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Effects of restriction on children's intake differ by child temperament, food reinforcement, and parent's chronic use of restriction

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Abstract

Parents' use of restrictive feeding practices is counterproductive, increasing children's intake of restricted foods and risk for excessive weight gain. The aims of this research were to replicate Fisher and Birch's (1999b) original findings that short-term restriction increases preschool children's (3–5 y) selection, intake, and behavioral response to restricted foods, and to identify characteristics of children who were more susceptible to the negative effects of restriction. The experiment used a within-subjects design; 37 children completed the food reinforcement task and heights/weights were measured. Parents reported on their use of restrictive feeding practices and their child's inhibitory control and approach. Overall, the findings replicated those of Fisher and Birch (1999b) and revealed that the effects of restriction differed by children's regulatory and appetitive tendencies. Greater increases in intake in response to restriction were observed among children lower in inhibitory control, higher in approach, who found the restricted food highly reinforcing, and who had previous experience with parental use of restriction. Results confirm that parents' use of restriction does not moderate children's consumption of these foods, particularly among children with lower regulatory or higher appetitive tendencies.

Keywords

restriction; inhibitory control; approach; food reinforcement; children

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BACKGROUND

Given the current obesogenic environment where palatable, energy-dense snack foods are readily available and heavily marketed to children, it is not surprising that children's diets are too high in added sugar and fat (Reedy & Krebs-Smith, 2010). In this context, effective approaches to limiting children's intake of palatable snack foods are needed. However, past research has revealed that restrictive feeding practices may heighten the attractiveness and intake of foods that have been previously restricted (Fisher & Birch, 1999a, 1999b). Fisher and Birch (1999b) found that restricting preschooler's access to a palatable snack food increased their intake of that food when it became available, and increased the frequency of positive comments, requests, and attempts to access this food during periods of restriction. A more recent study also suggests that children's temperament (e.g., inhibitory control) may moderate the negative effects of restriction on children's eating behaviors (Anzman & Birch, 2009). The current study aimed to replicate Fisher and Birch's (1999b) original finding that restriction increases children's eating responses to restricted foods, and to identify child-based characteristics that may increase the negative effects of restriction on children's eating behaviors.

Fisher and Birch (1999b) provided the first experimental evidence that restricting children's access to a palatable food increases their intake, selection, and behavioral response for that food. Children in an ongoing childcare program were served two similar foods at their regularly scheduled snack time. However, one of the foods was kept freely available during the entire snack period while the restricted food was only available for a short period during snack time. The restriction generated an increase in children's behavioral response to the restricted food and restriction itself; children made more comments about the snacks, "I want it!", clapping when access was granted, or pounding their fists on the table when access was no longer available. Children also took more scoops of the restricted food and consumed more of this food when it was briefly made available immediately after the restriction. Despite evidence for the short-term effects of restriction, when children were given unlimited access to the restricted food three weeks following the restriction, long term effects of the restriction were not observed. Since the publication of this seminal work, two other studies have demonstrated that even a one-time restriction to candy and fruit immediately increases children's desire for and intake of these foods (Jansen et al., 2008; Jansen et al., 2007); however, the Fisher and Birch study, in which foods were repeatedly restricted, has yet to be replicated, which was the aim of the current study. In addition, this study aimed to investigate whether the effects of restriction persisted by reassessing children's responses to the restricted snacks one week after the last restriction event.

New research has emerged highlighting the moderating role of regulatory dimensions of temperament on the effects of restriction. Anzman and Birch (2009) found that when 7-year old girls' perceived greater parental restriction *and* had lower inhibitory control—a self-regulatory dimension of temperament that refers to a child's reduced ability to plan and suppress inappropriate approach responses under instructions to do so, or in novel uncertain situations (Rothbart, Ahadi, & Evans, 2000)—, they displayed the greatest weight gain from ages 7 to 15, relative to their counterparts. In general, children lower in self-regulation show greater intakes of palatable, energy-dense foods (Riggs, Spruijt-Metz, Sakuma, Chou, &

Pentz, 2010) and it may be that these children are less able to control their intake of forbidden foods when access is given and thus be at greater risk for the negative effects of restriction.

The effectiveness of regulatory dimensions such as inhibitory control to modulate behavior in part depends on children's appetitive tendencies. For example, having high levels of approach—a reactivity-based dimension of temperament that refers to greater levels of excitement or positive affect experienced in anticipation of pleasurable activities like prizes and food (Rothbart et al., 2000)—may make it difficult for children to put on the "brakes" and control their impulses (Rothbart, Derryberry, & Hershey, 2000). Similarly, children who find palatable foods highly reinforcing may find it difficult to control their intake when in the presence of previously forbidden foods. The reinforcing value of food refers to how hard an individual will work to gain access to food (Epstein, Leddy, Temple, & Faith, 2007; Hodos, 1961), and provides a measure of individual differences in approach tendencies towards food by measuring differences in motivation to consume palatable food (Depoortere, Li, Lane, & Emmett-Oglesby, 1993; Roberts, Loh, & Vickers, 1989). The reinforcing value of food has been shown to predict food intake and excessive weight gain in children (Temple, Legierski, Giacomelli, Salvy, & Epstein, 2008; Hill, Saxton, Webber, Blundell, & Wardle, 2009). When viewed as an obesogenic profile, characterized by lower inhibitory control, higher reinforcing value of energy-dense foods, and greater approach or reward sensitivity (Davis et al., 2007), obese or overweight children may be at higher risk for the negative effects of restriction. In the current experimental study, we aimed to extend the work of Anzman and Birch (2009) by investigating whether individual differences in children's inhibitory control, approach, reinforcing value of the restricted food, and BMI percentiles were related to the effects of a short-term restriction on children's eating responses.

Lastly, having a history of parental restriction may also amplify the negative effects of future restriction events on children's eating behaviors. For example, in Fisher and Birch's (1999b) original work, mothers who reported repeated chronic use of restriction at home had children who selected a more palatable snack food immediately after its short-term restriction in a preschool setting. Given that restriction has been shown to increase children's responsiveness to external cues for palatable foods (Birch, Fisher, & Davison, 2003) and focus on restricted foods (Fisher & Birch, 1999b), children with past restriction experience may be more sensitive to future restriction events than children with less experience with restriction.

In summary, the current study had two aims. The first aim was to replicate Fisher and Birch (1999b) and show that a repeated restriction increases children's eating responses *immediately* following short intervals of restricted access, and to evaluate whether the effects of restricted access *persist* 1-week after the last restriction event. The second aim was to evaluate whether individual differences in inhibitory control, approach, the reinforcing value of the restricted food, weight status, and past experience with parental restriction predict change in children's eating responses to the restricted food, immediately after the restriction and 1-week after the last restriction event. For the purpose of this study, the reinforcing value of the restricted food was assessed using the relative reinforcing value

(RRV) of food task developed by Epstein and colleagues (Epstein et al., 2004; Temple et al., 2008) and adapted for use in the current preschool sample (Rollins, Loken, Savage, & Birch, 2013b). We hypothesized that children with lower inhibitory control would show greater increases in their behavioral response to, and intake and selection of the restricted food immediately after the restriction and 1-week after the last restriction event. Similarly, we expected greater change in eating responses among children with higher levels of approach, RRV of the restricted food, BMI percentile, and history with parental restriction.

METHODS

Participants

Subjects were 42 children (ages 3–5) and parents attending a full-day daycare in central Pennsylvania. Exclusion criteria included having a health condition that could impact food intake and known food allergies. Children were recruited via letters addressed to parents; parents provided consent for their family's participation. Upon providing their consent, parents completed two brief surveys; mothers completed the majority of surveys (80%). In the current paper, we excluded children with behavioral difficulties and who could not complete the procedures (n=2), were frequently absent during snack intake sessions (n=2), and had missing baseline data (n=1). This reduced the sample size to 37.

Design and procedural overview

The experimental design included a series of procedures and measures organized into brief sessions before and after a 2-week restriction period (Figure 1). Measures hypothesized to be more trait-like (e.g., inhibitory control) were assessed once before the 2-week period. All sessions and restriction events were completed between 2:30pm and 4:30pm (2.5 to 3 hours after a standard school-served lunch) in the preschool setting, lasted ≤35 minutes, and replaced the school-served afternoon snack.

Baseline—Children were first familiarized with our trained staff members and the liking task (Figure 1). The liking task was administered using six sweet snack foods marketed to children (e.g. graham crackers) and, in separate session, using eight savory snack foods (e.g. cheese crackers). Based on children's liking, Scooby Doo™ graham crackers (Kellogg, Battle Creek, MI) and Sponge Bob™ graham crackers (Kraft, Northfield, IL) were selected to be the restricted or unrestricted foods because they were only moderately liked (rank: 4.6 vs. 3.5, respectively; range 1 to 6), and did not differ in energy density (kcal/g; 4.5 vs. 4.5) and macronutrient composition. The two types of graham crackers were counterbalanced to be the restricted and unrestricted food by classroom. In a third session, the child version of the Child Feeding Question (KCFQ) was administered by research staff.

In the fourth and fifth sessions, children were given free access to generous portions of the unrestricted and restricted foods during 15-minute *ad libitum* snack sessions. Children were seated in small groups of 4 7 with a trained staff member at each table. Two large bowls of each study food were placed in the center of the table and children were instructed to serve themselves. Children were also served an 8-ounce carton of skim milk. The purpose of the fourth session was to familiarize children with the two study foods to reduce novelty effects;

in the fifth session, children's intake, selection, and behavioral response to the snack foods at baseline were measured. In the sixth session, children completed a hunger task (Fisher & Birch, 1999b) and the RRV of food task. If a child reported that they were full in the hunger task, the RRV of food task was not administered and the child was approached on a subsequent day to complete the RRV of food task.

Restriction period—During the restriction period, children participated in 4 sessions, 2 per week (Figure 1). Consistent with Fisher and Birch (1999b), all the snack sessions—baseline, restriction, and post-test—were 15-minutes in duration. The restriction snack sessions were the same as the snack sessions during baseline, except that the restricted food was only available for a 5-minute interval that began 5 minutes after the start of the 15-minute snack period, while the unrestricted food was available for the entire 15-minute period.

Post-test—A post-test snack session was completed one week after the 2-week restriction period (Figure 1). In this session, children had unlimited access to generous portions of the restricted and unrestricted foods. Lastly, children's height and weight were measured.

Parents received $10 for their family's participation and each classroom received $50. The Pennsylvania State University Institutional Review Board approved all study procedures.

Measures and procedures

Liking task—Children's liking of the study foods was measured using the Birch liking assessment (1979). Each child was first familiarized with three non-gendered faces visually representing "really yummy", "really yucky", or "just okay". The child was then asked to categorize each food, in self-selected order, by first tasting it and then placing it in front of the face that best represented their liking of that food. After all the foods were categorized, the child was instructed to place the foods in order from most liked to least liked to obtain ranked liking scores ranging from 1 (least liked) to 6 (most liked).

Selection and intake—Children's selection (i.e., number of scoops) and intake of the restricted and unrestricted foods were measured using video recordings of all snack sessions. Trained coders counted pieces of each food eaten by each child. All coders were trained until they independently achieved 70% on a criterion videotape. Inter-*rater* agreement was acceptable for both foods for intake (ICC's: >.70) and selection (100% agreement). Average gram weight of each brand of cracker was used to convert number of pieces eaten into grams. Using manufacturer's information, number of grams eaten was converted into calories consumed for each 5-minute interval (e.g. first 5 minutes) of the snack sessions.

Behavioral observation—Children's vocalizations and behaviors in response to the restricted food and restriction itself (e.g., saying "I want it", physical attempts to get access to the restricted food) were measured by coding the videotaped observations of snack sessions, using an observation checklist developed by Fisher and Birch (1999b). All coders were trained on the observational checklist until they independently achieved 70% on a criterion videotape. Inter-*rater* agreement was acceptable for both graham crackers for behavioral response (ICC's: >.70). A behavioral response score for the restricted food was created by summing the frequencies of children's vocalizations and behaviors related to the restricted food or restriction itself, for each 5-minute interval of each snack session.

RRV of food task—The RRV of the restricted and unrestricted foods was measured using an RRV of food task (Epstein, Wright, et al., 2004; Rollins, Dearing, & Epstein, 2010) that was adapted for use in the current preschool sample (Rollins, Savage, Loken, and Birch, 2013b). Children completed the RRV of food task individually in stations and could work for access to one-piece portions of the restricted food by clicking on one computer mouse and the unrestricted food on another mouse. The computer mice were connected to two hidden computers that recorded the number of clicks on independent concurrent PR schedules. The schedule of reinforcement for both foods began at a ratio of 4 and then doubled (8, 16, 32, 64, 128, 256, 512, 1028, 2056) each time a reward was earned. Children were instructed that they 1) would receive the rewards as soon as they were earned, 2) could only click on one mouse at a time, and 3) would be finished when they no longer wished to earn access to any of the graham crackers. Children were asked to tell the interviewer when they were finished earning snacks. Children were instructed that they could eat their rewards as they earned them and anytime during the task, but that they could not take the rewards out of the room when they were done working for snacks. Each child was left alone in the station to complete the task. On average, children spent 14.4 ± 10.0 minutes working to access the snack foods and 9 children had their task terminated at 30 minutes, the maximum duration of the task. To examine whether preference for the restricted food predicted greater change in eating response after the restriction, a score of %RRV was calculated as the number of responses made for the restricted food divided by the total responses made for both foods.

Inhibitory control and approach—Children's inhibitory control, a dimension of regulation, and approach, an index of reactivity, were assessed by parent report using the Children's Behavior Questionnaire (CBQ; Rothbart, Ahadi, Hershey, & Fisher, 2001). Inhibitory control was measured using 13 items (e.g., "[Child] can wait before entering into new activities if s/he is asked to") and approach using 13 items (e.g., "When s/he sees as toy s/he wants, gets very excited about getting it") on a Likert-type scale (1= "extremely untrue" to 7= "extremely true"). Inhibitory control and approach subscales were created by averaging item responses and had moderate internal consistency (α = .74, α = .67; respectively).

History of parental use of restriction—Three measures of parental restriction were used in the current study: the parent and child versions of the CFQ, and the parent RAQ. Child measures may be less biased in their assessment of restriction because they measure children's perceptions of their experience of restriction, which often do not correlate with parent reports (O'Malley, unpublished honor's thesis). The CFQ restriction subscale provides a more global measure of restriction, in contrast to the RAQ, which assesses specific restrictive feeding strategies, including "keeping snack foods out of reach". The latter was shown to be a salient measure differentiating between profiles of controlling feeding practices in Rollins, Loken, Savage, and Birch (2013a).

The restriction subscale (8 items; e.g., “I have to be sure that my child does not eat too many sweets”) from the CFQ (Birch et al., 2001) was used. The subscale was measured using a 5-point Likert scale and responses were averaged; internal consistency was .77 in the current sample. To measure child perceived restriction, trained interviewers administered the child version of the CFQ (i.e., KCFQ; Carper et al., 2000), which was piloted in children 3–6 years of age in our lab. The restriction subscale was composed of 10 items (e.g., “If you ask for a snack, does mommy [or daddy] let you have it?”) and response options were “no”, “sometimes”, or “yes”. A score for child perceived restriction was created by averaging these items; internal consistency was .85 in the current sample. Lastly, to measure parents' use of the controlling practice of keeping snack foods out of children's physical reach, parents were asked, “At home, do you try to keep any of these foods out of your child's reach, so that your child cannot physically reach it?” This question was asked about each of six snack foods (graham crackers, cheese crackers, butter crackers, goldfish crackers, vanilla wafers, and pretzel crackers). A percentage score was created for ‘out of reach’ by dividing the number of foods parents reported keeping out of reach by the total number of foods (i.e. 6), representing the proportion of study foods parents kept out of reach.

Child BMI—Child height and weight were measured in triplicate by trained staff members. BMI percentiles were calculated using the 2000 CDC Growth Charts (Kuczmarski et al., 2000); BMI percentiles of ≥85th were used to classify children as overweight and >95th as obese.

Child age and gender, and household income were reported in the parent survey.

Analytical Plan

Except where noted, all data analyses were completed using SAS version 9.3 (SAS Institute Inc., Cary, NC, USA). To increase the reliability of the eating response measurements during the 2-week restriction period, children's intake, selection (i.e., number of scoops taken), and behavioral response to the restricted and unrestricted foods were averaged across the four snack sessions completed in the restriction period. Pearson correlations were calculated on the key variables of interest (e.g., inhibitory control, approach, past experience with restriction) to evaluate relations between potential covariates (i.e., child's age and gender, food assignment, liking of the restricted food) and outcome variables (i.e., intake, selection, and behavioral response). Significant covariates were entered into all adjusted models.

Repeated measures ANOVA models were used to evaluate if children's selection, intake, behavioral response to the restricted food increased from baseline to 1) immediately after the 5-minute intervals of restricted access (i.e. restriction period) and 2) 1-week following the restriction period (i.e. post-test). In each model, time (i.e., restriction) was used as the within-subjects factor. For the models evaluating change immediately after 5-minutes of restricted access, children's eating responses made in the first 5-minute interval of the baseline session was compared to the responses made in the second 5-minute interval of the restriction sessions. The second 5-minute interval of the restriction sessions was used because it was the first and only opportunity children had access to the restricted food. In models evaluating change from baseline to 1-week after the restriction period (i.e. post-test), the eating responses made in the first 5-minute interval of the baseline and post-test sessions were compared. To adjust for change in children's intake across the intake sessions, children's eating responses were also evaluated as a percentage of total (restricted food + unrestricted food) responses for both foods; however, the results were similar to the unadjusted findings and therefore are not presented.

Hierarchical linear regression models were used to evaluate whether child inhibitory control, approach, BMI percentile, %RRV of the restricted food, and past experience with restriction predicted greater change in children's behavioral response, selection, and intake of the restricted food. Hierarchical regressions were used because they allowed for the evaluation of each predictor in terms of R^2 estimates. In each model, significant covariates were entered as Step 1 along with the baseline measure of the outcome variable (e.g., intake at baseline). Next, the predictor of interest (e.g., inhibitory control) was entered into step 2. When the predictor was at least marginally significant (i.e., $p<.10$), the sample was divided using median splits on the predictor to yield high and low groups (e.g. high inhibitory control, low inhibitory control). Mean differences in the outcome at the two different time points (e.g., baseline vs. restriction) were evaluated within each group using paired sample t-tests. For example, intakes of the restricted food at baseline and immediately after the 5-minute intervals of restricted access were compared for children in the low inhibitory control group, and then children in the high inhibitory control group. Lastly, in cases when two predictors were correlated, both predictors were tested in one hierarchical linear regression model to determine if each predictor remained statistically significant in the presence of the other. Unfortunately, due to our small sample size, we were not able to enter all the predictors into one regression model.

Cook's D and leverage estimates were examined in all models. In the hierarchical regression models predicting intake during the restriction sessions, two participants were identified who consistently had multivariate influence on the models and modified the significance of the parameters. Overall, these children tended to score very low or very high on several predictor variables (e.g. approach, inhibitory control) of interest. As a result, these children were excluded from the hierarchical regression models. In addition, the sample size differed slightly for some of the analyses due to missing data. Not all parents returned the parent surveys: three families did not return the keeping snack foods 'out of reach' and household demographics parent surveys, and six families did not return the CFQ restriction survey and approach and inhibitory control measure. Families who did not return the surveys did not differ from families who returned the surveys in terms of the predictors and outcomes. Lastly, analyses examining the RRV of food task include 35 of the 37 children; two children were removed for failure to understand instructions in the RRV of food task.

RESULTS

Descriptive statistics are shown in Table 1. On average, children were 4.5 ± 0.7 (mean ± SD) years old, from middle- to high-income households, and primarily White, non-Hispanic. Children had BMI percentiles of 55.3 and only 16% of the sample had percentiles >85th percentile, which was below national estimates (Ogden, Carroll, Kit, & Flegal, 2012).

Children's approach levels were similar to the normative data provided for 3–5 year olds in Rothbart et al. (2000), while the inhibitory control scores were slightly higher than the published normative means and ranges for this age group. Inhibitory control was inversely correlated with approach ($r=-.37$, $p<.05$) and child-perceived restriction ($r = -.34$, $p<.10$); no other inter-correlations between key variables of interest (BMI, inhibitory control, approach, past experience with restriction) and potential covariates (i.e., child's age and gender, food assignment, liking of the restricted food) reached statistical significance. In addition, parents reported intentionally keeping, on average, 62% of the 6 types of snack foods out their child's physical reach; however, there was wide variability across parents, with 59% of parents reportedly keeping *all* of the snack foods out of reach and 32% keeping *none* of the foods out of reach. Only 9% reported that they kept some of the 6 snack foods out of reach. Across the sample, no mean differences in the ranked liking of the restricted and unrestricted foods were observed at baseline (2.9 vs. 3.0, $p > .05$; data not shown).

Inter-correlations between potential covariates (i.e., age, gender, food assignment, liking of restricted food) and the outcome variables revealed that children's liking and age were positively correlated with intake of the restricted food immediately after the 5-minute intervals of restricted access ($r = .42$, $p<.01$; $r = .43$, $p<.01$; respectively). Food assignment predicted behavioral responses ($r=.46$, $p<.01$), selection ($r=.50$, $p<.01$), and intake ($p = .34$, $p<.05$) of the restricted food at post-test, in which children with Scooby Doo™ as their restricted food showed greater eating responses at post-test. In light of these correlations, the following models were adjusted for age, food assignment, and liking of the restricted food; however, given that the adjusted and unadjusted results demonstrating the main effects of restriction were not different, and the unadjusted results are presented.

Main effects of restriction

At baseline, no initial group differences in children's behavioral response, intake, and selection for the restricted food and unrestricted food were observed. As shown in Figure 2, a main effect of restriction was observed for children's behavioral responses to the restriction ($p < .01$), with children's behavioral response doubling immediately after the 5-minute intervals of restricted access. A main effect of restriction was also observed on children's intake of the restricted food ($p < .01$; Figure 2); children's intake of the restricted food, on average, increased 60.5% from 25.8 ± 24.9 kcal at baseline to 42.5 ± 21.8 kcal immediately after the 5-minute intervals of restricted access. In contrast, no effects of the restriction were observed on children's selection of the restricted food immediately after the 5-minute intervals of restricted access or on children's eating responses 1-week after the restriction period (*p's* >.05).

Individual differences in the effects of restriction on food intake, behavioral response and selection

The secondary aim of this research was to examine individual differences in the immediate (i.e, snack intake after the restricted food became available in the restriction sessions) and persistent effects (i.e, one week following the restriction sessions) of the restriction on children's eating responses, using measures of inhibitory control, approach, BMI, RRV of the restricted food, and past experience with restriction. For these analyses, independent hierarchical linear regression models were used for each predictor and the standardized beta values and R^2 values are presented. In the cases when two predictors were correlated (i.e., inhibitory control and approach; inhibitory control and child-perceived restriction), both predictors were tested in one hierarchical linear regression model to determine if each predictor remained statistically significant.

Inhibitory control—After adjusting for intake at baseline and covariates, inhibitory control predicted children's intake of the restricted food immediately after the 5-minute intervals of restricted access ($\beta = -.31$, $p < .05$; $R^2 = .09$). As shown in Figure 3, children with low inhibitory control had intakes of the restricted food that were higher immediately after the 5-minutes of restricted access than at baseline; whereas no difference was observed for high inhibitory control children. It is worth noting that the results did not change after approach, a dimension of temperament moderately correlated with inhibitory control, or child-perceived restriction were added to the hierarchical linear regression model (data not shown).

Approach—Approach marginally predicted children's intake of the restricted food immediately after the 5-minute intervals of restricted access ($\beta = .27$, $p < .10$; $R^2 = .06$). As shown in Figure 3, high approach children consumed more calories immediately after the 5-minutes of restricted access than at baseline, whereas no difference was observed for low approach children. The results remained the same after inhibitory control was added to the hierarchical linear regression model (data not shown).

BMI—No effect of BMI percentile on children's intake of the restricted food was observed immediately after the 5-minute intervals of restricted access (data not shown).

RRV—Children's initial %RRV of the restricted food predicted greater change in children's intake of the restricted food immediately after the 5-minute intervals of restricted access ($\beta = .32$, $p < .05$; $R^2 = .09$). As shown in Figure 3, children who found the restricted food more reinforcing relative to the unrestricted food had greater change in their intake of the restricted food.

Past restriction experience—Parents' reports of keeping snack foods out of reach predicted children's intake immediately after the 5-minute intervals of restricted access ($\beta = .33$, $p < .05$; $R^2 = .11$). To explore this relation, a dichotomous score was created where 1=*all* snack foods kept out of reach (comprised 59% of the sample) and 0=*none* or *some* snack foods were kept out of reach. As shown in Figure 3, children whose parents reported keeping *all* snack foods out of reach increased their consumption of the restricted food immediately after the 5-minute intervals of restricted access. Parents and children's reports on the parent and child-versions of the CFQ restriction subscales did not predict change in children's intake.

In contrast to the associations of child characteristics with food intake reported above, no associations with these characteristics (i.e., inhibitory control, approach, BMI percentile, RRV of the restricted food, and past restriction experience) were observed for other behavioral outcomes (selection and behavioral response to the restricted food) immediately after the 5-minute intervals of restricted access, or on change in eating responses 1-week after the restriction period.

DISCUSSION

The current study provides evidence that restricting access to a palatable food increases children intake of and comments, requests, and attempts to access this food immediately after it becomes restricted, replicating the findings reported in Fisher and Birch (1999b). This study also extends previous work by examining individual differences in the effects of restriction on children's eating responses. Children lower in inhibitory control showed greater increases in their intake of the restricted food immediately after the restriction, while no change was observed for children higher in inhibitory control. A similar finding was observed for children with higher approach and RRV of the restricted food, who had greater increases in their intake of the restricted food immediately after the restriction, relative to children with lower approach or who found the food less reinforcing. Lastly, parents who reported keeping *all* palatable snack foods out of their child's physical reach at home, a controlling feeding practice, had children who increased in their intake of the restricted food immediately after the restriction, while no change was observed among parents keeping *none* or *some* of the snack foods out of reach. No effects of the restriction were observed 1-week after the restriction period ended.

Main effects of restriction

As hypothesized, we found that a short-term restriction increased children's intake and behavioral response immediately after the food was restricted, thereby replicating Fisher and Birch's (1999b) and the more recent work of Jansen et al. (2007, 2008). However, unlike Fisher and Birch (1999b), we found that the restriction had no effect on children's selection (i.e., number of scoops taken) of the restricted food. This might have been due to the size of the scoops (held ~22g of study foods) children used to serve themselves in the present study, which were selected to accommodate the size of the graham crackers. In Fisher and Birch (1999b), children used scoops that held ~7g of the study foods.

The restriction did not have persistent effects on children's eating responses one week following the restriction. This finding is consistent with Fisher and Birch (1999b), who reported that the effects of restriction on children's selection, intake, and behavioral response did not persist three weeks after the restriction ended. It may be that the four restriction trials used in the present study were not adequate to produce long-lasting changes in children's eating behaviors. Among parents who use restriction as a feeding practice, its utilization to control children's intake may be consistent and chronic, occurring daily over months or years. This frequent use of restriction, measured using maternal reports, has been shown to predict increased eating in the absence of hunger (EAH), a measure of eating in response to the presence of palatable foods while satiated, among children cross-sectionally (Fisher & Birch, 1999a) and over time (Birch et al., 2003). Despite the absence of persistent effects in the current study, among families where restriction is chronically imposed, the short-term effects of restriction can have long-term consequences.

Individual differences in the immediate effects of restriction

Children lower in inhibitory control consumed significantly more of the restricted food immediately after it became restricted, while no change in intake was observed for children higher in inhibitory control. This is consistent with Anzman and Birch (2009), who found that when low inhibitory control was coupled with high parental restriction, greater increases in girls' BMI from age 7 to 15 were observed; in contrast to those with higher inhibitory control who had lower BMI trajectories, regardless of restriction level. A similar effect was observed in Rollins, Loken, Savage, and Birch (2013a), in which girls with lower inhibitory control *and* high maternal use of coercive, controlling feeding practices showed the highest increases in eating in the absence of hunger from age 5 to 7, while less change was observed among high inhibitory control girls, regardless of maternal use of controlling feeding practices. As suggested by Anzman and Birch (2009), restrictive feeding practices may only have negative effects among children with low inhibitory control; our findings are consistent with this view.

Children higher in approach increased their intake of the restricted food immediately following restriction, while children lower in approach showed no change. This novel finding is consistent with the defining characteristic of high approach children, who show greater reactivity while in the presence of rewarding stimuli such as palatable foods. Depending on their regulatory abilities, high approach children in general may have greater difficulty "putting on the brakes" and regulating their impulses (Rothbart et al., 2000). Similar to children lower in inhibitory control, high approach children may also be at risk for the negative effects of restriction, particularly when their approach tendencies exceed their ability to inhibit their behaviors.

Children who found the restricted food highly reinforcing increased their intake of the restricted food to a greater extent than children who found the restricted food less reinforcing. These findings are consistent with findings from past work with older children showing that the RRV of food predicts caloric intake (Temple et al., 2008) and weight gain during childhood (Hill et al., 2009). For children who find a palatable snack food highly reinforcing, limiting their intake of this food after it has been restricted may be especially challenging. In the current environment, palatable foods are widely available and highly reinforcing, and are often the foods that parents tend to restrict (O'Dea, 1999). The current findings emphasize the need to identify alternatives to restriction to moderate children's intake of these foods.

We did not find that children's BMI predicted eating responses after the restriction period. To our knowledge, this is the first study to explore the association of BMI with children's eating responses to restriction. It may be that while BMI has been shown to predict parents' use of restriction (Rhee et al., 2009; Rifas et al., 2010), it may not impact how young children respond to restriction. Instead, child characteristics such as behavioral inhibition and RRV of food, which are more closely related to children's eating behaviors (Riggs, Spruijt-Metz, Sakuma, Chou, & Pentz, 2010; Temple et al., 2008), may be better predictors of how children respond to restriction. However, it is also possible that the failure to observe a significant effect of BMI is due to the small sample size and the relatively low percentage of overweight children in the sample.

Parents who reported intentionally keeping *all* of the sweet and savory crackers out of their child's physical reach had children who consumed more of a palatable snack food (i.e. sweet cracker) after it was restricted. This finding is consistent with Fisher and Birch (1999b), who found that children's past restriction experience predicted greater selection of the restricted food immediately after the restriction. Based on the broader parenting literature, keeping *all* sweet and savory crackers out of children's physical reach may be a form of negative parental control in which parents put a physical barrier between a child and desired object to enforce compliance (Karreman, van Tuijl, van Aken, & Deković, 2006); findings to date indicate that this approach tends to predict lower delay of gratification during childhood (Houck, 2004). Parents who report keeping *all* sweet and savory crackers out of their child's reach may also use other controlling feeding practices, and the consistent chronic use of these practices may provide children with few opportunities to practice self-regulatory abilities (Costanzo & Woody, 1985). Keeping *all* sweet and savory crackers out of reach may increase children's attention to forbidden foods and, as the current study shows, encourage increased intakes of these foods when access is given. No significant effects were observed among the more global measures of parental restriction (i.e., CFQ) and child perceived restriction (i.e., KCFQ). However, this may have been due to the measurements themselves. The 'out of reach' subscale was specific to six types of sweet and savory crackers typically consumed as snacks, while the CFQ and KCFQ measured the restriction across all foods including candy, other snack foods, at both mealtimes and snacking occasions. For some parents, the use of restriction may depend on the type of food and eating occasion, for example, desserts may be restricted but savory snacks like popcorn and pretzels are not (O'Dea, 1999).

The same child characteristics that put children at risk for the negative effects of restriction may also elicit parents' use of restriction. For example, lower behavioral inhibition and higher reinforcing value of palatable snack foods have been shown to predict children's intake of these foods (Riggs et al., 2010) and weight gain (Anzman & Birch, 2009; Temple et al., 2008), the latter of which has been linked to parents' increased restriction use (Rhee et al., 2009; Rifas et al., 2010). In Rollins, Loken, Savage, and Birch (2013a), the highest levels of approach were observed among girls whose mothers had the most controlling restrictive feeding profile. As suggested by the authors, mothers may have responded to girls' approach tendencies to rewarding items and activities (e.g., food and eating) by limiting access to savory and salty crackers and keeping them *all* out of reach. Given the effects discussed above, particularly for children having these risk factors, alternative strategies are needed that effectively limit children's intake of palatable snack foods.

Strength and limitations

The current study had several strengths. We replicated the main findings reported in Fisher and Birch (1999b), providing additional evidence that a short-term restriction of a palatable snack food increases children's intake and behavioral response to this food. This is also the first study to provide evidence that aspects of child temperament, namely inhibitory control and approach, and individual differences in the reinforcing value of forbidden foods modulate the effects of restriction on children's intake of palatable snack foods. This study also has several limitations. The small sample size may have reduced our power to detect individual differences in the effects of restriction on children's eating responses. However, several steps were taken to enhance our power including the within-person design of the study and repeated measures of intake during the restriction period. In addition, prior to the current study, a small pilot experiment (n=15) was conducted using the restriction protocol and study foods used in the current study, and we produced the same finding showing that restricted access increased children's intake of the restricted food during the restriction period (data not shown). The ecological validity of the study may be limited given that children's response to restriction in the classroom may differ from their response to parental restriction in the home. However, given that parental restriction is often practiced on a chronic-level, over long periods of time, and has been shown to predict intake of restricted foods in a laboratory setting (Fisher & Birch, 1999a), it is likely that the same children who were susceptible to the negative effects of restriction in the classroom would show similar susceptibility in the home and vice versa. More work is needed to determine whether the effects of restriction are in fact that or due to individual differences among children such as inhibitory control or approach, which may elicit more restriction at home and also manifest individual differences in children's response to experimental restriction in the preschool setting. Lastly, the sample was highly homogenous—high-income, most White, and from well-educated families.

Findings from the current study provide additional evidence that restricting children's access to a palatable food increases their intake and behavioral response to restricted palatable snack foods, replicating the major findings of Fisher and Birch (1999b). The research also extends these findings, providing evidence that children with low inhibitory control and high approach, who find forbidden foods highly reinforcing, and whose parents report the use of controlling restrictive feeding practices show greater susceptibility to the negative effects of restriction on food intake. In the current obesogenic environment, where palatable, energy-dense foods are widely available and inexpensive, parents' chronic use of restriction is not an effective approach to moderating children's consumption of these foods. However, currently, there is scant evidence to inform guidance for parents and caregivers regarding alternatives to the use of restriction. Research is needed to identify alternative feeding strategies that successfully promote moderation in children's intake of preferred, palatable foods and foster the development of self-regulation in children.

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Highlights

- Restriction increases children's intake of restricted snack foods
- Restriction increases comments and behavioral responses to restricted snacks
- Effects of restriction differed by children's regulatory and appetitive tendencies
- Children with lower inhibitory control were more susceptible to restriction effects
- Children with high appetitive tendency were more susceptible to restriction effects

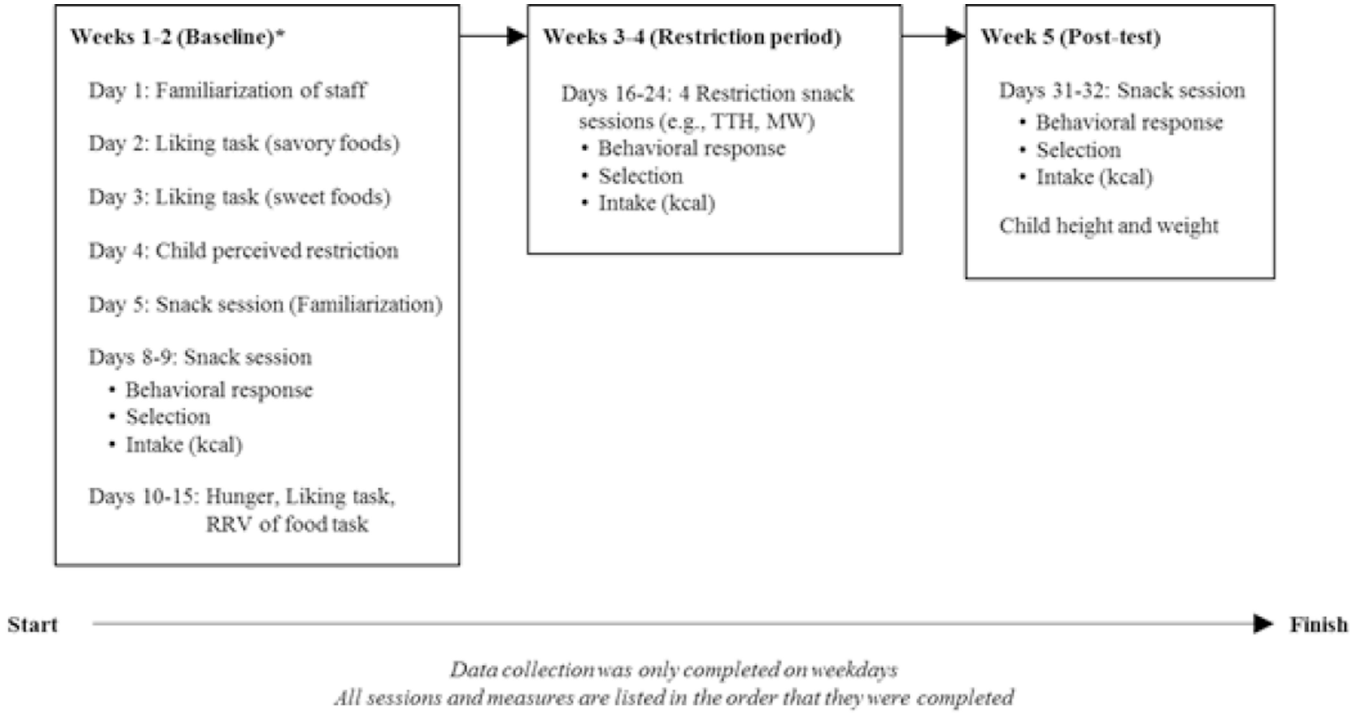

FIGURE 1.

Timeline of data collection measures and procedures.

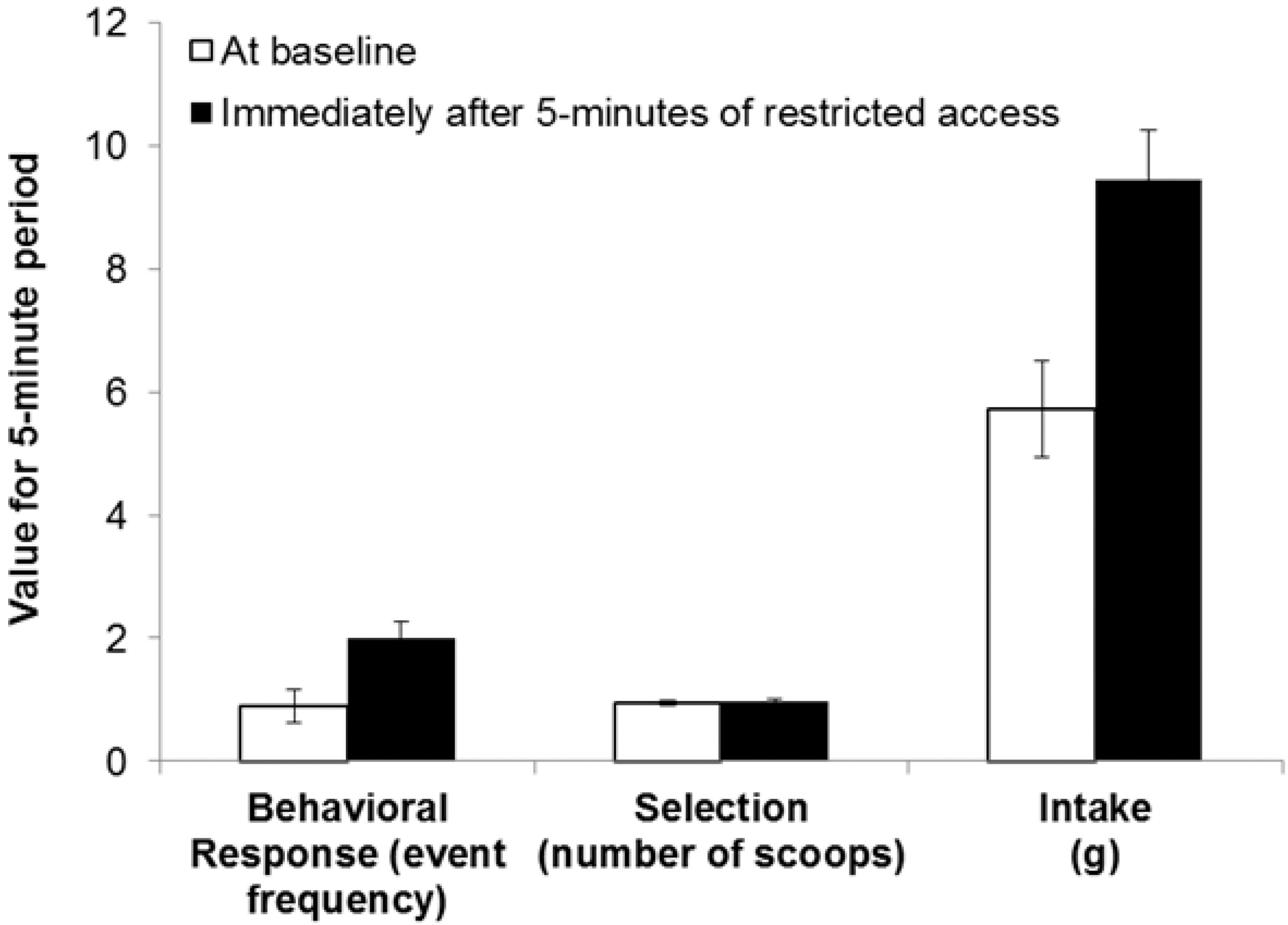

FIGURE 2.

Immediate effects restriction on children behavioral responsea, selection, and intake of the restricted food during 5-minute intervals of unrestricted access at baseline (□; before the restriction) and immediately after 5-minute intervals of restricted access (■) (n = 37).a Plotted values are means ± standard errors. ** Significantly different from unrestricted sessions: **$p < .01$.

[a] Frequency of vocalizations (e.g., "I like it"), behavioral responses (e.g., pounding fists on table), and physical attempts to obtain the restricted food.

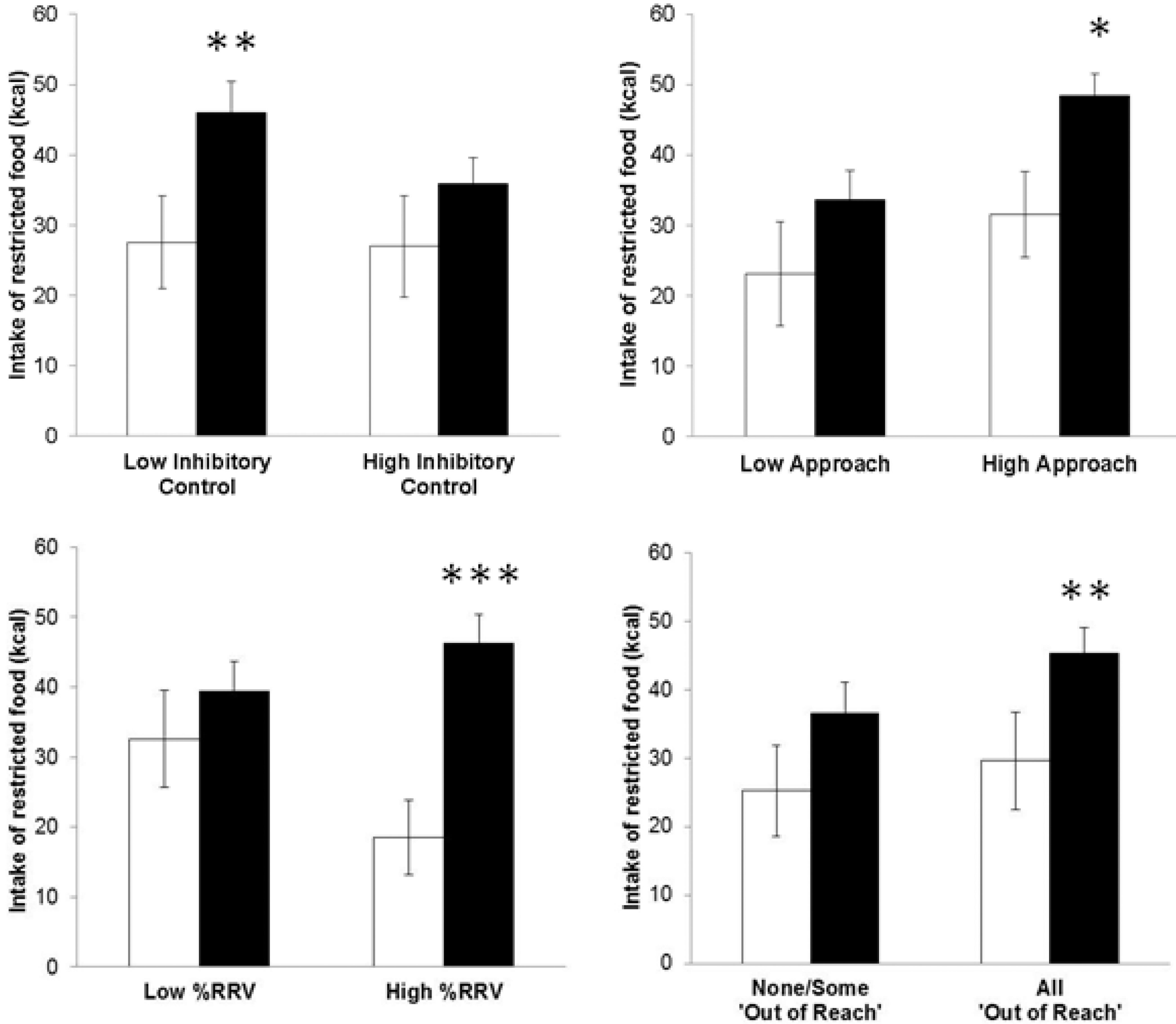

FIGURE 3.

Effects of inhibitory controla, approacha, %RRVb of the restricted food, and parent's reports of keeping snack foods out of reach[c], and the on change in children's intake of the restricted foods during the 5-minute intervals of unrestricted access at baseline (□; before the restriction) and immediately after the 5-minute intervals of restricted access (■) (*n* = 37).[d] Plotted values are means ± standard errors. *,**,***Significantly different from unrestricted sessions: *$p < .05$, **$p < .01$, ***$p < .001$.

[b] Percentage of responses made for the restricted food divided by total responses made for the restricted and unrestricted foods using the RRV of food task (Rollins, Loken, Savage, & Birch, 2013b).

Table 1

Sample characteristics

Variable	Mean (SD)	Range
N (male/female)	37 (13/24)	
Child age (years)	4.5 (0.7)	3.0 to 5.8
Background characteristics		
Family Income	$81,000 – $100,000	>$20,000 – >$100,000
Mothers' education, years	18.9 (1.5)	12–20
Fathers' education, years	18.2 (1.8)	12–20
Mothers' BMI	22.8 (4.0)	15.4 to 35.5
Fathers' BMI	27.3 (5.6)	18.6 to 45.0
Child Race: *n* (%)		
White	28 (75.7%)	
Asian	5 (13.5%)	
Black	1 (2.7%)	
Not specified	3 (8.1%)	
Child Non-Hispanic: *n* (%)	33 (89.2%)	
Key variables of interest		
Child BMI percentile	55.3 (24.8)	3.2 to 95.8
RRV of restricted food (%RRV)[a]	52.6 (25.5%)	0 to 100
Inhibitory control	5.2 (0.7)	4.1 to 6.6
Approach	5.1 (0.6)	3.8 to 6.4
Parental restriction	3.3 (0.7)	1.9 to 4.6
Child perceived restriction	1.8 (0.5)	1.0 to 2.7

Note: BMI = body-mass-index, RRV = relative reinforcing value of food

[a]Percentage of responses made for the restricted food divided by total responses made for the restricted and unrestricted foods using the RRV of food task (Rollins, Loken, Savage, & Birch, 2013b).