



A New Method for Quantifying Outcomes in Discounting

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Introduction

Discounting has been defined as a decrease in the subjective value of an outcome as the delay to or uncertainty of receiving the outcome increases (for a review, see Green & Myerson, 2004). Research has evaluated how consumable and non-consumable rewards are discounted and suggests that when delay to receipt is manipulated, consumable outcomes (e.g., food and drugs) are discounted more steeply than money, but the different consumables were not discounted differently (Estle, Green, Myerson & Holt, 2007). Interestingly, Estle et al. found no reliable differences between outcome types when the probability of receipt was manipulated.

Previous research has not quantified consumable and non-consumable outcomes in similar units. For example, Estle et al. asked participants to choose between monetary outcomes expressed as dollars and, in different conditions, food outcomes expressed in units (e.g., number of candy bars). Odum and Rainaud (2003) compared the discounting of money with matched monetary amounts of a consumable outcome. For example, participants were asked to choose between \$100 worth of candy now or \$200 worth of candy after a certain delay.

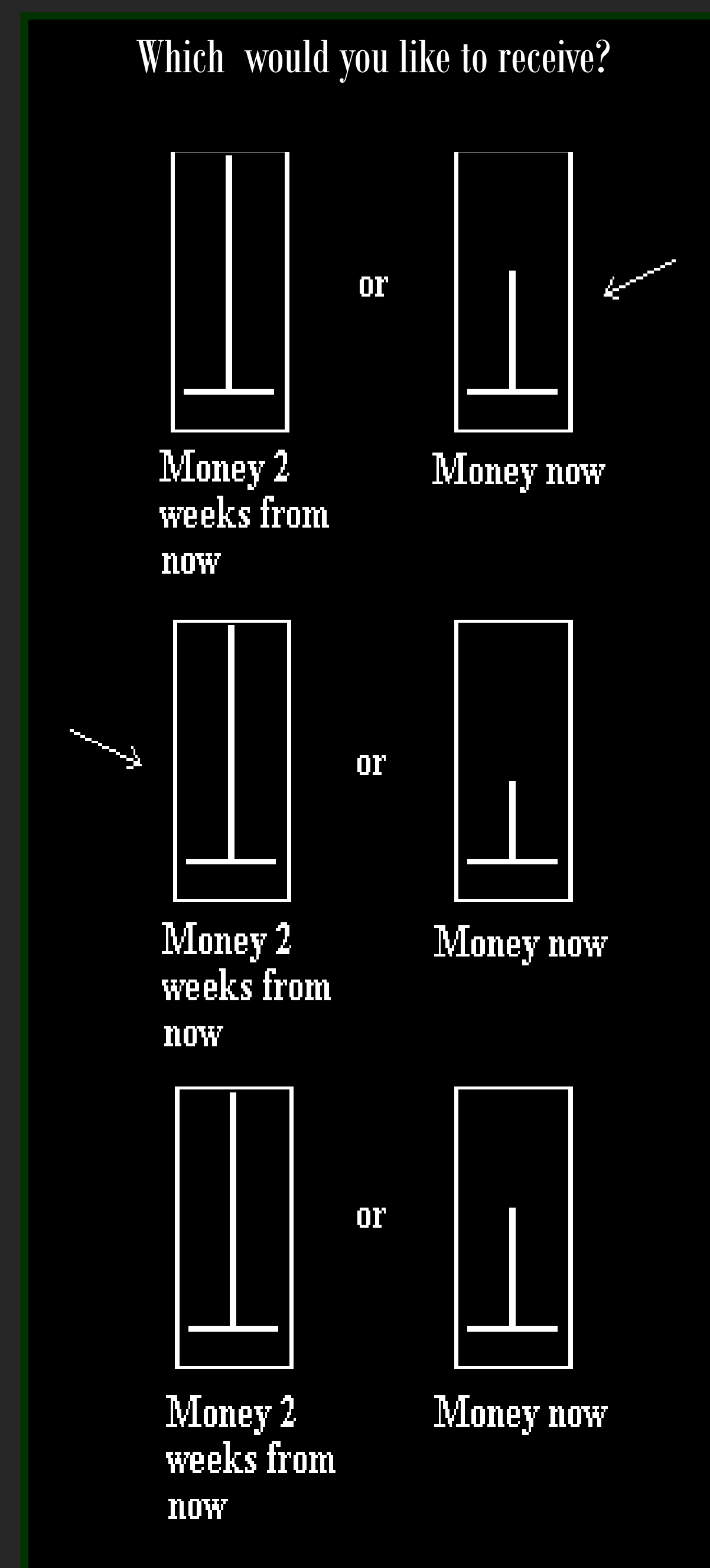
The purpose of the present study is to validate an approach to quantifying various rewards that allows for the comparison of qualitatively different rewards on a quantitatively similar scale. Participants in the present study made decisions about the receipt of large and small amounts of money at different delays and probabilities. The amounts of money were presented both in terms of dollar amounts and lines of different vertical lengths (representing the amounts).

Method

46 participants took part in a web-based choice task where they were asked to make decisions about different amounts of money quantified in terms of dollar amounts and in terms of different length lines. The dollar amounts condition consisted of choices about hypothetical amounts of money, with both delay to and probability of receipt manipulated. The lines condition consisted of hypothetical choices between two lines of different vertical lengths. Participants were told that a full length line (a line that went all the way to the top of the box) represented \$1000 and any decrease in length represented proportionally less value. That is, a line that is half the length represents \$500 because it only extends half way to the top of the box.

A repeated measures design was used where each participant experienced both delay and probability discounting tasks for each condition (dollar amounts and lines) at both smaller and larger amounts.

A staircase procedure that converged rapidly on the amount of immediate reward equal in subjective value to the delayed reward was used. So that after each successive choice, the length of line (or dollar amount) representing the value of the immediate or certain hypothetical outcome was adjusted in such a way that when the greater, less probable or more delayed outcome was chosen, the value of the certain or immediate outcome was increased in an attempt to elicit a change in preference. If the certain outcome was chosen, its value was decreased in an attempt to elicit a change in preference. By the fourth decision in each choice situation, an indifference point between the two lines (or amounts) was reached, which served as an estimate of the subjective value of the outcome.



Results

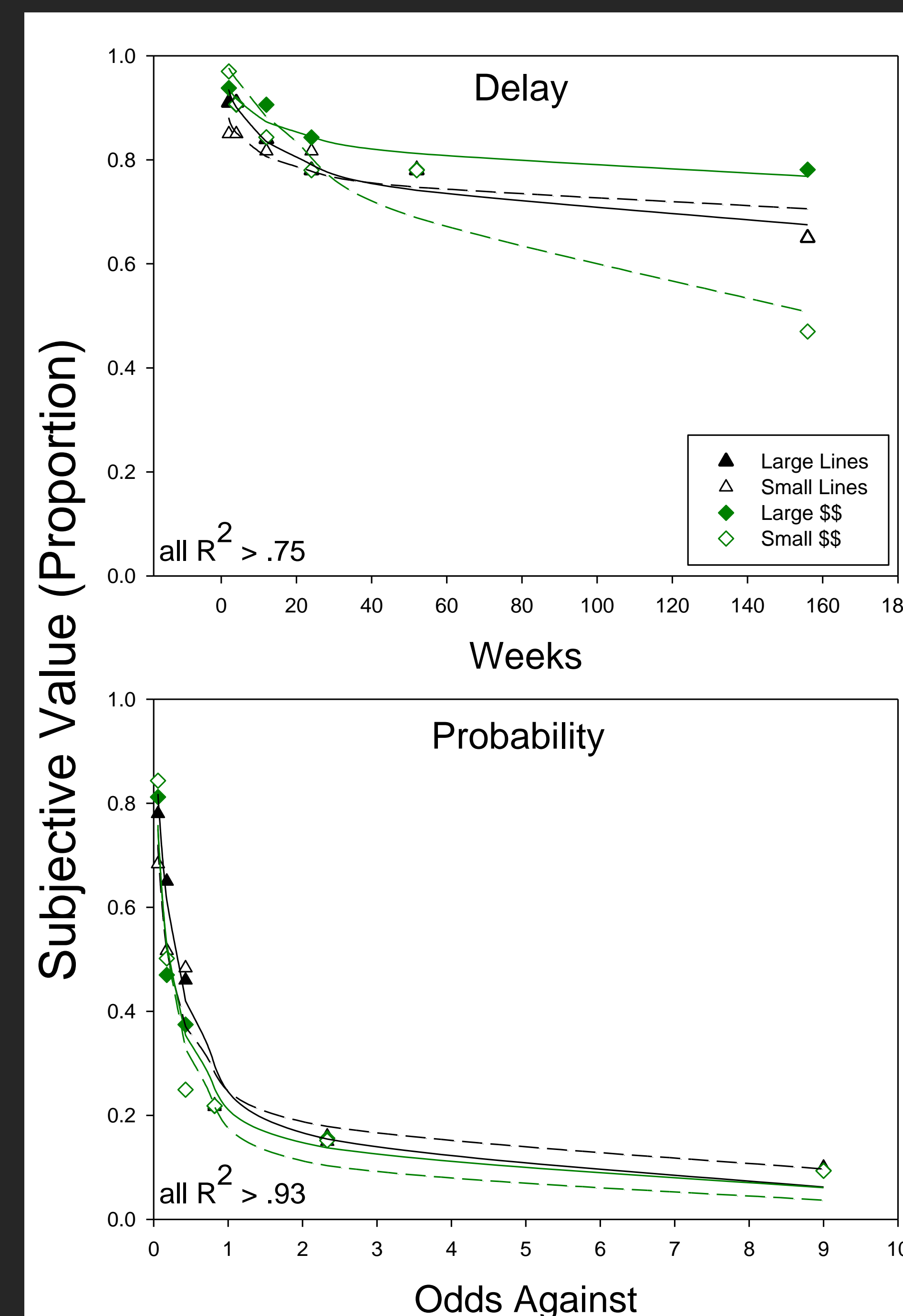


Figure 1. The top panel shows the median subjective values when the outcomes were delayed and best fitting lines (all R-squared values > .75). The bottom panel shows the median subjective values and best fitting lines when the outcomes were uncertain (all R-squared values > .93).

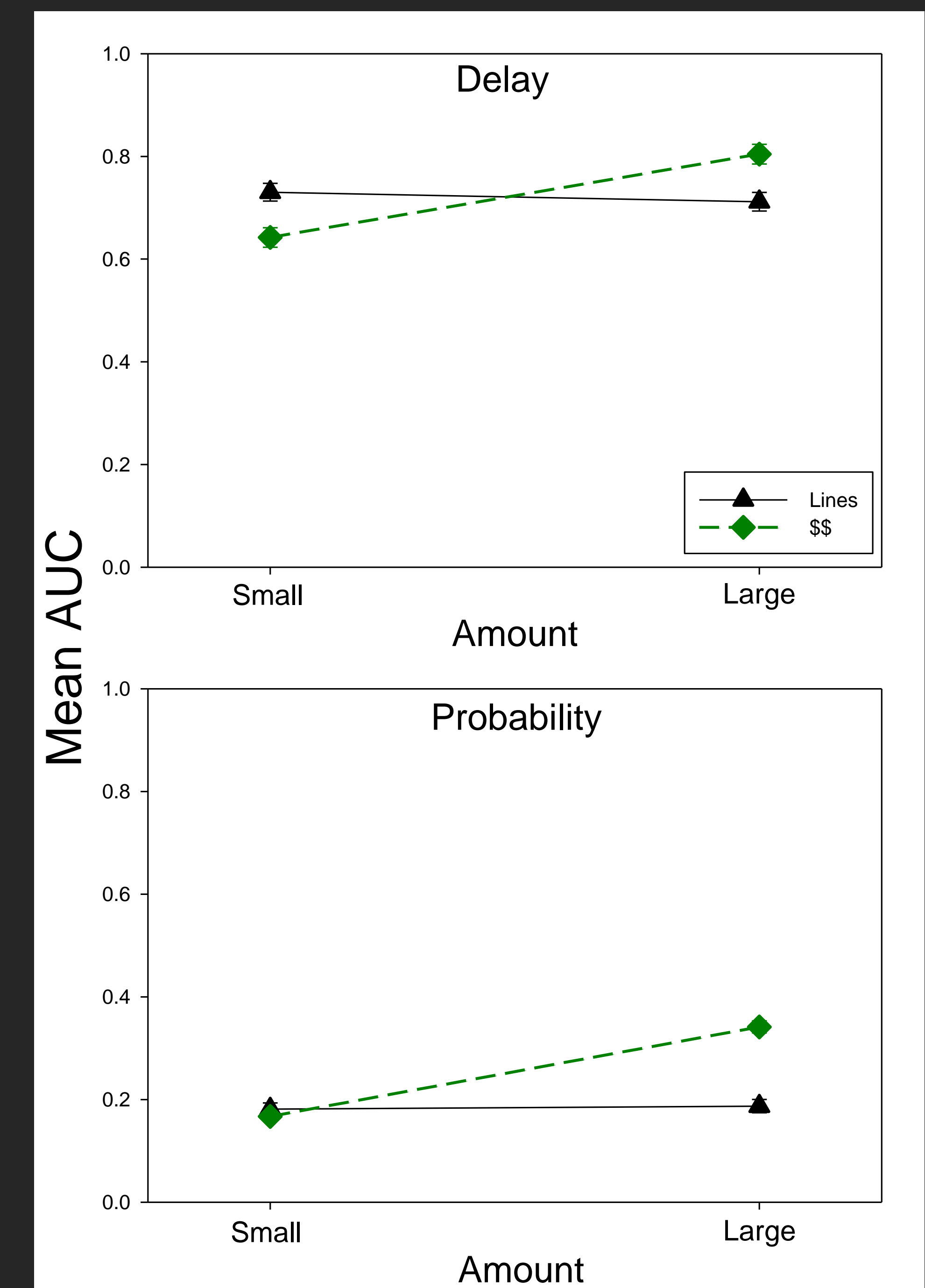


Figure 2. The figure shows the mean area under the curve for both delayed and probabilistic outcomes. A larger area under the curve represents shallower discounting, whereas a smaller area under the curve represents steeper discounting.

Discussion

The purpose of the present study was to validate a new approach to quantifying consumable rewards with the purpose of creating a means for the comparison of qualitatively different rewards on a quantitatively similar scale.

The subjective value of both money expressed as dollars and lines decreased as a function of the delay to (or odds against) its receipt increased. A hyperboloid function [$V = A / (1 + kX)^s$] provided a good fit to the obtained data (best fitting lines are shown in Figure 1).

With delay discounting there were no reliable differences between the outcome types, money expressed as both dollars and lines were discounted similarly. There was an effect seen of amount ($p < 0.05$), as well as an amount by type interaction (2x2 repeated measures ANOVA). The effect of amount demonstrates that small amounts were discounted more steeply than large amounts. The amount by type interaction was produced by the difference between how money expressed as dollars, but not lines was affected by amount.

With probability discounting there were no reliable differences between how the two amounts were discounted. Between outcomes, money expressed as dollars was discounted less steeply than money expressed as lines at trend level ($p = 0.056$). Money expressed as dollars was affected by amount, but not money expressed as lines, contributing to a trend toward a significant type by amount interaction.

Past research that has evaluated how money (as expressed exclusively as dollars) is discounted when its receipt is delayed or uncertain has found that as the delay to or probability of receipt is manipulated the subjective value decreases. The fact that the different lengths of lines that represented different amounts of money were discounted very similarly to the same amounts of money expressed as dollars suggests that this new method is an effective way to quantify qualitatively different rewards on a quantitatively similar scale. Future researchers will be able to utilize this new method of quantifying rewards to study the discounting of many different outcome types.