Impulsivity: Comparing Delay Discounting and Go/No-Go Procedures while Assessing Experimental Brevity

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INTRODUCTION

Impulsivity has been frequently measured using several different procedures. One is termed Delay Discounting, which describes how reinforcer value is discounted as delays to reinforcer delivery increases. This procedure assesses choice preferences for smaller-sooner over larger-later reinforcers.

Delay Discounting has been correlated with behaviors exhibited by different populations, including substance abusers and problem gambling.

However, quantitative determinations of delay discounting can be time consuming. Despite this limitation, few studies have investigated procedural manipulations to reduce the number of sessions to stability.

A second commonly utilized procedure, called the Go/No-Go task, measures impulsivity through "impaired inhibition"; whereby number of responses made during a signaled "Go" (food available) and "No-Go" (extinction) periods are measured across multiple sessions.

The current research compared these two common procedures to see whether their measures of impulsivity correlated. Additionally, this study examines ways to minimize the number of sessions required to reach stability with delay discounting.

METHODS

Delay Discounting

Six Rhesus Macaques served as subjects. All made repeated choices between a small reinforcer (1 banana pellet) delivered immediately, versus a larger (x) amount delivered after an adjusting delay. If the "smaller-sooner" (SS) option was chosen, the delay to the "larger-later" (LL) alternative decreased by 10%. Conversely, if the LL was chosen, the delay to the LL subsequently increased by 10%. Indifference points were quantified when subjects alternated between the two options about equally often (see Figures 1 and 2).

In an attempt to reduce sessions required per condition, starting adjusting delays were manipulated. In some conditions, the adjusting delay started at a low initial delay (10s), which is typical from prior research. Other conditions were run in which the adjusting delay started at the predicted indifference point based on Mazur's (1987) hyperbolic discounting equation: $V=A/1+kD.$ with k = 0.05 (see Table 1). For instance, when the larger pellet amount was 8, subjects started that condition with the large amount delayed by 140s. Each subject completed at least 6 conditions with different large pellet amounts.

Go/No-Go Task

To compare impulsivity across assays, subjects were also exposed to a Go/No-Go task. In this procedure, subjects were presented with alternating 30-minute "Go" periods (in which responses were reinforced in the presence of a green light) and 10-minute "No-Go" periods (in which a red stimulus light was presented and no responses were reinforced). Of interest is the number of responses emitted during "No-Go" periods, which is thought to represent weak response inhibition (a measure of impulsive action).

Table 1.

AMOUNT	1 pellet	2	4	6	8	16
DELAY (k = 0.05)	0s	20s	60s	100s	140s	300s

FIGURES

Figure 1. Procedural Schematic

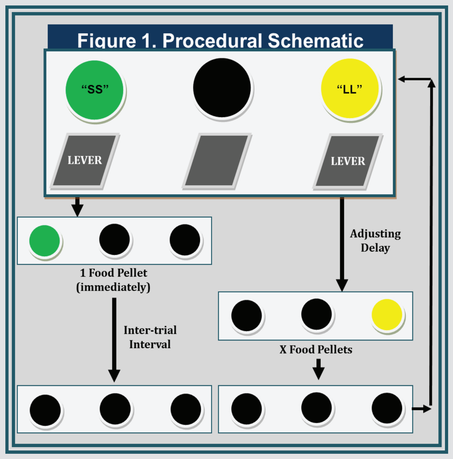


Figure 3. Average Number of Sessions to Stability

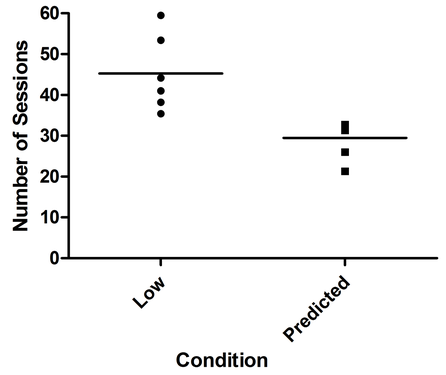


Figure 4. Correlation between Delay Discounting and Go/No-Go Measures

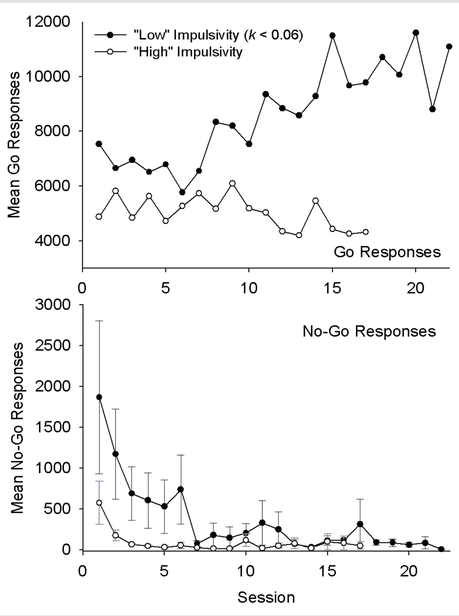
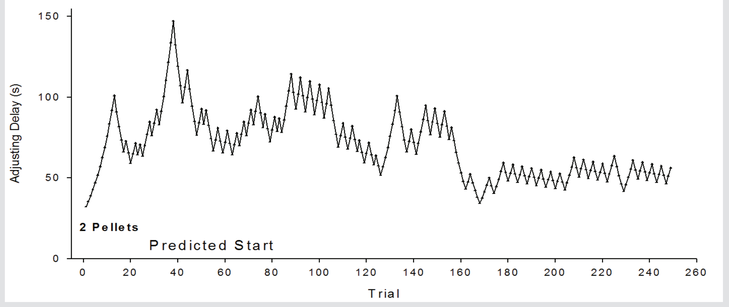


Figure 2. Trial-by-Trial Sample Performance



SUMMARY OF RESULTS

Reducing Sessions to Stability:
Results indicate that utilizing the predicted equivalent delays (based on the hyperbolic discounting model) effectively reduces the amount of time it takes to collect delay discounting data. Figure 3 demonstrates the number of sessions to stability for both the low and predicted delay conditions. These data illustrate how stability can be reached more rapidly by using predicted delays.

Impulsivity Assessments:
Subjects displayed a good amount of individual variability in impulsivity, as measured by delay discounting. Based on their obtained k values, we placed the subjects into either "low" impulsivity ($k < 0.06$) or "high" impulsivity groups in order to compare responses in the Go/No-Go paradigm. This comparison is displayed in Figure 4. The top panel of the figure demonstrates that the more self-controlled ("low" impulsivity) subjects made substantially more responses during food-reinforced (Go) periods. The bottom panel mirrors this result but during the No-Go (non-reinforced) periods - more impulsive subjects, as measured by delay discounting, actually made fewer "impulsive" errors on the Go/No-Go task.

DISCUSSION

This study provides a novel method for reducing data collection time for researchers utilizing the delay discounting model. This is particularly important because this model has been widely correlated with impulsive clinical populations and is therefore frequently utilized (in particular, to assess methods to increase self-control choices).

These data also compared the results of two procedures used to describe the concept of impulsivity. While these assays have been reported to describe the behavior of the same populations (e.g., drug abusers), our data suggest that the results are indeed not correlated. Given that delay discounting procedures have been widely validated across many populations traditionally considered to be impulsive, we hypothesize that the Go/No-Go procedure assesses a different aspect of impulsivity.

This research was supported in part by: NIDA Grants R01DA015449, R01DA020669, T32DA007268-19 and the University of Wisconsin-Eau Claire Faculty/Student Research Collaboration Grants program
Special thanks to the Office of Resarch and Sponsored Programs
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