Appetite 120 (2018) 123–129

Contents lists available at ScienceDirect

Appetite

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

Repeatability of the infant food reinforcement paradigm: Implications of individual and developmental differences

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ARTICLE INFO

Article history:
Received 16 November 2016
Received in revised form
1 August 2017
Accepted 10 August 2017
Available online 12 August 2017

Keywords:
Infant
Food reinforcing ratio
Temperament
Novelty
Repeatability
Obesity

ABSTRACT

The relative reinforcing value of food versus engagement in other behaviors may be related to the development of obesity, and interventions to reduce FRR may prevent the development of obesity. Our laboratory recently developed a paradigm to measure the reinforcing value of food versus an alternative behavior (i.e., playing with bubbles) in infants using a computerized laboratory task, during which infants press a button to earn reinforcers following a progressive ratio schedule of reinforcement. The primary purpose of this study was to examine the short-term (within 2 weeks) repeatability of this measure, specifically the outcome of infant food reinforcing ratio (FRR), or how hard infants will work for food relative to the alternative. The secondary aim was to examine whether infant age and temperament dimensions related to novelty responsiveness (high intensity pleasure and approach) moderated the repeatability of FRR. Thirty-seven infants aged 9–18 months completed this study. Repeated measures analysis of variance (ANOVA) showed no differences between time 1 and time 2 in responding for food ($F = 0.463$, $p = 0.501$), bubbles ($F = 1.793$, $p = 0.189$), or overall FRR ($F = 0.797$, $p = 0.378$). Regression models showed the association between BUB P_{max} at time 1 and time 2 were moderated by infant age ($p = 0.04$), with greater repeatability in older infants. Linear regression models also demonstrated that the infant temperamental dimension of high intensity pleasure significantly predicted BUB P_{max} at time 1 ($\beta = 2.89$, $p = 0.01$), but not at time 2. Overall, our findings support the repeatability of this measure for food portion of the reinforcement task, but demonstrated that the measure of non-food portion of the task required modification, in particular among children younger than 13 months old.

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1. Introduction

Food is a strong motivator of behavior and is a primary reinforcer as it satisfies a basic biological need (Epstein & Leddy, 2006). However, there are large individual differences in the reinforcing value of food versus non-food alternatives in infants, children, and adults. The relative reinforcing value of food is related to energy intake and is cross-sectionally (Epstein et al., 2007; Rollins, Loken, Savage, & Birch, 2014) and prospectively (Carr, Lin, Fletcher, & Epstein, 2014; Epstein, Yokum, Feda, & Stice, 2014) related to weight. In children and adults, relative reinforcing value of food can be measured in a variety of ways, including the use of a standard laboratory computerized task that quantifies how much effort an individual will engage in to obtain food (Epstein, Carr, Lin, Fletcher, & Roemmich, 2012; Temple, Legierski, Giacomelli, Salvy, & Epstein, 2008) and questionnaires that assess the construct of the reinforcing value of food (Epstein, Dearing, & Roba, 2010; Reslan, Saules, & Greenwald, 2012).

Abbreviations: food reinforcing ratio, FRR; Body mass index, BMI; weight for length, WFL; maximum schedule achieved for food, Food P_{max}; maximum schedule achieved for bubbles, BUB P_{max}; Analysis of variance, ANOVA; reinforcing value of food measured at time 1, Food $P_{max}1$; reinforcing value of food measured at time 2, Food $P_{max}2$; reinforcing value of bubbles measured at time 1, BUB $P_{max}1$; reinforcing value of bubbles measured at time 2, BUB $P_{max}2$; food reinforcing ratio obtained at time 1, FRR1; food reinforcing ratio obtained at time 2, FRR2.

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http://dx.doi.org/10.1016/j.appet.2017.08.012
0195-6663/Published by Elsevier Ltd.

The relative reinforcing value of food had been measured in children as young as 3 years of age (Rollins et al., 2014) through older children (Temple et al., 2008), adolescents (Epstein et al., 2014), and adults (Carr et al., 2014; Epstein et al., 2007; Saelens & Epstein, 1996). To understand the origins of food reinforcement, our laboratory developed a paradigm to measure the reinforcing value of food and alternatives to food in infants, allowing us to extend the study of food reinforcement to children as young as 9 months of age (Kong, Eiden, et al., 2016). This paradigm uses a computerized task [food reinforcing ratio (FRR) task] in the laboratory, during which infants press a mouse button to earn reinforcers in the form of the infants' favorite food and a non-food alternative, such as watching Baby MacDonald™ video, playing with bubbles, and listening to music. Behavior during this task has been linked with infant weight status, with results suggesting that overweight and obese infants had a higher FRR primarily due to a lower reinforcing value of the non-food alternatives (Kong, Feda, Eiden, & Epstein, 2015). To support the importance of the reinforcing value of non-food alternatives, we have shown that increasing the reinforcing value of the non-food alternative can reduce the FRR (Kong, Eiden, et al., 2016). Therefore, being able to understand how high FRR develops at the earliest possible age may prevent future obesity risk and its sequelae, as FRR is a modifiable behavior, which can be the target of interventions before the development of obesity (Buscemi, Murphy, Berlin, & Raynor, 2014; Kong, Eiden, et al., 2016). However, further examination of the measurement properties of the FRR task is needed before it can be implemented on a larger scale. In particular, research on the repeatability of the task may be important as infants are notoriously labile (i.e. fussiness due to teething, nap interruption) and experience great fatigue effects on task performance.

In addition, it is possible that age may impact the repeatability of the FRR task as infants change in their developmental skills and how they interact with aspects of their environment as they develop (i.e., adaptation to novel environments, toys, strangers). Food is a primary reinforcer and is present at birth, as evidenced by avid sucking for food in infancy that, in turn, predicts later weight gain (Stunkard, Berkowitz, Schoeller, Maislin, & Stallings, 2004). As a result, the reinforcing value of food may be more stable than the reinforcing value of non-food alternatives, which are learned behaviors, and infants may differ in terms of what stage of learning they are studied. Our study population, between ages 9 and 18 months, is of a sizeable age range given the rapid growth and development that occurs within the first 2 years of life. For example, compared to a 9-month-old, infants 1-year-old and older are more independent, assertive, have been consuming solid food for a longer period of time, and have better fine motor skills to feed themselves. Additionally, we observed that infants 1-year and older are more likely to use communication, either verbal or signed, to signal they are done at the end of the FRR task, versus children younger than 12 months with whom we have to rely more on subjective signs (distraction, avoidance, etc.) (unpublished data). Therefore, it is important to consider the role of age in infants' responding over time with the FRR task.

Furthermore, individual differences in temperament are present at birth and are reflected in infants' varying reactions to standard laboratory tasks (Goldsmith & Rothbart, 1999). Previous research has shown that cuddliness and rate of recovery from distress, measured by the Infant Behavior Questionnaire-Revised, were related to the FRR assessed across three independent samples of infants (Kong, Anzman-Frasca et al., 2016). The repeatability of the infant FRR task over time might be affected by the variability in infant temperament. Specifically, individual differences in responding to novelty may affect infants' responses to the FRR task over time, as the elements of the task move from being novel to familiar across repeated visits. The Infant Behavior Questionnaire-Revised, which can be used beginning 3 months after birth (Gartstein & Rothbart, 2003), reliably measures a number of aspects of infant temperament. This measure includes dimensions of temperament related to responses to novelty, including high intensity pleasure, defined as "the amount of pleasure or enjoyment related to high stimulus intensity, rate, complexity, novelty, and incongruity", and approach, defined as "rapid approach, excitement, and positive anticipation of pleasurable activities" (Gartstein & Rothbart, 2003). We examined the association between these dimensions of temperament and the FRR task outcomes in this study.

The primary purpose of this study was to examine short-term repeatability (within 2 weeks) of the FRR task among 9–18 month old infants. The secondary aim of this study was to examine the roles of 1) infant age and 2) temperament dimensions reflecting novelty responsiveness in influencing the repeatability of FRR task over time.

2. Material and methods

2.1. Participants

Thirty-seven infants aged 9–18 months and their biological mothers completed this study. Inclusion criteria were selected in order to facilitate successful completion of the FRR task and increase generalizability to the population of normally-developing infants in the age range of interest. Infant inclusion criteria were as follows: age 9–18 months; born $\geq$37 weeks; birth weight $\geq$2500 grams; no developmental delays mentioned at the most recent well child check-up. Maternal inclusion criteria included: maternal age of 18 years or older; no high-risk pregnancy; no smoking or illicit drug use during pregnancy; alcohol use of <4 alcoholic drinks per occasion or average of <1 alcoholic drink per day during pregnancy. Offspring of mothers who smoked or used illicit drugs during pregnancy have an increased risk for conduct problems (Gaysina et al., 2013), which may lead to non-completion of the computer task.

Of the 51 infants who met inclusion criteria, 14 infants were excluded from the final analysis due to: not playing any of the food/non-food reinforcement task (n = 6); crying excessively and/or behavioral issues during the task (n = 3); mother's failure to complete all four laboratory visits (n = 3); mother's failure to complete the Infant Behavior Questionnaire- Revised (n = 2). The final dataset of 37 infants included 19 females and 18 males.

2.2. Procedures

Potential participants were recruited through flyers distributed around the community (i.e. grocery stores, restaurants, community centers) and web based advertisements (i.e. listservs, craigslist, Facebook, Twitter). Recruitment documents did not include any wording on food or eating, eliminating the potential for bias of recruiting infants with caregivers that were concerned about their infant's eating or weight.

Upon receiving an inquiry from a prospective participant, information about the study was given over the phone and verbal consent was obtained in order to screen them for eligibility criteria. The initial screening questionnaire could be done via phone or online.

If eligible, participants were scheduled for 4 laboratory visits. The first two visits (time 1) were scheduled within two days of each other, if possible, and the third and fourth visits (time 2) were scheduled for the following week, also within two days of each other. During time 1, infants performed the computerized