A laboratory environment previously associated with a palatable diet can result in overfeeding in rats


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Received: 12-03-2016  Accepted: 13-07-2016  DOI: 10.18805/ijar.v0iOF.4555

ABSTRACT

Enriched and non-enriched laboratory environments produce various biological and behavioral effects on laboratory animals. One of the most impacted aspects in this regard is eating behavior. We examined associations between enriched vs. non-enriched environments and palatable vs. non-palatable diets on food intake in rats. Experiment 1 demonstrated that there are no significant differences in palatable food consumption irrespective of whether rats were exposed to enriched or non-enriched environments (P>0.05). In contrast, experiment 2 demonstrated that a combination of exposure to either of these environments and palatable food is enough to produce overfeeding in rats (P<0.05). These outcomes in rats may offer significant inferences in regards to the regulation of eating behavior in humans.

Key words: Environment, Food intake, Palatable food, Weigh, Rats.


INTRODUCTION

Laboratory animal housing environments can be categorized as being either enriched or non-enriched depending on the availability of non-food social and material elements (Olsson et al., 2002; Balcombe, 2006; Makowska et al., 2016; Mering et al., 2015). Exposing rats to enriched environments has been shown to have positive effects on numerous areas: brain development (Maegle et al., 2015); plasticity (Mora, 2013); the performance of complex behaviors (Costa et al., 2015); and the speed with which memory and learning tasks are executed (Birch et al., 2013).

Laboratory environments may also have direct effects on eating behavior, particularly on food consumption (Wansik, 2004). Much of the research about eating behavior has focused on the macro-nutrient composition and palatability of foods (Martire et al., 2015). However, studies on these aspects could be inconclusive or even misleading if they do not consider the importance of non-food factors present in the study environments (Costa et al., 2015). Animals seem capable of learning how conditioned stimuli (CS) can be paired with reinforcers in the presence of external cues (Petrovich et al., 2007). The fact that certain behaviors may repeat themselves in different environments promotes the notion that they are persistent (Weingarten, 1984).

Prior studies have demonstrated that rats eat large amounts of food when they are exposed to palatable or cafeteria diets (Shafat et al., 2009; Martire et al., 2014; Zeeni et al., 2015). In the cafeteria diet model, animals are provided with an assortment of common human “junk foods”. We proposed to ask whether the cafeteria diet model produces the same results when paired with enriched and non-enriched environments. The aim of this study was to investigate whether associations resulting in overfeeding can be shown to exist between the cafeteria diet model and enriched and/or non-enriched environments.

MATERIALS AND METHODS

Two experiments were performed in accordance with Mexican standard NOM-062-ZOO-1999 on technical specifications for the production, care and use of laboratory animals. Rats were given 24-h ad libitum access to food and water and subjected to a 12 h light-dark cycle. Their body weight ranged from 250 to 300g at the beginning of the experiment. In Experiment 1, Wistar rats (n=16) were randomly selected to be fed highly energetic and palatable foods (cafeteria diet; CAF) in either an enriched environment (CA) or in a non-enriched environment (CB) for four weeks. In Experiment 2, Group 1 (n=8) received standard food (ST) in CA in Phase 1. The same group later received CAF in CB (Phase 2). Finally, half of the Group 1 rats (1A) were returned to Phase 1 conditions, while the other half received ST in CB (1B). Group 2 (n=8) was exposed to the same procedure but received ST in CB in Phase 1 followed by CAF in CA in Phase 2. The rats’ food intake was recorded daily between 9:00 and 10:00. In the case of the individually-housed rats, 24-h food intake was evaluated throughout the study via
calculated weekly averages. Body weight was measured at the same time of day using a digital scale. In CA, animals were housed in plastic cages whose floors were lined with sawdust, which was replaced daily. CA also contained a range of interactive stimuli including tubes, toys, paper and blanket material. In CB, animals were housed in wood cages whose floors were lined with stones and water. Both cages were equipped with a metallic grille on the top and two compartments for administering food and water.

**Statistical analysis:** Data are reported as mean ± SD. The results were analyzed using a t-test analysis. A p value equal to or less than 0.05 was considered to be statistically significant.

**RESULTS AND DISCUSSION**

**Food intake:** There was no difference in CAF food intake in rats housed in CA or CB during experiment 1 (Group 1: 22.22±3.42 vs. Group 2: 22.40±3.05; P=0.06). The order of rat housing had a distinct effect on food intake. Group 1 rats housed firstly in an enriched environment and later in a non-enriched environment ate more when they were in the latter environment (Phase 1: 21.02± 2.58 vs. Phase 2: 23.42±3.73; P=0.01). Group 2 rats housed firstly in a non-enriched environment and later in an enriched environment ate similarly in both environments (Phase 1: 22.42± 3.12 vs. Phase 2: 22.38±2.99; P=0.64) (Fig 1).

Results obtained from experiment 2 showed that group 1 rats housed in CA ate significantly more ST diet than group 2 rats housed in CB during Phase 1 (Group 1: 22.84±3.95 vs. Group 2: 20.92± 2.56; P<0.001). Food intake did not differ between groups in phase 2 (Group 1: 22.42± 3.25 vs. Group 2: 22.00±2.22; P=0.68). Consequently, rat subgroups that were previously fed in an environment associated with CAF diet in phase 2 ate significantly more ST diet during phase 3 than rat subgroups fed in an environment associated with ST diet in phase 2 (1A=21.68±2.84 vs. 2A=29.90±5.06; P<0.001/1B=28.56±5.54 vs. 2B=21.63±3.11; P=0.01).

**Body weight:** No body weight differences between groups were observed during experiment 1 (Group 1: 278.70±10.88 vs. Group 2: 275.95±11.39; P=0.49). An intragroup comparison revealed that group 1 rats weighed the same in both phases (Phase 1: 270.84±7.73 vs. Phase 2: 286.55±7.34; P=0.95), while group 2 rats weighed more in the second phase than in the first phase (Phase 1: 267.50±9.42; Phase 2: 284.40±9.42; P=0.000). Body weight measurements from experiment 2 showed differences until the third phase.

![Graphs](image_url)

*Fig 1.* Food intake (a) and body weight (b) in both experiments. All data are presented as means ± SD. Significant differences between groups were calculated by using an unpaired t test.
Animals weighed more when they remained in the same environment as they did in phase 2, when they received CAF diet (1A=308.81±6.61 vs. 1B=339.22±11.75; P<0.001/2A=343.51±12.90 vs. 2B=303.96±5.48; P<0.001). Rats ate the same quantity of CAF diet in both environments (CA and CB) (P>0.5). However, rats ate more in the conditioned environment when it had been paired with CAF diet than when it had been associated with ST diet (P<0.5). This demonstrates the importance of the availability of palatable food in a particular environment. These results are supported by previous studies. Sansa et al. (2009) demonstrated the effect of a conditioned environment on the intake of high-calorie dense food. Rats were exposed to the condition of having either free access to food in one environment or no food in another environment. Subsequently, half of the rats received high-calorie dense food while the others half received low-calorie dense food. Finally, groups were tested in both environments. The results proved that high-calorie dense food conditioning promotes a stronger association between environment and feeding behavior. This result suggests that the composition of food is a powerful stimulus in terms of producing and maintaining the effects of conditioning.

Another study found similar effects. Adult rats were conditioned to associate chocolate cookie intake (palatable food) to cages with external cues that were different than the cues present in cages were they were only fed chow. Animals were tested in the cage where only chow was available to determine whether the cues paired with palatable food could result in the overeating of plain chow. Rats consumed significantly more chow when exposed to cues previously paired with chocolate cookies than when exposed to those that had been paired with chow (Boggiano et al., 2009).

With respect to body weight data from experiment 1, rats weighed the same irrespective of the availability of a CAF diet. A previous study had also reported no differences in the body weight of rat pups that were fed cafeteria diets (containing food items such as cookies, candies, bacon, biscuits, chocolate and peanuts). However, in this study rat pups did show a significant increase in body fat mass (Castro et al., 2015). In experiment 2, some studies showed that rats housed in large cages filled with toys weighed less (and obviously, consumed less food) than rats housed in standard laboratory cages. This result showed consistency with a previous finding (Abou-Ismail et al., 2011) that animals housed in an enriched environment engaged in more physical activity than those in a non-enriched environment.

Normally, palatable diets consist of foods with high caloric density (Nasser, 2001). The association between previous exposition to palatable food and subsequent overfeeding is highly significant and suggests a contributive association with obesity (Appelhans et al., 2016). For this reason, animal models exist as a viable method for testing alternative approaches to the regulation of eating behavior (Hebebrand et al., 2014). In summary, the present study indicated that the environment in which palatable food was consumed may contribute to subsequent overfeeding under varied environmental conditions. Sufficient pairings with palatable food consumption enabled the environment to acquire conditioned properties that stimulated eating. For this reason, it is important to identify the role of particular eating environments in the control and prevention of overfeeding. Behavioral strategies designed to manipulate non-food cues in different environments could lead to modifications in palatable food meal size. In conclusion, our findings provide evidence that CAF palatable diet was effective for the development of overfeeding behavior.

CONFLICT OF INTEREST

We have no conflict of interest to declare.

REFERENCES


