

# **Effects of Attention Allocation on Habituation to Food Cues in Normal-Weight and Overweight Children**

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## **Abstract**

Despite the rising prevalence of pediatric overweight, minimal research has been conducted to understand the basic biological processes underlying overweight in children. The present translational study assesses changes in physiological response (i.e., salivation) to food over time. The primary aims were to examine whether salivation patterns in children vary based on weight status and/or allocating attention to a distracter task.

Participants were 30 normal weight and 30 overweight children ages 9-12. All children were presented with nine one-minute trials of a food stimulus (French fries). During each intertrial, participants either listened to sequential one-minute presentations of an audio book (distracter task) or listened to white noise (no-distracter-task control). Rates of salivation were measured using a validated procedure (the Strongin-Hinsie Peck method) and analyzed via repeated measures ANOVA. The rate of change in salivation over trials differed significantly by weight status ( $p = .04$ ) but not by distracter task condition ( $p > .10$ ). Specifically, regardless of distracter task condition, normal weight children habituated to food cues while overweight children did not. Results suggest that children's physiological response to food is related to weight status. Such atypical habituation patterns could potentially lead to overconsumption, thus serving as a possible causal or maintaining factor in childhood overweight. Implications and future directions are discussed.

## **Introduction**

Over the past two decades, overweight (OW) in youth and obesity in adults has been rising in the United States at an alarming rate (Robinson & Killen, 2002), with current data estimating that 31% of children and adolescents ages 6-12 are classified as OW or at risk for OW (Hedley et al., 2004).

There are numerous negative effects associated with OW in youth including medical problems such as type II diabetes, hypertension, and high total cholesterol, as well as psychosocial consequences such as being stigmatized, marginalized, and rejected (Goldfield & Chrisler, 1995; Wilfley et al., in press). Pediatric OW is a known risk factor for the development of eating disorders as well as for adult obesity. Additionally, pediatric OW increases the risk of adult morbidity and mortality independent of adult obesity status (Must et al., 1992).

In spite of growing attention to this epidemic problem, little translational research has been done in the area of pediatric OW – that is, research on how basic biological processes underlying OW and obesity inform behavioral approaches to its treatment and prevention. Existing research on the treatment of OW can be supplemented with basic laboratory studies exploring the biological processes that bring about dysregulated eating in OW youth. The proposed research is a translational study on habituation, a basic biological process that influences ingestive behavior in OW youth. Potential implications of the study would include applying knowledge of the habituation process to enhance and refine the eating-regulation component of existing treatment and prevention strategies.

Habituation, the process of decreasing responsiveness after repeated exposure to a stimulus, is one important factor thought to influence ingestive behavior. In particular, data in both non-human primates and humans show that repeated presentations of food cues lead to habituation (measured via salivation), and that habituation is associated with the termination of eating episodes (Wisniewski, Epstein, & Caggiula, 1992). In addition, the composition of foods presented (Epstein, Saad, Handley, Roemmich, Hawk, & McSweeney, 2003) and competing environmental stimuli (Epstein, Saad, Giacomelli, & Roemmich, 2005) can slow the rate of habituation. These findings are significant, as delayed termination of eating episodes would lead to increased caloric intake and thus overeating. To summarize this body of research, findings suggest that termination of a particular eating episode is related to a decrease in salivation after repeated exposure to food cues, and that the nature of food presentation (e.g., variety of foods vs. single food item) and competing attention-demanding activities (e.g., playing a video game while eating) interfere with this process. In addition, some subgroups of humans show irregular patterns of habituating. For example, adults with bulimia nervosa show a reverse pattern of habituation where repeated presentation of food cues leads to an increase in responding (Wisniewski, Epstein, Marcus & Kaye, 1997), suggesting that variations in the habituation process are associated with distinctive eating patterns.

Data from a recent investigation on this topic (Epstein et al., 2005) suggest that normal-weight adolescents allocating attention to computer/audio book tasks habituate to food cues slower when the task demands high attention than lower attention. It is currently unknown whether this finding will extend to or possibly be more pronounced in OW youth. Thus, the proposed research aims to extend the Epstein et al. (2005) findings to the pediatric OW population. This study could help to explain longitudinal data suggesting a strong dose-response relation between television watching and OW in children (Gortmaker, Must, Sobol, Peterson, Colditz, & Dietz, 1996). That is, if the interference of attention-demanding tasks on habituation is more extreme in OW youth, this finding would provide insight into the basic biological processes behind the Gortmaker et al. (1996) findings and offer a new avenue of focus for OW prevention and treatment programs based on these biological mechanisms.

The specific aim of this study is to investigate the influence of attention-demanding activities on habituation in normal-weight and OW youth. This study will be a replication and extension of experiment 2 from the Epstein et al. (2005) paper.

## **Methods**

Over a one-year period, 30 9- to 12-year-olds who were OW (Body Mass Index [BMI] greater than the 95<sup>th</sup> percentile for age and sex) and 30 normal-weight 9- to 12-year-olds (BMI less than the 85<sup>th</sup> percentile for age and sex) were recruited from the St. Louis metropolitan area using fliers, posters, and newspaper advertisements with \$25 offered as compensation for participation. The study was conducted at the Psychological Service Center (PSC), located on the West Campus of Washington University. Participants were randomly assigned to one of two groups: Audiobook or no Audiobook. As with the Epstein et al. (2005) study, the Audiobooks for the proposed study were three selections from a series of Bunnica children's audiobooks and were used as the attention task during the

study. Children in the Audiobook condition were given brief descriptions of each story and asked to choose their most preferred one.

The experiment consisted of 11 habituation trials (i.e., two habituation practice trials followed by nine test trials). Each habituation trial consisted of the experimenter bringing a food stimulus (i.e., 37 grams of Burger King French fries served on a 9-inch plate and heated on high in the microwave oven for 25 seconds in a separate room) into the experimental room and having the participant smell and look at the food for one minute while it was held approximately 3 inches from the participant's nose. After each trial, salivation was measured using the Strongin-Hinsie Peck method (Peck, 1959). Total time for each participant was approximately 1.5 hours.

In between each habituation trial, a one-minute intertrial took place. During this intertrial, children in both conditions listened to an auditory stimulus using headphones. Participants in the Audiobook condition listened to a compact disc of their selected audiobook for sequential one-minute presentations. These participants were asked to pay attention to the audiobook and told that they would be asked questions about it at the conclusion of the experiment. In the no Audiobook condition, participants did not attend to an audiobook and instead listened to a compact disc of white noise and sat quietly for the same time duration.

After the experiment was over, participants in the Audiobook condition answered multiple choice questions (two to three questions) based on the story they heard to verify they attended to the task; these questions were written at a third-grade level.

## **Results**

Participants were 28 males and 29 females ages 9 to 12 years. The average adolescent was  $10.5 \pm 1.2$  years of age. Average baseline salivation was  $1.57 \pm 1.14$  g. Normal-weight participants had an average BMI of  $17.55 \pm 1.36$  kg/m<sup>2</sup> and BMI percentile of  $52.27 \pm 19.1$ . OW participants had an average BMI of  $28.88 \pm 4.19$  kg/m<sup>2</sup> and BMI percentile of  $98.03 \pm 1.30$ . The sample was 28.1% Non-Hispanic African American, 68.4% Non-Hispanic Caucasian and 3.5% Non-Hispanic mixed race.

The two-way interaction between condition and blocked trials was non-significant [ $F(4,57) = 1.25, p = .31$ ]. However, there was a significant main effect of blocked trials [ $F(4,57) = 6.07, p = .001$ ] and a significant interaction of weight status with blocked trials [ $F(4,57) = 3.54, p = .015$ ]. Post hoc simple contrasts revealed that regardless of condition (audiobook vs. no audiobook), the normal-weight group habituated [ $F(1,27) = 2.58, p = .122$ ] while the OW group did not [ $F(1,30) = 4.71, p = .039$ ].

## **Discussion**

This study sought to explore one mechanism of the environmental (e.g., television viewing) and biological (habituation via salivation) influence on OW in children. The primary objectives of the study were to determine if salivation patterns varied based on weight status and/or allocating attention to a task. Results demonstrated that salivation patterns varied by weight status but not by task condition. More specifically, it was found that across conditions, normal-weight children habituated to food cues over time while OW children did

not. These findings suggest that normal-weight and OW children have different biological responses to food.

The salivation pattern (increasing salivation over trials) for the OW group is similar to those previously reported for obese women and women with bulimia nervosa (Epstein, Paluch, & Coleman, 1996; Wisniewski et al., 1997). In all cases, salivation patterns generally increased over time for the target group (no habituation; obese women; OW children; women with bulimia nervosa) and decreased for the control group (habituation; normal-weight, no eating disorder symptoms) suggesting that certain eating patterns may be associated with irregular patterns of habituating to food.

### **Implications and Future Directions**

OW in children and adult obesity has increased dramatically over the past two decades. There are numerous medical, psychosocial and economic consequences associated with OW. In addition, child OW is a known risk factor for the development of adult obesity and, increases the risk of adult morbidity and mortality independent of adult obesity status. Given these consequences, risk factors and the potential health benefits resulting from successful treatment, the WHO (2003) recently declared successful long-term treatment of childhood OW the most promising direction to address this epidemic. While there are effective short-term treatments available for OW children and adolescents, relapse rates remain high. To best improve the current treatment options, translational research exploring the underlying causal and maintaining factors of OW are needed. Only then can we apply the knowledge from these basic studies to design optimal treatments to both prevent and cure OW.

OW children are consuming energy well beyond their physical needs. Results from the present study suggest that this overconsumption may be related to their biological response to food. In particular, the salivation patterns found in this study indicate that OW children eat past the point of satiety whereas normal-weight children do not. This salivation pattern may be an early marker of individuals who go on to develop OW and/or other eating disturbances. In addition, these findings raise the possibility that OW children may not be able to rely on their internal signals of hunger and satiety to regulate their food intake which in turn could help to explain the refractory nature of this condition.

To determine if the lack of habituation observed in OW children is indicative of an inability to biologically regulate food intake, replication of habituation studies with OW samples is required. In addition, correlational data assessing the strength of the relation between objective (blood glucose, stomach distension) and subjective measures of hunger and fullness (self-report questionnaires) would be informative. Lastly, an extensive follow-up study that would allow us to objectively measure weight maintenance and its relation with salivation is warranted. For example, offering OW children a standard weight loss treatment and assessing habituation patterns at baseline, post treatment and one-year follow-up. This type of study would allow a test of whether habituation patterns at baseline predict weight status at post treatment (weight loss) or one-year follow-up (weight maintenance). If OW children (or a subset of these children) are indeed unable to regulate their hunger and fullness cues, a stronger focus on portion control may be a useful strategy to improve prevention and treatment programs.

In summary, it is well documented that approximately half of OW children become obese adults (Serdula et al. 1993; Freedman et al., 2004; Must et al., 1992; Whitaker et al., 1997). Given the poor success of weight-loss treatments for adults with obesity, it is imperative that we intervene with children and adolescents before their OW tracks into adulthood. The findings from the present study suggest that the positive energy balance, which characterizes this condition, may be related to biological as opposed to environmental factors. Future research is needed that evaluates whether this lack of habituation among OW children is in anyway facilitating the maintenance of their OW status. If confirmed, these findings could potentially offer novel strategies to improve long-term success in both treatment and prevention of OW.

### **Summary in Lay Language**

We are interested in better understanding the environmental and biological variables that are involved in the cause and/or maintenance of obesity in youth. With the support of the Longer Life Foundation, we tested: 1) whether basic biological responses to food differ between normal-weight and obese children; and 2) whether these basic responses differ when focusing attention to something while eating (e.g., watching television). To test this, we recruited 60 children (30 normal-weight and 30 obese) and repeatedly measured their saliva while smelling food. At the same time, half the children listened to a story while the other half sat quietly. We did not find that focusing attention on other activities while eating impacted basic responses to food. However, we demonstrated that biological processes in obese children do indeed differ and may limit their ability to self-regulate food intake, potentially leading to overconsumption. These findings suggest that obese and normal-weight children have different biological responses to food. Important recommendations from this study include tailoring current treatments to focus on portion control.

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