Prior Beliefs and Experiential Learning in a Simple Economic Game

By

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Abstract

Psychologists and more recently neuroscientists have become increasingly interested in understanding the cognitive and neural substrates underlying human judgment and decision-making under uncertainty. While traditional economic approaches have made considerable advances in modeling human decision-making behavior, many unexplained anomalies remain. In this study, the technique of priming participants to expect a condition and comparing subsequent behavior with unprimed, naïve participants was used to give quantitative insight into these expectation effects. However, it is unclear to what extent initial expectations have long-lasting effects on learning. By inducing expectations in a simple decision making game and controlling the actual conditions experienced by participants, the strength and lasting effects of fairness beliefs on behavior and learning can be described. In groups that received the same offers, the expectation inducement modulated behavioral responses. Additionally, participants accurately internalized the probabilities of different offer amounts based on experience in the experiment.

Introduction

Deciding between options is a task that confronts humans repeatedly each day. Even simple choices, like whether to eat toast or cereal for breakfast, involve a number of computations: how did each food taste the last time you ate it, how long will each take to make, how much does each cost, how full will you feel after eating each, and more. The way that humans utilize value, time delay, and experience to make basic decisions has been studied in several ways, from basic reinforcement learning models to models of rational decision making (see Camerer, Loewenstein, and Prelec, 2005 for a review).

One area of research involves biases and heuristics that automatically guide behavior in specific directions. Numerous phenomena have been discovered, including risk and uncertainty aversion, framing effects, and the asymmetrical weighting of gains and losses. These findings have been integrated with existing economic theory to create realistic, descriptive theories of human decision making, such as Kahneman and Tversky's Prospect Theory (Kahneman and Tversky, 1979) and Cumulative Prospect Theory (Tversky and Kahneman, 1992).

Of particular interest to social scientists are the processes involved in social decision making, and how and in what ways the added complexity of accounting for other self-aware and behaving creatures changes the underlying neural computations. Social decision making introduces a host of new problems, as the beliefs, preferences, desires, and knowledge of other actors much be taken into account (Fehr and Camerer 2007; Lee 2008). To reduce the cognitive resources needed to behave optimally in social situations, humans have developed heuristics or rules-of-thumb for different circumstances. Inequity aversion is one such "shortcut," and leads to behavior that fails to maximize personal gains in favor of more equitable outcomes for others. Inequity is so aversive (at least in some individuals and societies) that it is associated with increased activation in the insula, a brain region that responds strongly to physically displeasing stimuli (Sanfey 2003; Hsu, Anen, and Quartz, 2008).

To make it possible to systematically study such complex behaviors, economists and psychologists have made use of simplistic economic games to isolate specific decision processes. The Ultimatum Game is one such game, in which pairs of participants have the opportunity to split an amount of money between both of them. One player proposes a split of the money (for example, 60% for themselves and 40% for their partner), while the other player can then either accept or refuse the proposed split. When the offer is refused, neither player receives anything. If the game was played between two rational agents, the responder would accept any non-zero offer, since any amount of money is better than nothing; knowing this, the proposer should offer the minimum non-zero amount allowed.

However, over the hundreds of experiments studying this and similar games, humans have not behaved as rational decision theory prescribes. Instead, most proposers offer around half of the total amount, while responders reject highly unfair offers around 50% of the time (Camerer 2003). One clear explanation is a preference for equity in rewards between self and others. The utility of an equitable outcome (zero for each player) outweighs the utility that is lost from not maximizing monetary profits. Note that this preference for fairness must necessarily be highly situational: when playing poker or a sport, it is not expected that one player will put another player's welfare above his or her own.

Manipulating conceptions of fairness in the Ultimatum Game is surprisingly simple, requiring only the suggestion that most offers are usually fair or unfair (Sanfey, submitted/unpublished). The behavioral effects of expectations of fairness or unfairness can be examined by performing this belief manipulation. In addition to changing behavior towards unfair offers, this will also alter participants' perceptions about fairness within the game and about the experience they actually had in the game.

Methods

- Subjects:

    106 undergraduate students from introductory psychology courses (mean age 18.7, 58% female) participated in the study. Each received course credit for participating, as well as a small ($0 to $5) payment depending on their choices in the game. The only condition for participation was proficiency in reading, writing, and speaking English.

    Participants were randomly assigned to one of four groups. The study used a 2x2 design: participants were induced to expect either fair or unfair offers in the Ultimatum Game and received either a predominantly fair or predominantly unfair distribution of offers.

- Materials:

    This study sought to explain how expectations of fairness or unfairness will influence both behavior and self-reported perceptions about offers in the Ultimatum Game. The independent variables were the expectation and distribution of offers. Expectations were induced with a single sentence in the instructions.

    Measurements were made of the rejection rates of each offer amount ($1 through $5) in each of the three blocks, the subjective rating of a "fair" offer pre- and post-test, and the self-reported probability ratings of each offer amount pre- and post-test. First, the acceptance rates of all offers were compared between groups. Then, the acceptance rates of all offers were compared in the first block of 30 trials and the last block of 30 trials to determine any learning effects over time. Participants were also asked both before and after the Ultimatum Game trials what they consider a fair offer. Finally, participants filled out a distribution of offers table before and after the trials, indicating the likelihood that a random offer will be each amount from $0 to $7.

The experimental paradigm was programmed in the E-prime stimulus delivery package. Participants were reminded how to play the Ultimatum Game before they started. They then completed 90 trials spread between three blocks. Each trial consisted of four screens: a three-second fixation/filler screen that said "The next offer will be made in a moment," a four-second screen with the Proposer's picture and ID, an input screen that displayed the current offer and prompted the participant to accept or reject, and a final four-second outcome screen that displayed how much the participant and Proposer ended up receiving. The distribution of offers each participant received depended on their group. Those with a “fair distribution” received 70% fair offers ($4 and $5) and 10% each of the remaining offer amounts ($3, $2, and $1). The “unfair distribution” was composed of 70% unfair offers ($1 and $2) and 10% each of the remaining amounts ($3, $4, and $5).

- Procedure:

Participants began by having the general outline of the experiment explained to them, including that they would complete a number of computer trials that would last around thirty minutes. Participants filled out a consent form and read instructions that explained the Ultimatum Game. Participants took a short instructions quiz to make sure they understand the game and then filled out predictions about offers from other “average” college students. After this, the participants began the experiment.

Participants began the trials by seeing a reminder of how to play the Ultimatum Game. Participants completed the three blocks of thirty trials each, with an opportunity to take a break between each block. Upon the completion of the trials, participants retook the instructions quiz and filled out another offer prediction table. Finally, participants were debriefed, given the opportunity to ask questions, paid an amount of money based on a randomly selected trial, and dismissed.

- Data Analysis:

Several different analyses were performed. Independent sample t-tests were used to compare the fair and unfair expectation groups on their pre-test rating of a fair offer, their predicted average offers distribution, and their first block rejection rates of unfair offers. A 2x2 repeated measures ANOVA was used to compare the change in acceptance rates of offers overall and between the first and third blocks, the change in pre- and post-test ratings of fair offers, and the pre- and post-test average distribution of offers, all between groups.

Hypotheses

We predicted that manipulating expectations and actual distributions of offers would systematically change behavior and perceptions of fairness in the Ultimatum Game. Specifically, having incongruous expectations and actual distributions were hypothesized to lead to predictable changes in rejection rates over time (as participants were forced to modify their prior belief to match their accumulating experience) and subjective perceptions of fairness and "normal" offers.

Participants who were led to expect mostly offers of $4 and $5 will rate these offers as more frequent than unfair offers and will report a relatively high offer amount as "fair." Participants who expect mostly offers of $1 and $2 will rate these offers as more frequent than fair offers and will report a relatively low offer amount as "fair."

Acceptance rates of offers will vary depending on the experimental group. Acceptance rates for the fair/fair group will be low and stable throughout the experiment. Similarly, acceptance rates for the unfair/unfair group will be high and stable. We expect this to occur because a participant in either of these two groups will have their initial expectations confirmed by the distribution they experience. Conditions in which expectation and distribution differ will see changes in the percentage of unfair offer rejections over time, such that the fair expectation/unfair distribution starts with high rejection rates that decline over time and participants with unfair expectation/fair distribution begin with low rejection rates that increase over time.

The post-test ratings of fairness and frequency of offers will correspond to the actual distribution of offers received, rather than initial expectations. This will indicate learning on the part of the participants, as they must modify (or maintain) their initial beliefs to account for the offers they are actually receiving.

Results

A univariate ANOVA was used to determine how well acceptance rates were predicted by expectation and distribution (see figure 1). Distribution (fair or unfair) was highly significant ($p < 0.001$). Expectation (fair or unfair) approached significance ($p = 0.1$), while the interaction between expectation and distribution had a similar result ($p = 0.09$), indicating a differential affect of expectation depending on the distribution. Indeed, participants with a fair distribution accepted the same proportion of offers regardless of expectation; however, in the unfair distribution condition, participants with an unfair expectation accepted over 14% more of their total offers.

While the pre-test ratings for each group were not statistically different, the post-test ratings were determined predominantly by the distribution (see figures 3 and 4). The post-test ratings almost matched the actual distribution of offers, such that each group's aggregated ratings of the likelihood of each offer amount were at most 5% off of the actual distribution they received.

The post-test probability ratings were influenced not at all by the expectation inducement. This is likely because the distribution focused on what the participant experienced by asking about what range of offers they would expect from an average group of peers. If a post-test measure had focused on fairness, an expectation effect likely would have emerged.

Discussion

Several of the main predictions were supported by the data. The main effect of distribution was highly significant, although the expectation main effect only approached significant. The expectation by distribution interaction was found to be approaching significance as well. Overall, the data indicated that there was a ceiling effect for acceptance rates in the fair distribution condition; it appears that the expectation effect was overwhelmed by the huge change in offer distribution. When the distribution was unfair, an expectation effect emerged in the predicted direction. This pattern of behavior lends support to the idea that a subtle manipulation of prior beliefs can have strong behavioral effects, at least in the right context.

Offer amount was highly significant as expected, indicating that participants largely made their decision based on the monetary amount they would receive (see figure 2). The interaction between offer amount and distribution was significant (see figure 5). This means that, as predicted, participants reacted differently to different offer amounts depending on their distribution, as this changed the context in which each offer was appraised.

Several block effects were also significant. The block by distribution interaction points to acceptance rates changing over time differently depending on the distribution type. The block by offer amount interaction suggests that acceptance rates change over time differently depending on the offer amount. Finally, a three-way block by offer amount by distribution interaction also reached significance, which can be interpreted as acceptance rates for certain offer amounts changing over time differently depending on the distribution type.

Contrary to our predictions, the expectation induction affected neither the pre-test probability ratings, which were indistinguishable between groups, nor the post-test probability ratings, which depended entirely on distribution. This presents a different picture than certain past research: expectations or prior beliefs are evident in behavior (acceptance rates) but not in self-report, while learning about the distribution, assumed to be implicit, is actually the dominant factor in “explicit” self-report.

The results of this study help explain the behavioral effects that occur when prior beliefs and actual experience clash. By examining how expectations affect experiential learning in the Ultimatum Game, conclusions can be drawn about similar “real world” scenarios.

Situations in which initial beliefs may be at odds with reality can be explored using this experimental framework. Advertisements of products and first impressions when meeting someone for the first time are two such situations. Uncritical product loyalty and the perseverance of first impressions are both examples of the persistence of expectations, even when experience might conflict with these beliefs.

Future studies should look to examine other factors that influence learning in social and economic situations. What effect does emotional state have on rejection rates over time? Do people naturally converge toward the game-theoretic equilibrium of "accept all non-zero offers" if they play for long enough? How much would information about each partner, such as total amount won or average offer, influence rejection rates? Much more can still be learned from using simple economic games and measuring behavior in and perceptions about these situations.

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Figure 1: Acceptance rates of all offers by condition, showing group differences, main effect of distribution, and the interaction between expectation and distribution.

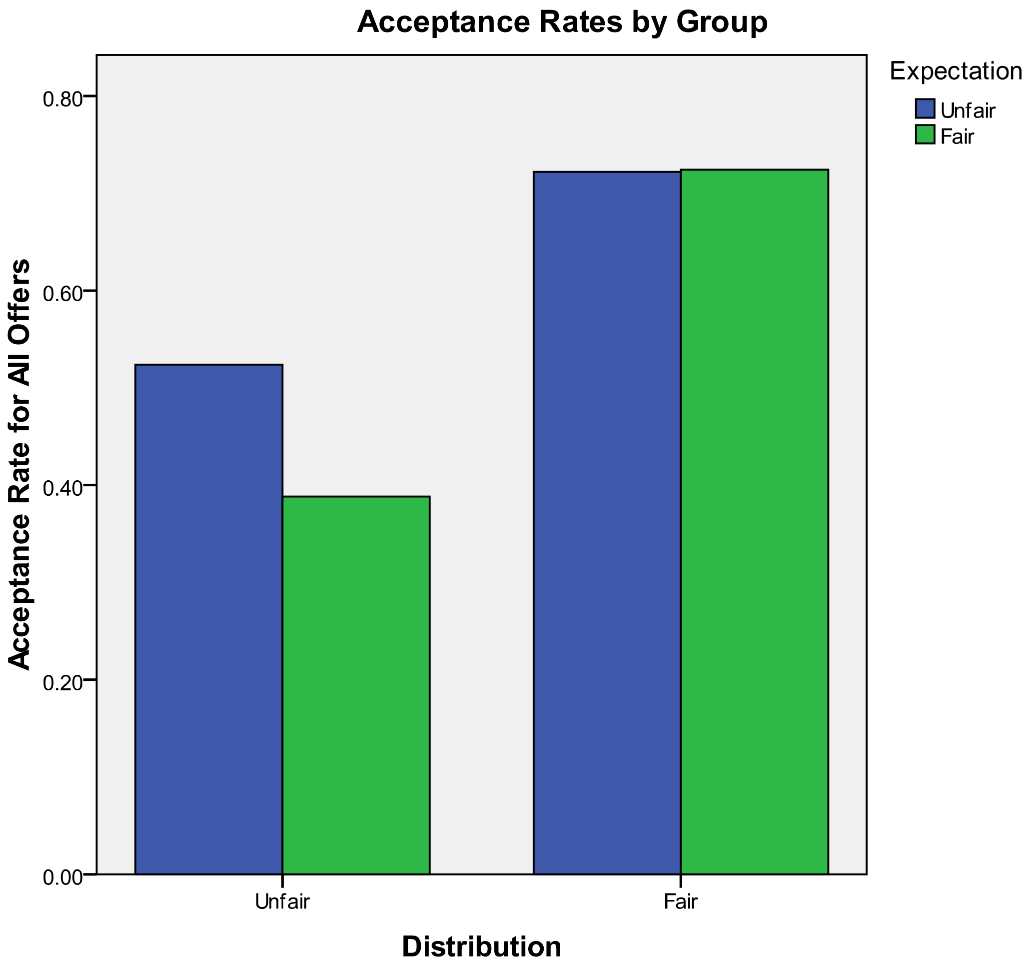

Figure 2: Acceptance rates of each offer amount. $3 offers, which were classified as neither fair nor unfair, were affected the most by condition: in the fair expectation / fair distribution condition, around 40% of $3 offers were accepted; in the unfair expectation / unfair distribution condition, the same figure is around 85%.

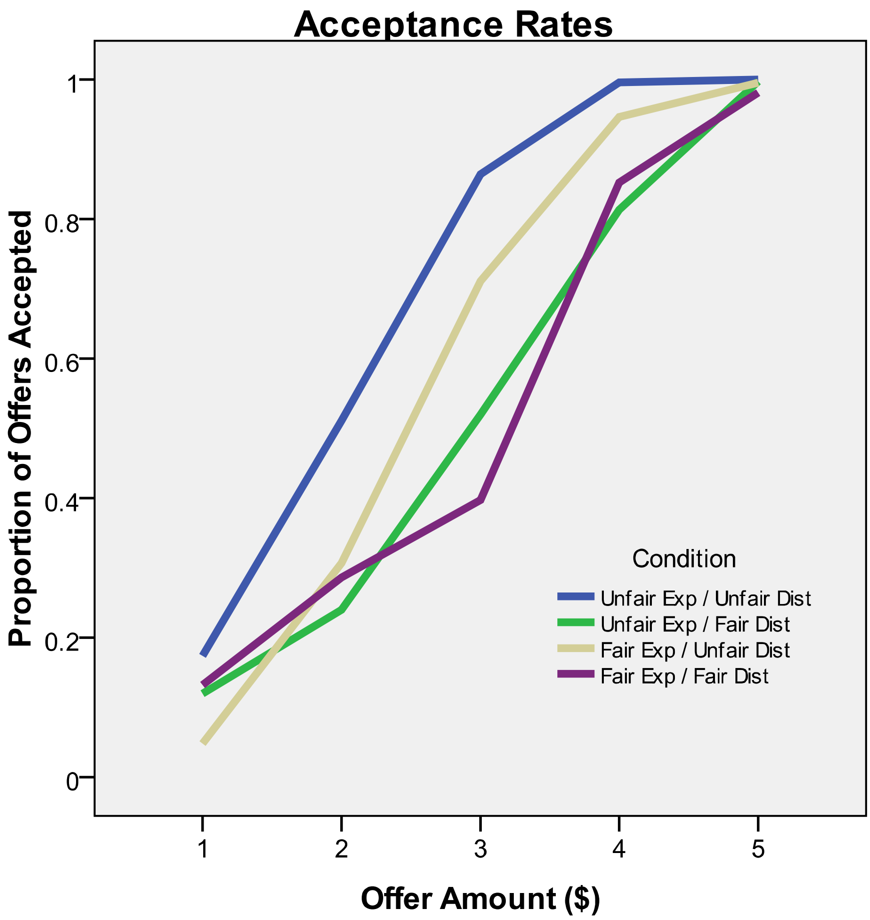

Figure 3: Pretest ratings of probability for all conditions, with no significant effect of expectation.

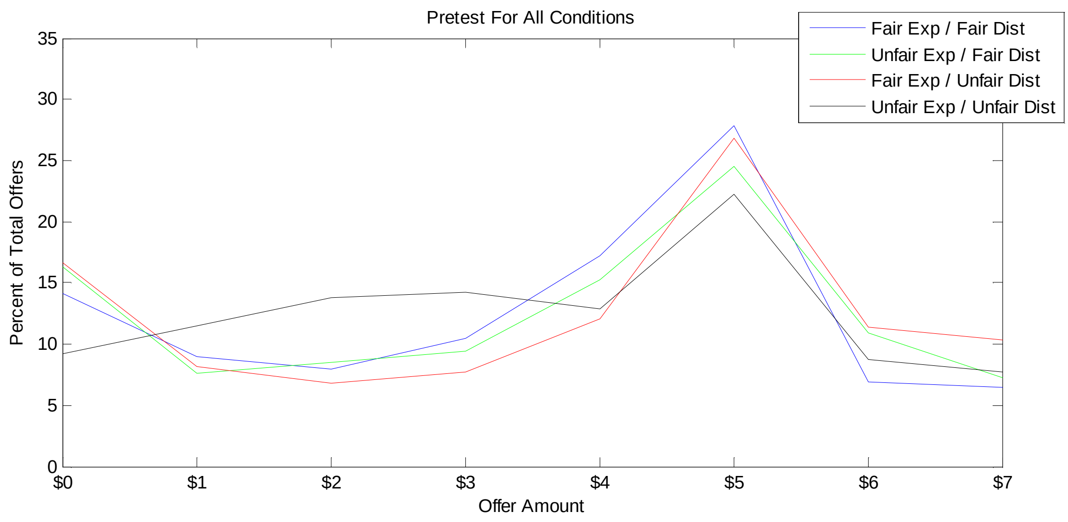

Figure 4: Posttest ratings of probability for each offer amount, with no significant effect of expectation.

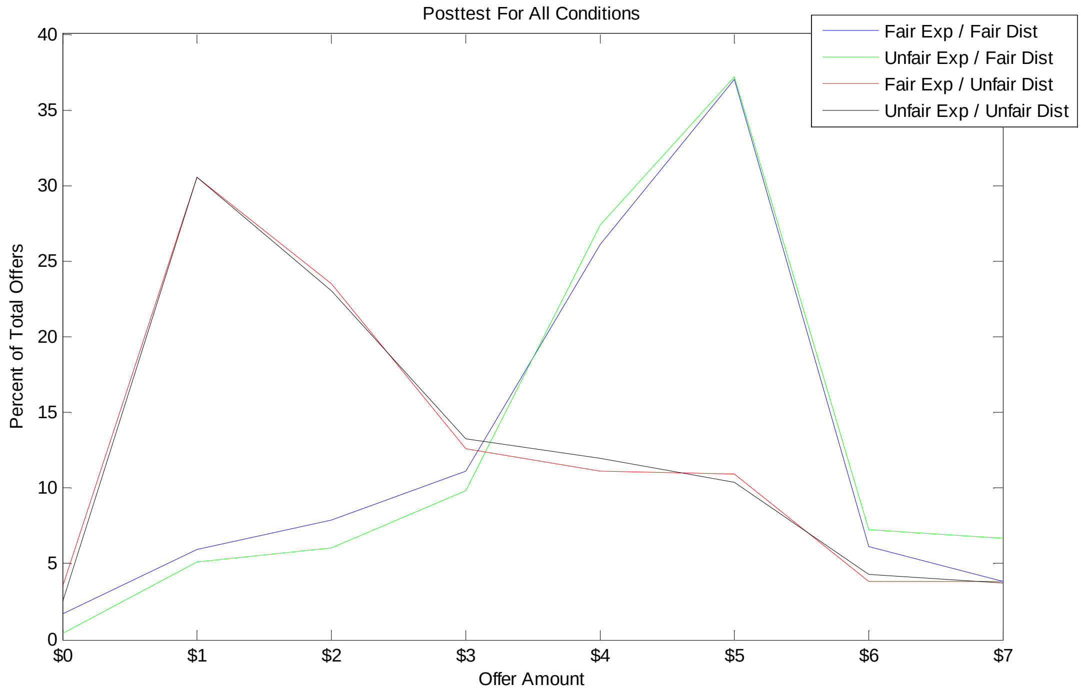

Figure 5: Offer amount by distribution interaction.