Appetite 72 (2014) 21–27

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Research report

Measurement of food reinforcement in preschool children. Associations with food intake, BMI, and reward sensitivity ☆

Brandi Y. Rollins [a,b,*], Eric Loken [b], Jennifer S. Savage [a,c], Leann L. Birch [a,b,c]

[a] Center for Childhood Obesity Research, The Pennsylvania State University, 129 Noll Laboratory, University Park, PA 16802, United States
[b] Department of Human Development and Family Studies, The Pennsylvania State University, 211 Henderson South, University Park, PA 16802, United States
[c] Department of Nutritional Sciences, The Pennsylvania State University, 110 Chandlee Laboratory, University Park, PA 16802, United States

ARTICLE INFO

Article history:
Received 4 March 2013
Received in revised form 3 August 2013
Accepted 18 September 2013
Available online 30 September 2013

Keywords:
Food reinforcement
Progressive ratio
Children
Obesity
Reward sensitivity
Measurement

ABSTRACT

Progressive ratio (PR) schedules of reinforcement have been used to measure the relative reinforcing value (RRV) of food in humans as young as 8 years old; however, developmentally appropriate measures are needed to measure RRV of food earlier in life. Study objectives were to demonstrate the validity of the RRV of food task adapted for use among for preschool children (3–5 y), and examine individual differences in performance. Thirty-three children completed the RRV of food task in which they worked to access graham crackers. They also completed a snack task where they had free access these foods, liking and hunger assessments, and their heights and weights were measured. Parents reported on their child's reward sensitivity. Overall, children were willing work for palatable snack foods. Boys and older children made more responses in the task, while children with higher BMI *z*-scores and reward sensitivity responded at a faster rate. Children who worked harder in terms of total responses and response rates consumed more calories in the snack session. This study demonstrates that with slight modifications, the RRV of food task is a valid and developmentally appropriate measure for assessing individual differences in food reinforcement among very young children.

Introduction

Food is a powerful reinforcer—it maintains the behavior on which its delivery or acquisition is dependent—and its reinforcing value is a salient determinant of food intake (Lappalainen & Epstein, 1990). Measured using operant responding protocols in which an individual works to obtain a food reward (e.g., by pressing a lever), the reinforcing value of food refers to how much an individual is willing to work for a reward (Epstein, Bulik, Perkins, Caggiula, & Rodefer, 1991; Epstein, Leddy, Temple, & Faith, 2007; Hodos, 1961) and reflects their motivation to consume this food (Depoortere, Li, Lane, & Emmett-Oglesby, 1993; Roberts, Loh, & Vickers, 1989). Higher reinforcing value of food has been linked to overweight in children and adults (Epstein et al., 2007; Temple, Legierski, Giacomelli, Salvy, & Epstein, 2008), greater body weight in rats (Ferguson, 1997), and excessive weight gain in childhood (Hill, Saxton, Webber, Blundell, & Wardle, 2009). Studying the development of food reinforcement early in life may further our ability to measure and understand early antecedents of obesity; however, developmentally appropriate measures of food reinforcement have not been adapted and validated for use with very young children. The objectives of the current study were to demonstrate the validity of a relative reinforcing value (RRV) of food task adapted to be developmentally appropriate for preschool children, and examine individual differences in task performance.

Among the growing number of human food reinforcement studies published in the past decade, the laboratory-based RRV of food task developed by Epstein and colleagues (Epstein, Leddy, et al., 2007; Lappalainen & Epstein, 1990; Rollins, Dearing, & Epstein, 2010; Temple et al., 2008) has been one of the most frequently utilized. Grounded in the traditions of operant responding and behavioral economics research conducted with animal models, primarily the rat, the RRV of food task measures the relative reinforcing value of one food when an alternative is readily available. In this task, an individual has an opportunity to work for access to two food rewards (or a food and a non-food alternative) concurrently on independent progressive-ratio (PR) schedules of reinforcement. With PR schedules, the amount of work required to obtain a food reward increases after each reward is obtained (e.g. 4, 8, 16, etc. level presses). The RRV of food can be measured as the breakpoint—i.e., the last completed ratio—or a variety of alternatives including

☆ *Acknowledgments:* This research was supported by the Ruth L. Kirschstein National Research Service Award Grant 1 F31 HL092721 and the Collaborative Research SBE Alliance: Great Lakes Alliance for the Social and Behavioral Sciences (GLASS) Grant 0750621. We thank Michele Marini at the Center for Childhood Obesity Research in Pennsylvania State University, University Park, PA for her excellent technical assistance.

* Corresponding author.
E-mail address: byr104@psu.edu (B.Y. Rollins).

0195-6663/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.appet.2013.09.018

the total number of responses made to access the food, or how quickly those responses are made (i.e. response rate).

To our knowledge, only one study has used a PR reinforcement schedule in very young children. In Chelonis, Gravelin, and Paule (2011), children aged 4–14 were given the opportunity to earn nickels on a PR schedule of 1, 11, 21, 31, and so on, for up to 10 min. Young children were willing to work on a PR schedule to access monetary rewards, and the breakpoints were higher for older children and boys. To date, however, individual differences in young children's performance on PR schedules to access food rewards has not been demonstrated. The RRV food task has only been used in children as young as 8 years old (e.g., Temple et al., 2008), and needs validation among younger children.

Performance on PR schedules is mediated in part by mesolimbic dopaminergic pathways that have also been implicated in addictive behaviors of drug abuse (Depoortere et al., 1993; Roberts et al., 1989), gambling (Comings et al., 1996), and more recently, chronic overeating (Johnson & Kenny, 2010; Stice, Yokum, Zald, & Dagher, 2011). Consequently, there is growing interest in examining PR performance as a predictor of risk for obesity, characterized by having greater preference, responsiveness, and consumption of palatable, energy-dense foods (Davis et al., 2007). For example, being overweight has been shown to predict greater motivation to work in the RRV of food task for palatable foods among children and adults (Epstein, Dearing, & Roba, 2010; Epstein et al., 2004; Saelens & Epstein, 1996; Temple et al., 2008). Children with greater reward sensitivity may also be predisposed to find highly palatable foods very reinforcing. Reward sensitivity is a psycho-biological trait mediated by the behavioral activation system that refers to having greater responsiveness to incentives and appetitive reinforcers (Gray, 1981; Pickering & Gray, 1999). Past studies show that individuals with high reward sensitivity are more susceptible to environments with easy access to fast food (Paquet et al., 2010) and have greater responsiveness to palatable, energy-dense foods (Beaver et al., 2006).

The objectives of the current study were to demonstrate the validity of a RRV of food task adapted to be developmentally appropriate for preschool children, and to examine individual differences in children's performance. Our first objective was to describe children's performance on the task, measured as the number of responses and response rate (i.e., number of clicks per minute) made for two very similar foods. The data for this study were gathered as part of a larger study, in which the RRV protocol was used to assess change in children's RRV of two types of food (i.e. Scooby Doo™ and Sponge Bob™ graham crackers) after access to one of the foods was restricted. The data were collected prior to the experimental manipulation, and the foods were selected to meet the needs of this larger study. While it is somewhat unusual to use two very similar foods concurrently in a RRV of food task—in past studies, typically a food item is compared to a non-food alternative (e.g., reading)—our purpose is to simply demonstrate the task for use in very young children, and investigate relations between RRV performance and individual characteristics that have been demonstrated in past work (e.g., Temple et al., 2008). In our second objective, we investigated whether individual differences in RRV performance differed by age and gender, BMI, and reward sensitivity. We hypothesized that children who had higher BMIs and reward sensitivity would demonstrate higher total responses and response rates. The third objective was to demonstrate the predictive validity of the task by investigating the relation between RRV performance and children's intake of the study foods in an ad libitum snack session. We hypothesized that children with greater total responses and response rates would consume more calories of each snack food.

Methods

Participants

Participants were 42 children (ages 3–5) and their parents attending a university-based, full-day daycare in University Park, Pennsylvania. Exclusion criteria included having a health condition that could impact food intake and known food allergies. Children from five classrooms were recruited via letters addressed to their parents; parents provided consent for their family's participation. Upon providing consent, parents were asked to complete a brief survey measuring household demographics and child reward sensitivity. Mothers completed the majority of all surveys (80%). For the current paper, we excluded children who did not complete the RRV of food or ad libitum eating tasks ($n = 9$), due to behavioral difficulties ($n = 1$), failure to understand instructions ($n = 2$), illness (e.g. cold, flu) ($n = 3$), or family travel ($n = 3$). This reduced the final sample to 33.

Procedures

The procedures were administered in two sessions completed in a separate room in the preschool facility 2.5–3 h after children had a standard lunch. Study sessions lasted no longer than 35 min, replaced the standard school-served afternoon snack, and were completed on separate days (no more than 4 days apart), with multiple measures occurring during the second session. Children's heights and weights were measured at the end of the study.

In the first session, children completed the ad libitum snack task. Children were seated in small groups of 4–7 children with a trained staff member at each table in their classrooms. Two large bowls of Scooby Doo™ graham crackers (in the shape of bones) and Sponge Bob™ graham crackers (in the shape of squares) were placed in the center of the table, and children were instructed to serve themselves using 1/3-cup scoops. Children were also served an 8-oz carton of skim milk. Snack sessions were videotaped.

In the second session, children completed the hunger, liking, and RRV of food tasks, in that order. The hunger assessment was re-administered following the RRV of food task to measure changes in hunger. If a child reported that they were full during the baseline hunger assessment, the RRV of food task was not administered. Up to 2 more attempts were made within 1–4 days to complete the RRV of food task; on the 3rd attempt, the RRV of food task was administered regardless of fullness. Twenty-three children completed the task on the first attempt; only 4 completed it on the third attempt. After the task, children were offered an 8-oz carton of skim milk and 30-g portion of another neutrally-liked snack food to meet school snack requirements (11 children accepted the food). Based on observations, the hunger task lasted 1–2 min and the liking task ~1 min. The total session (i.e., liking, hunger, and RRV of food tasks) lasted no longer than 35 min, and time spent in the RRV of food task was limited to 30 min. Parents were compensated $10 for their family's participation and each classroom received $50. The Pennsylvania State University Institutional Review Board approved all study procedures.

Measures

Ad libitum snack task

Children's ad libitum intakes of the two graham crackers were measured using video-recordings of a snack session scheduled at the regular snack time. Number of pieces eaten was later coded by trained research assistants. All research assistants were trained until they independently achieved 70% on a criterion videotape.