Appetite, 13*, 105-113.

Bolles, R.C., Hayward, L., & Crandall, C. (1981). Conditioned taste preferences based on caloric density. *Journal of Experimental Psychology: Animal Behaviour Processes, 7*, 59-69.

Capaldi, E.D. (1996). Conditioned food preferences. In Capaldi, E.D. (Ed.), *Why we eat what we eat: The psychology of eating* (pp. 53-80). Washington, DC: American Psychological Association.

Carter, F.A. & Bulik, C.M. (1994). Exposure treatments for bulimia nervosa: Procedure, efficacy, and mechanisms. *Advances in Behaviour Research & Therapy, 16*, 77-129.

Carter, F.A., Bulik, C.M., McIntosh, V.V. & Joyce, P.R. (2002). Cue reactivity as a predictor of outcome with bulimia nervosa. *International Journal of Eating Disorders, 31*, 240-250.

Crowther, J.H., Sanftner, J., Bonifazi, D.Z., & Shepherd, K.L. (2001). The role of daily hassles in binge eating. *The International Journal of Eating Disorders, 29*, 449-454.

Flaherty, C.F., & Checke, S. (1982). Anticipation of incentive gain. *Animal Learning & Behavior, 10*, 177-182.

Grilo, C.M.; Masheb, R.M.; & Wilson, G.T. (2001). Subtyping binge eating disorder. *Journal of Consulting and Clinical Psychology, 69*, 1066-1072.

Hayward, L. (1983). The role of oral and postingestional cues in the conditioning of taste preferences based on differing caloric density and caloric outcome in weanling and mature rats. *Animal Learning & Behavior, 11*, 325-331.

Jansen, A. (1998). A learning model of binge eating: Cue reactivity and cue exposure. *Behaviour Research and Therapy, 36*, 257-272.

Lucas F, Sclafani A. (1998). Differential reinforcing and satiating effects of intragastric fat and carbohydrate infusions in rats. *Physiology & behavior, 66*, 381–388.

Mackintosh, N.J. (1974). *The psychology of animal learning.* New York: Academic.

Maes, J.H.R., & Vossen, J.M.H. (1995). Differential inhibition using contextual stimuli. *Behavioural Processes, 37*, 167-184.

Pavlov, I. P. (1927). *Conditioned reflexes.* London: Oxford University Press.

Petrovich, GD, Ross, CA, Gallagher, M and Holland, PC (2007). Learned contextual cue potentiates eating in rats. *Physiology & behavior, 90*, 362-367.

Ramirez, I. (1994). Stimulation of fluid intake by carbohydrates: interaction between taste and calories. *American Journal of Physiology, 266*, R682-R687.

Rescorla, R.A. (1969). Pavlovian conditioned inhibition. P*sychological Bulletin, 72*, 77-94.

Sclafani, A., Nissenbaum, J.W., & Ackroff, K. (1994). Learned preferences for real-fed and sham-fed Polycose in rats: interaction of taste, postingestive reinforcement, and satiety. *Physiology & behavior, 56*, 331–337.

Treit, D. and Spetch, M.L. (1986). Caloric regulation in the rat: Control by two factors. *Physiology & Behavior, 36*, 311-317.

Tukey, J.W. (1977). *Exploratory Data Analysis.* Reading, Massachusetts: Addison-Wesley.

Van Vort, W., and Smith, G.P., (1983). The relationships between the positive reinforcing and satiating effects of a meal in the rat. *Physiology & Behavior, 30*, 279-284.

Vanderlinden, J., Dalle Grave, R., Fernandez, F., Vandereycken, W., Pieters, G., y Noorduin, C. (2004). Which factors do provoke binge-eating? An exploratory study in eating disorder patients. *Eating and weight Disorders, 9*, 300-305.

Warwick, Z.S., Synowski, S.J., Coons, V., & Hendrickson, A. (1999). Flavor-cued modulation of intake in rats: role of familiarity and impact on 24-h intake. *Physiology & behavior, 67*, 527–532.

Warwick, Z.S., Weingarten, H.P. (1996). Flavor-postingestive consequence associations incorporate the behaviorally opposing effects of positive reinforcement and anticipated satiety: implications for interpreting two-bottle tests. *Physiology & behavior, 60*, 711–715.

Weingarten, H.P. (1983). Conditioned cues elicit feeding in sated rats: A role for learning in meal initiation. *Science, 220*, 431-432.

Woods, S.C. (2005). Signals that influence food intake and body weight. *Physiology & behavior*, 86, 709–716.