

Short report

Decision processes in choice overload: A product of delay and probability discounting?



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ABSTRACT

Recent research in the behavioral decision making literature has demonstrated that humans hyperbolically discount the subjective value of options as the number of options increases (Reed et al., 2012). These findings provide a cognitive-behavioral synthesis of the “choice overload” phenomenon, also known as the “paradox of choice.” Specifically, these findings suggest that temporal discounting may serve as the underlying process contributing to this effect. As an extension, this study examined the effects of reward magnitude sizes had on rates temporal and options discounting. This manipulation was conducted to determine what role temporal discounting plays in discounting of options. The present results suggest that temporal discounting may not be the only process contributing to the choice overload effect.

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A growing body of literature in cognitive psychology has suggested that humans devalue the availability of options when making decisions due to cognitive phenomena such as diminished satisfaction and postdecision regret (e.g., [Iyengar and Lepper, 2000](#); [Iyengar et al., 2006](#); [Schwartz, 2004](#)). Known as *choice overload* – or the “paradox of choice” – this line of research directly challenges behavioral findings from the nonhuman laboratory that suggest preference for choice is ubiquitous ([Catania, 1980](#)). For example, using pigeons, Catania demonstrated that relatively more responding was associated with key presses (in the initial link of a concurrent chains schedule) that produced subsequent options for keys that resulted in reinforcement (terminal link) over those that resulted in no choice ([Catania, 1975, 1980](#); [Catania and Sagvolden, 1980](#); [Cerutti and Catania, 1986, 1997](#)). [Hayes et al. \(1981\)](#) investigated pigeons’ preference for choice using similar procedures to Catania and colleagues’ experiments with the inclusion of minor contextual manipulations regarding the presentation of choices (delays, obtained amounts of reinforcement). With these contextual modifications, pigeons no longer universally preferred choice; some response patterns actually suggest *aversion* to choice and preference for constraint. The notion that constraint is sometimes more valuable than having the freedom to choose is similar to the “paradox of choice” effect described by cognitive and social psychologists.

In an attempt to achieve a cognitive-behavioral synthesis of choice overload, [Reed et al. \(2011, 2012\)](#) proposed that choice overload might be an artifact of search costs (e.g., time, risk, and effort associated with choosing from many options), similar to those found in the animal foraging literature (see [Krebs and Davies, 1997](#)). Given that such dimensions may reduce the value of choosing, Reed and colleagues suggest that discounting may be the behavioral process that explains choice overload. In their initial study, [Reed et al. \(2011\)](#) asked human participants employed as direct care staff at a nonprofit school for children with developmental disabilities to make judgments on their choice of options in selecting a new program for a child on their caseload. In the initial trial of the task, participants could select their most preferred scenario from three options: (a) no choice (one program to select from), (b) limited choice (two programs to select from), or (c) extensive choice (three or more programs to select from). The number of programs comprising the extensive choice scenario doubled in each subsequent trial, up to 384 options. The proportion of staff choosing extensive choice decreased in a negatively accelerating nonlinear function and was well described by [Myerson and Green’s discounting model \(1995\)](#). These researchers concluded that the search cost hypothesis was thus confirmed, offering preliminary evidence that choice overload may be a product of discounting.

To parse the differential effects of search cost dimensions related to choice overload, [Reed et al. \(2012\)](#) conducted a follow-up study using within-subject comparisons of delay, probabilistic, and options (i.e., choice overload) discounting using a computerized task. The nonlinear function of options discounting appeared more visually similar to that of delay suggesting that delay discounting may be the process responsible for the devaluation of decisions

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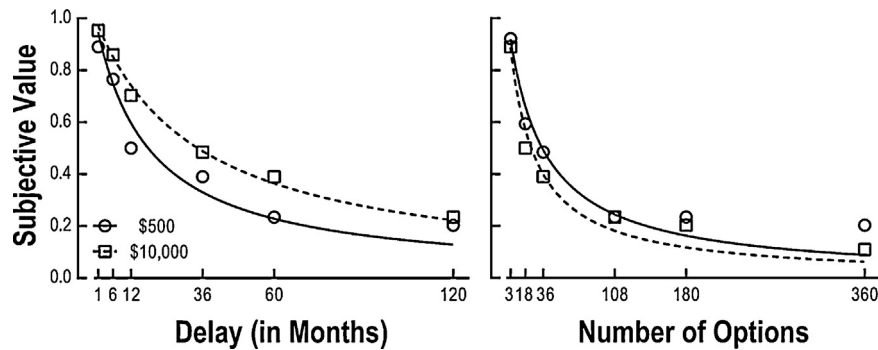


Fig. 1. Median proportional subjective value of \$500 and \$10,000 as a function of delay and number of options fit using Mazur's (1987) hyperbolic discounting equation. \$500 data paths are depicted with open circles and solid lines; \$10,000 data paths are depicted with open squares and dashed lines.

involving abundant numbers of options, possibly due to deliberation times when making extensive choices.

The present study sought to extend this line of research on whether choice overload is indeed reducible to delay discounting. Such a result would be consistent with Rachlin's (2006) perspective that much of our world can be reduced to a discounting function, with choice overload being no exception. To this extent, we aimed to evaluate whether increased magnitudes of the larger reward would produce shallower rates of discounting, similar to the robust effects captured in the delay discounting literature for both humans (e.g., Estle et al., 2006; Green et al., 1999) and nonhumans (Grace et al., 2012). To conduct this analysis, we exposed all participants to both low and high reward magnitudes for delay and options discounting tasks. If choice overload is reducible to delay discounting, we hypothesized that rates of discounting for the higher magnitude reward would be shallower than those for smaller rewards for both options and delay. Such findings would be in direct relation to previous research on delay discounting, and opposite the effects of probability discounting.

1. Methods

One hundred and fifty-six undergraduates (ages ranged from 18 to 58 yr, $M = 20.7$, 126 females) enrolled in an introductory behavioral science course were recruited and received extra credit for participation. Participants completed one 30 min session and during each session, groups of three to ten participants were tested in a computer lab in which they sat at individual computers and monitors.

Participants answered a series of hypothetical choice scenarios on a titrating amount discounting computer program identical to that used by Reed et al. (2012). For each of the six choice trials within each block, participants chose between two hypothetical monetary options (two large squares) – one larger option (a fixed amount; on the first trial either \$500 or \$10,000; LR) and one smaller option (an adjusting amount; on the first trial either \$250 or \$5000; SR) – each associated with either a delay or options value. Depending on the choice on the previous trial, the amount associated with the SR increased or decreased in order to determine the indifference point, or the point at which the two options were considered equal.

In total, four discounting assessments were administered; delay and options discounting assessments, each with LR reward sizes of \$500 and \$10,000. For the delay discounting assessment, the SR was always immediately available whereas the LR was available at differing delays. Delay values consisted of 1 month, 6 months, 1, 3, 5, and 10 yrs. For the options discounting assessment, the SR was always associated with two options whereas the LR was associated with differing number of options. Option values consisted of 3, 18,

36, 108, 180, and 360 options. The order of delay and options values within each discounting assessment was randomized according to a computer algorithm. However, the sequence of assessments (i.e., delay or options) was counterbalanced such that no participant ever completed the same type of assessment back to back.

For example, during one choice trial of the options discounting \$10,000 assessment, participants were presented with two hypothetical options to choose from; a \$5000 reward from two options (SR) or a \$10,000 reward from 108 options (LR). If a participant chose the LR option, the SR would increase by 50% for the next choice trial. However, if a participant chose the SR option on the first trial, the SR would decrease by 50% for the subsequent choice trial. This adjusting amount procedure progressed for six trials. The indifference point was calculated as the next SR value that would have been presented using the adjusting amount algorithm. For the options assessment, participants were not provided any specific instructions regarding what the options represented. However, if asked, the experimenter would explain that the options were up to the participant's imagination but that they were all worth the same amount as indicated on the screen.

2. Results

We fit individual participants' data using Mazur's (1987) hyperbolic discounting model (Eq. (1)). In this equation, V represents the subjective value of the reward, A represents the maximum amount of the reward, and X represents the independent variable, in this case delay or number of options. Finally, k is the free parameter solved for that indicates the rate at which the participant discounts a given reward.

$$V = \frac{A}{1 + kX} \quad (1)$$

Fig. 1 depicts the median proportional subjective value as a function of delay and number of options. A Wilcoxon signed-rank test was used to compare participants' rates of discounting between the two reward magnitudes for both discounting assessments. Fig. 2 displays the distribution of $\log k$ values for all participants. Results indicate significant differences for participants' rates of discounting between the different magnitudes for both discounting assessments. For delay discounting, there was a statistically significant decrease in participants' rates of discounting when the amount of the LR increased from \$500 to \$10,000; $W = -4453$, $p < .0001$. Thus, participants' rates of discounting were higher when the LR amount was \$500, but decreased when the LR amount was \$10,000. Conversely, there was a statistically significant increase in participants' rates of options discounting when the amount of the LR increased; $W = 2580$, $p = .02$. We calculated root mean squared error (RMSE) for all participants for each of the four discounting assessments; Eq. (1) adequately described the discounting functions.

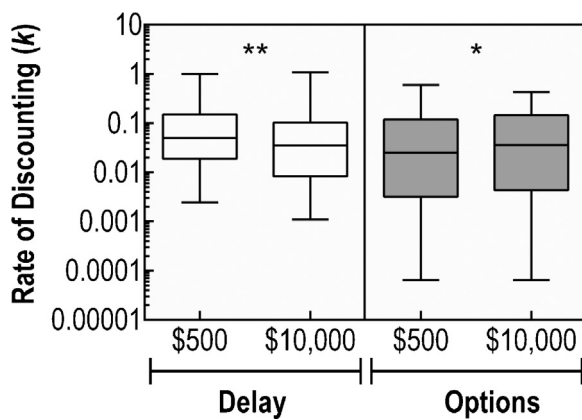


Fig. 2. Box and whisker distribution of participants' k parameter. Boxes depict 75% of participant's values around the median (horizontal bar within box) with whiskers ranging from the 5th to 95th percentile. Note the logarithmic y-axis. * $p < .05$; ** $p < .0001$.

For delay discounting \$500 and \$10,000, median RMSE was 61.31 (range: 5.55–221.5) and 1203 (range: 106.3–4362), respectively. For options discounting \$500 and \$10,000, median RMSE was 63.57 (range: 6.20–204.3) and 1208 (range: 108.5–4674), respectively.

A post hoc analysis was conducted to compare the effects of the magnitude manipulations on the s parameter of the hyperboloid model of discounting (Myerson and Green, 1995) given previous research has suggested this parameter is sensitive to such manipulations in probability, but not delay (McKerchar et al., 2010; Myerson et al., 2003). Specifically, s does not significantly differ between low and high reward amounts. The hyperboloid model of discounting is identical to Eq. (1) with the addition of the denominator raised to exponent s (when $s=1$, this reduces to Eq. (1)). For both delay ($W=108$, $p=.76$) and options ($W=-140$, $p=.60$) discounting assessments, there were no statistically significant differences between the parameters when the LR increased from \$500 to \$10,000.

3. Discussion

The present study sought to extend previous findings that humans discount the subjective value of the availability of choice alternatives as the number of options increase (Reed et al., 2012) and to examine the extent to which choice overload is reducible to delay discounting. Similar to previous research with both humans and nonhumans, the current results replicate the effect that, with respect to delay discounting, a larger reward size is associated with shallower discounting (Estle et al., 2006; Grace et al., 2012; Green et al., 1999; McKerchar et al., 2010; Myerson et al., 2003). However, an opposite effect was observed for options discounting. This pattern more closely resembles what has been shown with different reward sizes in probabilistic discounting (Estle et al., 2006; Green et al., 1999; McKerchar et al., 2010; Myerson et al., 2003).

Comparisons between the s parameter yielded no significant differences as a function of different reward sizes. Interestingly, this pattern is consistent with previous literature indicating s does not differ with respect to different reward amounts in the context of delay discounting. Thus, one possible explanation is that options discounting is a product of a combination of delay and probabilistic discounting. Contrary to Rachlin (2006), the current findings are consistent with Green and Myerson's (2004, 2010) work suggesting that discounting phenomena are not reducible to a single process.

The current results lead to a number of future directions. As we did not directly assess probability discounting using our within subject paradigm, future research should directly examine the relation between rates of discounting. In addition, our options

discounting task consisted of strictly obtaining a hypothetical reward as opposed to a purchasing task in which money is exchanged for a given reward, similar to what has been conducted in choice overload studies in the social psychology literature. Future research should examine how differences in obtaining a reward versus an exchange for a reward affects rates of discounting. Finally, to date, research in choice overload has been conducted exclusively with humans. It is unknown if this or a similar effect would be demonstrated with nonhuman organisms.

In sum, the current research has begun to help shed light on the processes underlying this paradoxical phenomenon. Discovery of the various processes contributing to this choice overload effect may result in enhanced structuring of critical situations in which a person is tasked to choose from a number of alternatives, such as retirement options or mutual funds. It remains unknown, however, whether choice overload is a uniquely human process emerging from verbal behavior and language. Future comparative studies across species using similar paradigms are necessary.

Author note

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