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Development and quantification of measures for risky and delayed food and monetary outcome choices

L.R. Rodriguez[a], K.L. Hendrickson[b], E.B. Rasmussen[a,*]

[a] Idaho State University, United States
[b] San Antonio Military Medical Center, United States

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ABSTRACT

Probability discounting (PD) measures risky choice patterns between smaller, more certain vs. larger, less certain outcomes. PD is associated with obesity as well as higher intake of foods high in fat and sugar. We developed and validated a brief PD task specifically for food-related choices–the Probabilistic Food Choice Questionnaire (PFCQ). We also validated a brief, existing PD monetary measure, the Probabilistic Monetary Choice Questionnaire (PMCQ) by comparing it to a titrating PD task. Participants (N = 110) were randomly assigned to either a food or money condition. Those assigned to the food condition completed the PFCQ and a more established, adjusting-amount PD task for hypothetical food outcomes. Those assigned to the money condition completed the PMCQ and a more established, adjusting-amount PD task. Participants also completed delay discounting (DD) tasks for the same outcome commodity. The PFCQ and adjusting-amount PD tasks strongly correlated across three magnitudes suggesting that the PFCQ may be a satisfactory and briefer measure for risky food choice. The PMCQ also showed significant correlations with the adjusting-amount monetary PD task, supporting its use for a brief measure of monetary discounting. For DD, the choice questionnaires demonstrated significant correlations with the adjusting-amount DD procedures, replicating previous research.

1. Introduction

Delay discounting (DD) is a measure of impulsivity that refers to the decrease in the subjective value of a reward as the delay to its receipt increases (Ainslie, 1975; Madden and Bickel, 2010; Rachlin et al., 1991). For example, individuals are presented with a series of smaller, immediate choices (e.g., $1 now) vs. larger, delayed (e.g., $10 in 1 day) outcomes. Choices are measured over a variety of different outcome amounts and delays (e.g., 10 days, 30 days, 1 year, 5 years, etc.). An individual who demonstrates relatively higher impulsive choice patterns would show a higher preference for the smaller, immediate outcomes relative to an individual who is more self-controlled.

The DD paradigm provides researchers and clinicians with an informative framework for understanding health-related behaviors such as cigarette smoking (Bickel et al., 1999; Friedel et al., 2014; Reynolds et al., 2004; Yi et al., 2007; Yi et al., 2016), opioid use (Kirby et al., 1999; Madden et al., 1997), and problematic gambling (Andrade and Petry, 2012; Holt et al., 2003; Madden et al., 2009). More recently, the DD paradigm has been used to examine factors that are related to obesity (Jarmolowicz et al., 2014; Weller et al., 2008). For example, obese individuals tend to prefer smaller, immediate amounts of food over larger, delayed amounts compared to their healthy-weight counterparts (e.g., Hendrickson and Rasmussen, 2013; Hendrickson et al., 2015; Rasmussen et al., 2010). Even a single food choice in early childhood (a la the marshmallow task) has been shown to predict obesity 30 years later (see Schlam et al. (2013)). Therefore, DD for food appears to be a fundamental behavioral process that underlies obesity.

One feature of the DD paradigm that researchers have tried to parse from the devaluing of a delayed outcome is the probability of its receipt. In other words, as delay to the outcome increases, the likelihood of receiving it also diminishes. For example, if someone was offered $100 tomorrow or after one year, not only would the value diminish with the delay, but the likelihood that an individual would receive it would also diminish. Because of this potential confounding variable, researchers have sought to determine the extent to which probability discounting and delay discounting are separate processes (see Green and Myerson, 2010, 2013; Rachlin et al., 1991).

Probability Discounting (PD), then, is the decrease in the subjective value of a reward as the odds to its receipt increase and has been identified as a measure of risky choice (Green and Myerson, 2010; Rachlin et al., 1991). Individuals are presented with the choice of receiving a larger, less certain outcome (e.g., $10 with a 90% chance of

* Corresponding author.
E-mail address: rasmerin@isu.edu (E.B. Rasmussen).

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receiving it) vs. a smaller, certain outcome (e.g., $7 with a 100% chance of receiving it). With this particular choice, participants tend to show a riskier pattern of responding by selecting the larger, less certain outcome over the smaller, certain one. However, as the odds of receiving the larger reward decrease (in this case, $10 with a 75% chance of receiving it), a shift in an individual's pattern of responding occurs, such that s/he is more likely to select the smaller, certain outcome ($7 for sure).

While both PD and DD have been associated with numerous health outcomes (e.g., illicit drug use, alcohol use, smoking, obesity, etc.; MacKillop et al., 2011; Madden and Bickel, 2010; the relation between the two processes is unclear. Different "impulsive" groups tend to demonstrate differential preferences between delayed and risky rewards suggesting that sensitivity to delay and risk taking are separate facets of impulsivity (Green and Myerson, 2013). For instance, some individuals who tend to prefer certainty also prefer immediacy, while others who tend to prefer immediacy prefer uncertain rewards. These differences suggest that both probability discounting and delay discounting can be conceptualized as separate, distinct processes (Green and Myerson, 2013; Jarmolowicz et al., 2012), though related to the construct of impulsivity (Green and Myerson, 2013; Rachlin et al., 1991).

1.1. Brief measures of discounting: choice questionnaires

A typical method of establishing PD is the adjusting-amount procedure in which participants select between two concurrently available options: a smaller, certain reward (e.g., $5 for sure) or a larger, less certain reward (e.g., 25% chance of receiving $10). The smaller, certain outcome is adjusted systematically until the individual switches from the smaller, certain outcome to the larger, less certain outcome (i.e., preference reversal). These preference reversals are used to determine the current subjective value of the larger, less certain reward or indifference points. Indifference points can be plotted against probabilities for larger, less certain outcomes (e.g., 0.9, 0.75, 0.5), which is often converted first to the odds against receiving it ($[1/p] - 1$; p = probability of receiving). The value of the larger, less certain outcome decreases in value in a hyperbolic manner as the odds against receiving it increase. For delay discounting, the procedure is similar, except choices are between smaller, sooner vs larger later options. A similar hyperbolic pattern is observed in the value of the delayed reward as delay to its receipt increases (e.g., from one day to one month; Mazur, 1987; Rachlin et al., 1991).

A number of studies employing the adjusting-amount procedure use computerized programs. There are a number of strengths with these methods, especially the Richards et al. (1999) task that includes a titration procedure that systematically increases or decreases amounts based on the participant's individualized choice patters, randomized presentation of choices, and the use of an unpredictable algorithm that not only disguises the nature of the task, but also re-presents questions that result in inconsistent responses. However, the one drawback is that these methodological strengths may result in the task taking a longer time to complete, for example, some participants may take up to 20 min (see Hendrickson and Rasmussen, 2013, 2017). This may be problematic with certain populations, such as children (Hendrickson & Rasmussen, 2017) or when research protocols are longer and participant fatigue is likely.

One common approach to establishing discounting patterns in a short period of time is to use choice questionnaires. The Monetary Choice Questionnaire (MCQ; Kirby and Marakovic, 1996; Kirby et al., 1999) is a well-established example. The MCQ is a 27-item measure that estimates an individual's pattern of delay discounting based upon predetermined discounting values derived from Mazur's (1987) hyperbolic equation. More recently, the Food Choice Questionnaire (FCQ; Hendrickson et al., 2015), which was patterned after the MCQ, estimates food discounting in a manner similar to the adjusting-amount food discounting procedure. The MCQ and FCQ have several advantages: One, they are brief in terms of administration and scoring time, which is often about 5 min. Two, the discounting values derived from them are strongly correlated with discounting measures from computerized and titrating procedures (Epstein et al., 2003; Hendrickson et al., 2015). Three, there is an opportunity to estimate discounting rates across a range of three reward magnitudes, which is a benefit because there is a robust literature showing that the degree of discounting for money (e.g., Amlung and MacKillop, 2011; Estle et al., 2006; Kirby and Marakovic, 1996*), food* (Hendrickson et al., 2015; Odum et al., 2006), as well as other commodities (e.g., Baker et al., 2003; Greenhow et al., 2015; Weatherly and Terrell, 2014) is inversely related to the outcome magnitude. (This is termed the "magnitude effect".)

Despite the number of studies that use probability discounting as measures of risky choice (e.g., Ohmura et al., 2006; Rasmussen et al., 2010; Reynolds et al., 2004), there are few choice questionnaires that have been used with probability discounting. One exception is a measure developed by Madden et al. (2009) called the Probabilistic Monetary Choice Questionnaire (PMCQ), which to our knowledge, has not yet been validated against a previously established probability discounting task.

Brief measures of probability discounting for other outcomes could have strong utility. For example, not only are obese individuals more impulsive for food, but they also have been shown to be risk-averse for food with titrating probability discounting tasks (Rasmussen et al., 2010). In addition, greater calorie consumption has been linked to increased gambling behavior (Chamberlain et al., 2017) suggesting that one's sensitivity to risk may play a role in eating behavior. Therefore, it would be important to have a brief measure of probability discounting for food to further examine underlying processes of eating behavior.

1.2. Purpose of study

The purpose of the current study was to establish a brief, easy-to-administer alternative measure of food probability discounting, the Probabilistic Food Choice Questionnaire (PFCQ), and validate it against a previously established computerized probability discounting task for food (Rasmussen et al., 2010; Richards et al., 1999). This would provide a companion measure to the more recently established Food Choice Questionnaire (FCQ; Hendrickson et al. 2015), a measure of impulsivity for food outcomes. Together, these alternative methods of discounting would allow for quicker assessment of food discounting patterns in situations where time and resources are a limiting factor. Additionally, we validated the use of the Probabilistic Monetary Choice Questionnaire (PMCQ; Madden et al., 2009) against an already established computerized monetary discounting task (Richards et al., 1999). For purposes of replicability, participants also completed either the FCQ or MCQ, which was compared to the computerized delay discounting task. Our main hypotheses were: 1) Probability discounting rates on the PFCQ and computerized food discounting task would significantly correlate; 2) Discounting rates from the PMCQ and computerized monetary probability discounting task would significantly correlate. We also expected to replicate previously established relations with discounting tasks and magnitude effects (e.g., Greenhow et al., 2015; Hendrickson et al., 2015). Specifically, delay discounting rates would decrease as reward magnitudes increased, whereas probability discounting rates would increase as reward magnitudes increased.

2. Material and methods

2.1. Participants

Participants ($N = 110$, 67 female) were undergraduate students enrolled in psychology courses from Idaho State University and recruited via SONA, an online subject pool ($M_{age} = 21.2$, $SD = 4.73$). Inclusion criteria were: current undergraduate status, 18 years of age or