Brain Responses to Food Logos in Obese and Healthy Weight Children

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Objective To evaluate brain activation in response to common food and nonfood logos in healthy weight and obese children.

Study design Ten healthy weight children (mean body mass index in the 50th percentile) and 10 obese children (mean body mass index in the 97.9th percentile) completed self-report measures of self-control. They then underwent functional magnetic resonance imaging while viewing food and nonfood logos.

Results Compared with the healthy weight children, obese children showed significantly less brain activation to food logos in the bilateral middle/inferior prefrontal cortex, an area involved in cognitive control.

Conclusion When shown food logos, obese children showed significantly less brain activation than the healthy weight children in regions associated with cognitive control. This provides initial neuroimaging evidence that obese children may be more vulnerable to the effects of food advertising. *(J Pediatr 2013;162:759-64)*.

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An environmental factor implicated in overeating—and ultimately obesity—is food marketing.[1] Every year, food and beverage companies spend more than $10 billion to market their products to children in the US.[2] The goal of these marketing efforts is to establish brand recognition, brand preference, and brand loyalty at a young age. Studies have shown that advertising is an effective means to this end. Research examining the effects of television food advertising on children has shown that children exposed to television advertisements will prefer advertised foods at higher rates than those not exposed to advertisements.[3] For example, one study found that preschoolers reported that foods wrapped in branded packaging tasted better than the same foods wrapped in generic packaging.[4] In addition, the amount of children's exposure to advertisements is directly correlated with the number of attempts they make to influence parents' purchases.[3]

A downside to food marketing is that advertising exposes children to unhealthy foods more frequently than healthy foods.[5] One study found an association between exposure to advertisements for energy-dense and micronutrient-poor foods and an increased risk of obesity in children.[6] Another study determined that compared with healthy weight children, overweight children consume significantly more calories in brand name foods versus generic foods.[7] These findings suggest that children carrying excess weight may be more responsive to food branding and thus at greater risk for marketing persuasion.

Functional neuroimaging studies examining brain activation in response to food images have identified brain regions related to both reward (limbic and paralimbic regions) and cognitive control (prefrontal cortices) in children.[8-11] However, to date few neuroimaging studies have examined brain activation to culturally familiar brands, and only one study has looked at food-related brands. Moreover, all of these studies have focused on healthy adults viewing culturally familiar logos. Findings have identified the dorsolateral prefrontal cortex (PFC), ventromedial PFC, orbitofrontal cortex (OFC), anterior cingulate cortex, ventral striatum, and hippocampus as involved in brand recognition.[12-16] Several of these areas—PFC, OFC, anterior cingulate cortex, ventral striatum, and hippocampus—are also involved in aspects of food motivation (both the "drive" and the "control" regions) and have been identified in functional magnetic resonance imaging (fMRI) studies that examined the cortical foundations of overeating and obesity.[8,10,17-19]

The aim of the present study was to compare neural responses to brand logos in obese and healthy weight children as they viewed food brand and nonfood brand logos. We hypothesized that children would demonstrate greater brain activation to food logos in "drive" regions (ie, ventral striatum and OFC) compared with the healthy weight children, and that the healthy weight children would demonstrate greater brain activation to food logos in "control" regions (ie, PFC) compared with the obese children.

fMRI	Functional magnetic resonance imaging
OFC	Orbitofrontal cortex
PFC	Prefrontal cortex

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Methods

The protocols for the pilot validation study and the main fMRI study were reviewed and approved by the Human Subjects Committee at the University of Kansas Medical Center. Before participation, written informed consent was obtained from each child's parent/legal guardian and written informed assent was obtained from each child.

A pilot validation study was first conducted to select the most appropriate logos for use in the fMRI study. Thirty-two children (13 males) aged 9-16 years (mean ± SD, 11.5 ± 2.2 years) used a 5-point Likert scale to rate 239 culturally familiar brand logos on 3 dimensions: familiarity, valence (happy/sad), and arousal (exciting/boring) (**Figure 1**). The Likert scale used was the same one used in stimulus validation studies for the International Affective Picture Set.[20] Based on the children's ratings, 60 food logos and 60 nonfood logos rated highly familiar were selected. Food logos as a group were matched on familiarity with nonfood logos [$t(118) = 0.33$; $P = .74$]. The food and nonfood logos were not significantly different on valence [$t(118) = 1.26$; $P = .21$] or arousal [$t(118) = 1.49$; $P = .14$]. A total of 120 logos were used in the fMRI paradigm in the main study (**Table I**; available at www.jpeds.com). Blurred baseline images were created from the food and nonfood logos using 3 iterations of a fast Fourier transform, rendering the logos unidentifiable (**Figure 1**); thus, the blurred baseline images were matched to the logos based on color, brightness, and intensity.

Twenty children (11 females), aged 10-14 years (mean, 11.85 ± 1.23 years), were recruited from local pediatric clinics and e-mails sent to University of Kansas Medical Center employees. All children were right-handed and in an age-appropriate grade. Exclusion criteria included participation in the pilot validation study, a major psychiatric diagnosis (eg, depression, attention deficit hyperactivity disorder) or neurologic illness (as determined by parental interview), and uncorrected impaired vision. All children spoke English as their primary language. Ten children were of healthy weight (mean body mass index percentile, 50.0 ± 19.7%), and 10 children were obese (mean body mass index percentile, 98.9 ± 1.7). There were no significant differences between the 2 weight groups in terms of age [$t(18) = 0.91$; $P = .38$], sex [$\chi^2 = 1.82$; $P = .18$], or parental income [$t(18) = 1.18$; $P = .26$].

The children and their parents completed several questionnaires, including those eliciting demographic data and self-control measures. Children were weighed and measured at the visit. Self-control was assessed using the impulsivity subscale of the 23-item Eysenck I6 Junior Questionnaire, which was created exclusively for use in children.[21] In this questionnaire, responses are "yes" or "no" to questions such as: "Do you generally do or say things without stopping to think?" None of the items specifically relate to eating behaviors or food. Higher scores on the measure are indicative of greater impulsivity.

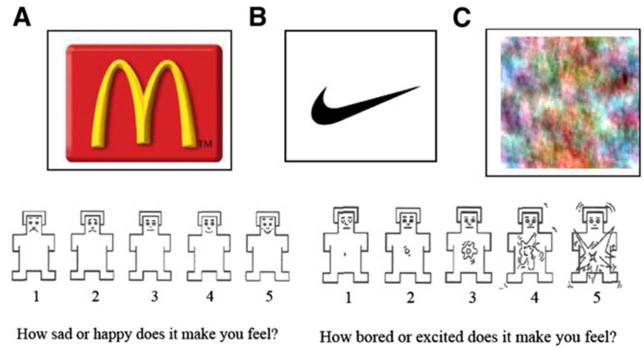

Figure 1. **A** and **B,** Examples of items from the pilot validation of logos before the main fMRI study. **C,** Example of blurred logo. Logos are registered trademarks and are the property of their respective owners.

The fMRI study was conducted at a minimum of 4 hours after the child's last food intake. Before the study, the procedure was fully explained to the child and parents, and the child provided a self-report hunger rating on a visual analog scale. The fMRI experiment consisted of a structural scan followed by 2 functional runs. The entire scanning session took approximately 45 minutes.

Data were acquired with a 3-T Allegra scanner (Siemens, Erlangen, Germany) at the University of Kansas Medical Center's Hoglund Brain Imaging Center. T1-weighted anatomic images were acquired with a 3-dimensional (3D) magnetization-prepared rapid acquisition with gradient echo sequence (repetition time/echo time = 23/4 ms, flip angle = 8°, field of view = 256 mm, matrix = 256 × 192, slice thickness = 1 mm). Each scan consisted of one anatomic scan and two 6-minute, 36-second functional sequences. Gradient echo blood oxygen level-dependent scans were acquired in 43 contiguous axial slices at an angle of 40° to the anterior commissure–posterior commissure line (repetition time/echo time 3000/30 ms, slice thickness = 3 mm [0.5 mm skip], in-plane resolution = 3 × 3 mm, 130 data points). To minimize susceptibility artifact in ventromedial prefrontal regions, all participants were carefully positioned so that the anterior commissure–posterior commissure plane was between 17° and 22° from axial in scanner coordinate space, ensuring that the 40° slice acquisition angle was applied in the same way for all subjects. In addition to minimizing susceptibility artifact, this procedure standardized head positioning between subject groups of widely divergent size (healthy weight and obese).

Using a previous study's block design, the 60 food logos, 60 nonfood logos, and blurred baseline images were displayed.[8] Each logo was presented only once to each participant. Functional scans involved 3 repetitions of each block of each stimulus type (ie, food logos), alternated between blocks of blurred images. Stimulus presentation time was