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People Do Not Discount Heavily in Strategic Settings, but They Believe Others Do

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Comments

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People Do Not Discount Heavily in Strategic Settings, but They Believe Others Do.

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Abstract

Several studies have shown that people greatly discount future benefits and costs. However, most of the direct laboratory evidence of this phenomenon has focused on individual choice experiments. This paper investigates the degree to which the timing of payments affects behavior in four commonly studies strategic settings: a Prisoner's Dilemma game, a Stag-Hunt game, a First Price Auction and a Second Price Auction. In all four settings, a two week delay in payoffs has a comparable effect to a 20% reduction in current payoffs. A follow-up study suggests that it is an individual's strategic response to the anticipated discount rate of others that might be driving this behavior rather than a participant's own discount factor.

Keywords: Strategic Behavior, Time Discounting, Experiments.

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1 Introduction

Most important economic decisions, including those in the realm of health, education, and business, require inter-temporal tradeoffs. Individuals must often choose between consuming less today or consuming more in the future. A glut of evidence from a growing body of literature suggests that people are rather impatient in the present. Specifically, the research indicates that in individual choice settings, people are willing to forgo fairly large future rewards for much smaller immediate gains (see Frederick et. al, 2002).[1]

However, there are a variety of reasons to think that discounting behavior may differ between individual and strategic settings. First, as compared to individual choice experiments, choices made in a strategic environments are much more complex. In individual choice discounting experiments, for example, subjects typically must consider a simple tradeoff between receiving a smaller amount, x, immediately or a larger amount, $x+m$, at a future date. In strategic settings, in contrast, a person must also consider how their own actions interplay with the action of the other player, and optimize given their set of higher-order beliefs. The additional complexity required to make strategic decisions could impact patience levels if people find the temporal aspect of the task to be non-salient or if they ignore it in order to simplify the problem. In fact, Deck and Jahedi (2013b), the one laboratory study of which we are aware that directly examines impatience in a strategic game, found that people do not as impatiently in Tullock contests as they do in individual choice settings. They show that observed bids were invariant with regard to the timing of the prize payment but not with the size of the prize.

Additionally, it is possible that the complexity involved in strategic games serves to tax the cognitive system. As such, dual-process theory predicts that people will rely more heavily on their intuitive system to guide their decision, which is generally associated with higher levels of impatience (see Shiv and Fedorikhin 1999; Hinson, et al. 2003; McClure, et al. 2004; Franco-Watkins, et al. 2010; and Deck and Jahedi 2013a). Another reason that discounting may differ between individual and strategic settings is given by Ainslie (2001) and Laibson and Yariv (2004) who argue that people may want to hide their impatience in the presence of others to avoid being exploited. It is possible, for example, that firms will try and identify impatient individuals in the marketplace and offer them worse trades. Likewise, it is possible that society as a whole shuns impatient people and so individuals may want to portray an image of patience in front of others. Patience, after all, is said to be a virtue.

This paper reports the results of two studies designed to investigate whether the same

[1] The studies vary in their estimates of the discount factor, but almost all of them find the discount factor to be much smaller than would be predicted by economic reflection.

level of discounting that exists so robustly in individual choice experiments also extends to strategic environments. Our first study examines whether time discounting exists in four commonly studied games: a Prisoner's Dilemma, a Stag-Hunt game, a First Price Auction, and a Second Price Auction. In the first two games, there are three main treatments that are used to identify how participants vary their strategies in response to a change in the size and a change in the date in which prizes are awarded. In the baseline treatment, benefits from cooperation are paid immediately; the other treatments either delay the benefits from cooperation by two weeks or reduce the benefits from cooperation but pay it immediately. The First and Second Price Auctions were altered across treatments so that the induced value for the prize was either realized immediately or in the future. The effect of a reduction in payment is based on the variation in induced values.

Our results indicate that in all four games, subject responses to delayed payment are not distinguishable from responses to reduced prizes. This suggests that people are treating delayed payments as if they are significantly reduced in size – a direct contrast to the findings of Deck and Jahedi (2013b). We conducted a second experiment to test whether the discrepancy could be explained by a biased belief that others are in fact more impatient than they actually are. This study is the first to examine whether people have accurate beliefs regarding the time preferences of others. Indeed, we find that people resoundingly think themselves to be more patient than other people. This carries through to strategic settings as well, where evidence suggests that behavior in the delayed treatments is not due to one's own discounting but rather their belief regarding the discounting of others.

The remainder of the paper is as follows. Sections 2 and 3 describe the experimental design and results, respectively, for the first study. Section 4 provides details regarding the second study. In Section 5, we offer a concluding discussion.

2 Experimental Design of Study 1

This study looks to examine the extent to which individuals respond to the size and timing of payments in strategic games. By holding the timing fixed and varying the payoff, one can identify how a change in the stakes impacts behavior. By holding the payment fixed and varying the timing, one can identify the degree to which discounting impacts behavior. Four commonly known games were utilized in this study: the Prisoner's Dilemma, the Stag-Hunt, a First Price Sealed Bid Auction, and a Second Price Sealed Bid Auction. Relative to a baseline, the games were modified so that in some treatments, the stakes were reduced whereas in other treatments, the payoffs were delayed by two weeks and thus the stakes are discounted at some rate $0 \leq \delta \leq 1$.

	TREATMENT 1: CONTROL	TREATMENT 2: REDUCED PRIZE	TREATMENT 3: DELAYED PRIZE
PRISONER"S DILEMMA	$\begin{array}{ccc} & \multicolumn{2}{c}{P_2} \\ & \textit{Green} & \textit{Black} \\ P_1 \ \textit{Green} & 2,2 & 7,0 \\ \textit{Black} & 0,7 & 5,5 \end{array}$	$\begin{array}{ccc} & \multicolumn{2}{c}{P_2} \\ & \textit{Green} & \textit{Black} \\ P_1 \ \textit{Green} & 2,2 & 6,0 \\ \textit{Black} & 0,6 & 4,4 \end{array}$	$\begin{array}{ccc} & \multicolumn{2}{c}{P_2} \\ & \textit{Green} & \textit{Black} \\ P_1 \ \textit{Green} & 2,2 & 2+\delta(5),0 \\ \textit{Black} & 0,2+\delta(5) & \delta(5),\delta(5) \end{array}$
THE STAG-HUNT	$\begin{array}{ccc} & \multicolumn{2}{c}{P_2} \\ & \textit{Blue} & \textit{Grey} \\ P_1 \ \textit{Blue} & 4.50,4.50 & 4.50,0 \\ \textit{Grey} & 0,4.50 & 10,10 \end{array}$	$\begin{array}{ccc} & \multicolumn{2}{c}{P_2} \\ & \textit{Blue} & \textit{Grey} \\ P_1 \ \textit{Blue} & 4.50,4.50 & 4.50,0 \\ \textit{Grey} & 0,4.50 & 8,8 \end{array}$	$\begin{array}{ccc} & \multicolumn{2}{c}{P_2} \\ & \textit{Blue} & \textit{Grey} \\ P_1 \ \textit{Blue} & 4.50,4.50 & 4.50,0 \\ \textit{Grey} & 0,4.50 & \delta(10),\delta(10) \end{array}$

	TREATMENT 1: CONTROL (HIGH INDUCED VALUE)	TREATMENT 2: REDUCED PRIZE (LOW INDUCED VALUE)	TREATMENT 3: DELAYED PRIZE (HIGH INDUCED VALUE)	TREATMENT 4: DELAYED PRIZE (LOW INDUCED VALUE)
FIRST PRICE AUCTION	$U_i = 6 + I_{WIN} \cdot [4.80 - b_i]$	$U_i = 6 + I_{WIN} \cdot [1.60 - b_i]$	$U_i = 6 + I_{WIN} \cdot [\delta(4.80) - b_i]$	$U_i = 6 + I_{WIN} \cdot [\delta(1.60) - b_i]$
SECOND PRICE AUCTION	$U_i = 6 + I_{WIN} \cdot [4.80 - b_j]$	$U_i = 6 + I_{WIN} \cdot [1.60 - b_j]$	$U_i = 6 + I_{WIN} \cdot [\delta(4.80) - b_j]$	$U_i = 6 + I_{WIN} \cdot [\delta(1.60) - b_j]$

Figure 1: **Four Games where the Size and the Timing of the Prize were Varied.**

Task 1. The Prisoner's Dilemma Game

In this task, subjects were informed that:

> Selecting Green pays you \$2.
> Selecting Black pays the other person R.

This procedure is derived from that of Holt and Capra (2000), which was designed to facilitate the understanding of the game's incentives. In this task R was either \$5 paid today (Treatment 1), \$4 paid today (Treatment 2), or \$5 paid in two weeks (Treatment 3). Reducing R from \$5 paid today to \$4 paid today lowers the returns to cooperation (selecting Black) in the Prisoner's Dilemma game by 20%. Since the opportunity cost of cooperation remains fixed at \$2, this change is expected to reduce cooperation *a priori*. Similarly, under the assumption that people heavily discount the future, changing R from being \$5 paid today to \$5 paid in two weeks is expected to diminish the incentive to cooperate *a priori*. A 20% reduction in the payment was selected because individual choice experiments often report discount rates for two weeks near 80%. Therefore, *a priori* we expect Treatments 2 and 3 to have similar behavior. If delaying payment has a bigger impact than reducing the prize, this would suggest that $\delta < 0.8$. If, on the other hand, pushing the benefit into the future has little or no impact on behavior, it would suggest that people do not discount the future reward much (i.e. $\delta \approx 1$). The three variations of the Prisoner's Dilemma Game are summarized in Figure 1.

Task 2. The Stag-Hunt Game

In this task, subjects were informed that:

> Selecting Blue pays you \$4.50.
> Selecting Grey pays you R if the other person selects Grey and \$0 if the other person selects Blue.

This task was constructed to be similar to Task 1. In this task, R was either \$10 paid today (Treatment 1), \$8 paid today (Treatment 2), or \$10 paid in two weeks (Treatment 3). Just as in the Prisoner's Dilemma game, reducing the payoffs from cooperating from \$10 to \$8 lowers the incentives to cooperate (selecting Grey) and thus is expected to lead to lower levels of cooperation.[2] Likewise, when the payoff from cooperating is delayed into the future, the incentive to cooperate is diminished under the assumption that people are impatient and thus we expect payment delay to yield less cooperation as compared to Treatment 1. As

[2] The payoff and risk dominant strategies coincide in Treatment 1 but not Treatment 2.

in the Prisoner's Dilemma game, the relative cooperation rate between Treatments 2 and 3 depends on the discount rate. Figure 1 shows the three variations of the Stag-Hunt game.

Task 3. The First Price Auction

In this task, subject were informed that:

> The price will equal the **higher** bid.
> My Value is R.

In this task, subjects were told that they had the opportunity to bid in an auction against *one* other person for a fictitious good. The person placing the higher bid would be the winner of the auction and would pay a price equal to his or her own bid. It was common information that each subject was given an endowment of $6 for this task from which a winning bid could be paid.[3] Furthermore, it was common information that both subjects' induced value for the good was drawn from a uniform distribution between $0 and $6. Each subject received one of two realized values that were drawn randomly in advance, $1.60 and $4.80. In the auction tasks, variation in realized values are used to identify how reducing benefit impacts behavior.[4] Subjects were also informed of when the winner would receive the induced value of the fictitious item. Thus the value of R was either, $4.80 today (Treatment 1), $1.60 today (Treatment 2), $4.80 in two weeks (Treatment 3), or $1.60 in two weeks (Treatment 4). As opposed to the first two tasks where subjects were matched with other subjects in the same treatment, in this task subjects in Treatments 1 and 2 were paired and subjects in Treatments 3 and 4 were paired. Figure 1 shows the profit function for each treatment where I_{win} is an indicator function that takes the value of 1 if the bidder wins the auction and 0 otherwise and the subscript i denotes the bidder.

Task 4. The Second Price Auction

In this task, subject were informed that:

> The price will equal the **lower** bid.
> My Value is R.

[3] Unlike Tasks 1 and 2, the auction tasks involved an explicit cost. Therefore, the subjects were given an endowment so that they could bear the consequences of their actions in order for the researcher to maintain control of the incentives of the subjects.

[4] For First Price and Second Price sealed bid auctions, the upper bound on the distribution of possible values is irrelevant under standard assumptions necessitating evaluation of lower payments by comparing across value realizations. We opted to use one set of realized values to keep the auction treatments similar to tasks 1 and 2 where there are two types of values: high and low. Given the random nature of the realizations, it was not possible to force the low value amount to be 80% of the high value amount.

This task was identical to Task 3 except for the price paid by the winner. The winner paid his or her opponent's bid. Subjects retained the same value and payment timing for the item in Tasks 3 and 4 and the endowments were the same. The objective functions for subjects in each treatment are shown in Figure 1 where the subscript j denotes the other bidder.

Experimental Procedures

Subjects played one version of each of the four tasks and did not know that multiple treatments were occurring simultaneously, thus the results presented in the next section are between-subjects. The experiments were hand-run and each subject was presented with a single sheet of paper. The sheet contained the four tasks, labeled Tasks 1 through Task 4, and subjects were required to select an action in each task. The order of the tasks was similar for everyone but subjects could respond in any order that they wished and could go back and change their responses if they felt so inclined. Subjects were paid for only one of the tasks. After all responses were collected, a four sided die was rolled in front of the subjects to decide which task would count towards their payoff. This procedure was known to the subjects in advance. Complete texts of the data collection instruments are available in the Appendix.

The experiment involves intertemporal tradeoffs for some treatments, and thus it is important to minimize any transaction cost or uncertainty that is associated with the collection of future disbursements. Andreoni and Sprenger (2010) discuss this issue in detail pointing out that additional transaction costs or uncertainty regarding future payments could be mistakenly be interpreted as increased discounting of future payments. This has led research to employ a variety of approaches when conducting salient experiments over multiple time periods.[5] This paper follows the approach of Horowitz (1991) and Deck and Jahedi (2013b) who conduct the experiment with students in class. This approach has the advantage that it eliminates the transactions costs for collecting future payments and it may reasonably be argued to eliminate the risk associated with future payments being made given that it is legitimized by the instructor. However, in any experiment the researcher must be concerned with maintaining dominance (Smith 1982) including the specific issue of demand effects such as students attempting to please their instructor (Zizzo 2010). Eckel and Grossman (2000) report that subjects are more cooperative in the classroom than in the laboratory, but they find no difference in their primary treatment effect (the effect of matching versus rebates) between the two locations. In fact, Zizzo (2010) offers no evidence that classroom experiments

[5]For example, Kirby and Marakovic (1995) hand deliver payments in the evening and Coller and Williams (1999) only use future periods to keep transaction costs and risk fixed.

yield different treatment effects than the lab.[6] To reduce the possibility of experimenter or teacher demand effects, the experiments were not conducted with the researchers' classes and the participants were assured that their decision to participate and their responses would not be shared with the instructor who was not involved with conducting the study.[7]

At the beginning of a 80 minute class period, the researchers entered the classroom and presented the students with the opportunity to voluntarily participate in a study that would last approximately 10 minutes. Large brown envelopes were distributed to students, who were instructed to take one if they wished to participate. Inside the large envelope was one version of the response form and one or two white business envelopes depending on the treatments. The business envelopes were labeled either "Money Received Today" or "Money Received in Two Weeks," as appropriate. The envelopes also had a place for the subjects to write their names. Once the subject completed the response form, the response form and business envelope(s) were returned to the large brown envelope and then collected by the researchers. Once all of the large envelopes were collected, the researchers rolled the die to determine which task would be used to calculate payoffs, then left the room as the instructor began class as normal. In another room, the researchers determined each subject's payoff. Cash payments were placed inside the business envelopes. Envelopes labeled "Money Received Today" were taken back to the classroom that day approximately 5 minutes before the class was scheduled to end and were returned to the individuals. Envelopes labeled "Money Received in Two Weeks" were taken back to the classroom 5 minutes before the end of class two weeks after the experiment was conducted and distributed. Any money not claimed in two weeks was brought to the next class meeting and thus the two weeks represented the minimum delay. Only a handful of subjects did not receive their payment in two weeks and all of these people were paid during the following class.

3 Experimental Results

The results are summarized in Table 1. Behavior in each of the four tasks are analyzed separately. As discussed in the previous section, we anticipate that reducing the gains from cooperation will lower cooperation rates in games and that bidders with lower values will bid less in auctions, thus statistical comparisons of these treatments rely on one-sided tests.

[6]In a recent paper, Cason and Plott (2012) make use of the classroom to administer experiments testing the validity of the popular Becker, DeGroot, and Marschak (1964) procedure.

[7]The data were collected from undergraduate business school classes. While the researchers are professors in the business school, neither had taught any of the students in the classes where data were collection. While some of the subjects may have participated in other research experiments, none had participated in any related studies.

Table 1: **Summary of Experimental Results.**

	Today Treatments		2-Week Delay Treatments	
	Treatment 1	Treatment 2	Treatment 3	Treatment 4
% Cooperate in Prisoner's Dilemma	$R = \$5$ 63% (0.09)	$R = \$4$ 43% (0.10)	$R = \delta \cdot \$5$ 45% (0.08)	
% Cooperate in Stag-Hunt	$R = \$10$ 74% (0.09)	$R = \$8$ 46% (0.10)	$R = \delta \cdot \$10$ 50% (0.08)	
Subjects in Games	27	28	42	
Average Bid in First Price Auction	$R = \$4.80$ \$4.16 (0.22)	$R = \$1.60$ \$2.75 (0.29)	$R = \delta \cdot \$4.80$ \$3.54 (0.31)	$R = \delta \cdot \$1.60$ \$2.67 (0.20)
Average Bid in Second Price Auction	$R = \$4.80$ \$3.74 (0.27)	$R = \$1.60$ \$3.14 (0.32)	$R = \delta \cdot \$4.80$ \$2.92 (0.35)	$R = \delta \cdot \$1.60$ \$3.15 (0.30)
Subjects in Auctions	28	27	21	21

The same is true for treatment comparisons in which benefits are delayed. However, with no *a priori* reasons to think that reducing and delaying benefits will have differential effects, comparisons between such treatments rely on two-sided tests.

Behavior in Task 1. The Prisoner's Dilemma Game

When the reward to cooperation was \$5 paid today, 63% of the subjects acted cooperatively. When the reward fell to \$4 today, only 43% of the subjects acted cooperatively. This change is in the anticipated direction as the treatment lowers the returns to cooperation and is significant (one-sided p-value = 0.07 using a two sample proportion test). When the \$5 reward is pushed into the future by two weeks, the observed cooperation rate is 45%. This change is consistent with the prediction that subjects exhibit heavy discounting and the difference is significant (one-sided p-value = 0.077).

There is no statistical difference (two sided p-value = 0.847) between cooperation rates when the reward is \$4 today (43%) or \$5 in two weeks (45%). We cannot reject the hypothesis that pushing the reward two weeks into the future leads to any different behavior than reducing the immediate value of the prize by 20%.

Behavior in Task 2. The Stag-Hunt Game

When the cooperative outcome was \$10 paid today, the cooperation rate was 74%. When the reward was reduced by 20% to \$8 paid today, the cooperation rate fell to 46%. This change is statistically significant (one-sided p-value = 0.018). When \$10 reward is pushed two weeks into the future, the observed cooperation rate fell to 50%. This change is consistent with the prediction that people are discounting the future (one-sided p-value = 0.023 using a two sample proportion test).

There is no statistical difference (two-sided p-value = 0.774) between cooperation rates when the reward is \$8 paid today or \$10 paid in two weeks. Thus, again it appears that pushing the reward two weeks into the future does not have a different effect on behavior than reducing the reward paid today by 20%.

Behavior in Task 3. The First Price Auction

The average bid by subjects who had a high valuation today was \$4.16 and the average bid by subjects who had a low valuation today was \$2.75.[8] Subjects clearly responded to their induced values in the auction (one-sided p-value < 0.001 using a two sample proportion test). This same pattern is true when rewards are pushed two weeks into the future. Bidders with high valuations for a future prize bid \$3.54 which is more than what bidders with low valuations bid for a future prize, \$2.69 (one-sided p-value < 0.013).

The timing of the reward is also important. Bidders with high valuations bid more when the prize is rewarded immediately \$4.16 than when it is rewarded two weeks into the future \$3.54 (one-sided p-value = 0.051). This is consistent with discounting a two week period by approximately 15% ($\approx \frac{\$4.16-\$3.54}{\$4.16}$). Bidders with low valuations also lower their bids when the payment is deferred into the future, but the difference is not significant. The average bid drops from \$2.75 when the prize is paid today to \$2.69 when the prize is paid in the future (one-sided p-value = 0.436). This result may be evidence of a "throw-away bid" phenomenon where bidders with low values act as if there is virtually no chance of their winning and bid erratically (see Cox, et al. 1992). Perhaps if the bidder thinks she is unlikely to win, then she may see no reason to consider the timing of the reward.[9] All of these treatment comparisons

[8] The risk neutral Nash equilibrium bid function is $\frac{Value}{2}$. Thus, when a subject has a value of \$4.80 (\$1.60) the risk neutral equilibrium bid would be \$2.40 (\$0.80). However, unlike most auction experiments which attempt to test theoretical predictions and thus have subjects bid in a series of auctions to gain experience, our objective is to identify how the prize impacts behavior for a given experience level. The logistical constraints of the experiment preclude repetition and this lack of experience in a particular auction may add noise to the observed behavior, but there is no *a priori* reason to think that it is correlated with the treatment.

[9] It is also possible that the example bids of \$2.25 and \$3.50 on the response form influenced behavior

are also supported by Kolmogorov-Smirnov tests based upon the distributions of bids.

Behavior in Task 4. The Second Price Auction

For Second Price Auctions, the theoretical prediction is that people bid their value. However, many experiments have shown that subjects do not truthfully reveal their values in this auction and often bid above their value (see Kagel 1995). Recent work by Cason and Plott (2012) on the closely related Becker, DeGroot, and Marschak (1964) procedure sheds light on the various ways subjects naively believe they should act strategically in such settings.[10]

In the Second Price Auction when people were bidding for a prize today, those with high valuations bid \$3.74 which is more than those with low valuations bid, \$3.14 (one-sided p-value < 0.078). This pattern no longer holds once the prizes are pushed out into the future. For future prizes, those with low valuations actually ended up bidding \$3.15 which is higher than the \$2.92 that those with high valuations bid on average.

When the reward is pushed into the future, high value bidders reduce their bid from \$3.74 to \$2.92, an approximately 21% discount ($\approx \frac{\$3.74-\$2.92}{\$3.74}$). This reduction is significant (one-sided p-value $= 0.033$). Again, low valued bidders do not appear to discount the future (\$3.14 vs. \$3.15, one-sided p-value $= 0.509$ using a two sample t-test). These conclusions are also supported by Kolmogorov-Smirnov tests comparing the distributions of bids between treatments. As in the First Price Auction, the lack of a discounting for low valued bidders may be due to their assuming that they have virtually no chance of winning the auction and thus that the timing of the prize is irrelevant. Low value bidders could also be acting spitefully and bidding above value in an attempt to increase the price that someone else has to pay.

4 Study 2: Decomposing Own Discounting from Beliefs about Discounting

In the four tasks discussed above, observed behavior is consistent with subjects exhibiting a significant amount of discounting. In both of the cooperation games, subjects reduced their cooperation rates when the payoff from cooperating was delayed. In both of the auctions, high-valued subjects reduced their bids once prizes were awarded in the future. The results seem to suggest that the heavy discounting that is typically present in individual choice

leading subjects to place bids near these values, which could lead to overbidding by low value bidders.

[10]The Becker, DeGroot, and Marschak (1964) procedure is essentially a Second Price Auction against another bidder behaving randomly.

experiments also extends to strategic settings. However, this finding would be in direct contrast with that of Deck and Jahedi (2013b) which find *no* evidence of discounting in Tullock contests, despite the fact that the two studies follow very similar protocols.[11] One possible explanation is that there is something structurally different between the tasks studied in the current paper and the Tullock contest studied in Deck and Jahedi (2013b).

For a two person Tullock contest, where one's chance of winning a prize is based on one's share of the total investment, optimal behavior does not vary substantially with the discount rate of the other bidder. To see this, suppose that player i were bidding to receive a prize of size P immediately against player j, who would receive the prize P in the future, which he discounts by δ_j. It is simple to show that the optimal bid for player i depends only slightly on the discount rate of player j, since $b_i^* = \frac{\delta_j P}{(1+\delta_j)^2}$. For a prize size of $P = 5$, as in Deck and Jahedi (2013b), this implies that a change in player i's belief of the other's discount factor from $\delta_j = 1.0$ to 0.6 would lead to a change in bid from $b_i^* = \$1.25$ to \$1.17. While the discount factor of the opponent has a negligible effect on one's optimal bid in a Tullock contest, an individual's own discount factor impacts the optimal bid more dramatically.

In contrast, for the tasks examined in this study, both by the individual's own discount rate as well as their belief regarding the other person's discount rate is important for behavior. For example, in the Stag-Hunt game an impatient person may not want to play cooperatively when the prize is delayed because the action is risky and the upside potential is reduced. A patient person may also choose not to play cooperatively due to a belief that the other person is impatient and thus will be unwilling to take the risky cooperative action.[12] In a First Price Auction, one could reduce his or her own bid either because the future value is lower or as a strategic reaction to the belief that others will bid lower due to their impatience.[13] Thus, an explanation for the two seemingly disparate results is that people do not exhibit strong discounting in strategic games but believe that others do.

To separate the strategic effect of one's own discounting from the beliefs regarding others'

[11] There are some procedural differences between the studies. In this study, (1) we use a two-week delay rather than a one-week delay for future prizes, (2) we abstain from offering a \$1 future payment in addition to any salient earnings, and (3) we conduct the experiment in a later date and in a different room, but with the same general subject pool. We argue that the procedural differences do not account for the difference in results between the current study and Deck and Jahedi (2013b) because the individual discount rates (as described later in this section) are almost identical.

[12] The decision not to cooperate when the reward is delayed could also be due to higher order beliefs, such as one's belief that the other person believes one is impatient.

[13] Beliefs about the impatience of others theoretically do not matter in Second Price Auctions; however, as discussed in the previous section, bidders often act as if they should be strategic in which case beliefs do matter. In the Prisoner's Dilemma game a self-interested player would never cooperate regardless of the timing of payment or their beliefs about others' impatience. However, if people care about the outcomes of others and recognize the opportunity for mutual gain then one's own discount rate as well as one's beliefs about the impatience of others come into play.

discounting, we conducted a second experiment. Two concurrent strategies are employed: (1) we directly measure individual's own discount factors along with their beliefs regarding others' discount factors, and (2) we isolate the effect of an individual's own discount factor in the setting used in the first study by presenting asymmetric information regarding the payment date to the subjects.

In order to directly elicit an individual's own discount factor, we used a standard individual choice procedure that asks participants to make a series of six binary choices between money paid immediately and money paid in two weeks. The first choice was between $5 paid today and $5 paid in two weeks. For each successive choice the amount of money paid today was reduced by $0.50 while the amount paid in two weeks was held constant (e.g., $4.50 today vs. $5.00 in two weeks). The row at which a subject switches from choosing less money immediately to choosing more money in the future is used to approximate an individual discount factor. Subjects were informed that only one of the rows could be used to determine their actual payment. The task can be found in the Appendix.

In order to measure an individual's beliefs about the discount rates of others, we elicited each subject's prediction regarding the percentage of people in the session (excluding themselves) that preferred receiving the money today for each of the six choices in the direct elicitation task described above. As explained to the subjects, these predictions were incentivized with a quadratic scoring rule so that truthful reporting was optimal. Subjects were informed that only one of these predictions could be used to determine their payoff. The task can also be found in the Appendix.

The methodology of Study 2 was designed to be as comparable as possible to that of Study 1. This experiment was conducted in the classroom in a fashion similar to the first experiment. The incentive levels were kept constant by maintaining that there were four tasks, each with a payoff of approximately $5, of which one was randomly selected for payment. Because of the addition of the two discount elicitation tasks, two of the original tasks were dropped. Ultimately, we opted to include the Prisoner's Dilemma and Stag-Hunt games over the First and Second Price Auctions because of the large variation in bidding behavior in the auctions, especially for those subjects who had relatively low values.

To isolate the effect of an individual's own discount factor in strategic settings, we match players from two treatments of the Prisoner's Dilemma and Stag-Hunt games against one another. The players from *Treatment 1′* receive nearly identical instructions as those in Treatment 1 from Study 1.[14] In what we term the *Hybrid* treatment, the other player is

[14] The difference between these two nearly identical response forms is that in Study 1 the subjects were told in the general instructions that all money was paid to them today since there was no possibility of future payment on any of the tasks whereas in Study 2 these subjects were told that they received their money from the game today in the task specific directions because the individual discounting and belief elicitation

given the following additional information for the Prisoner's Dilemma and Stag-Hunt games respectively:

> *Prisoner's Dilemma*:
> If this task is randomly selected for payment, the person you are matched with will receive all of his or her money today. If you select Green you will receive the $2 today. However, if the other person selects Black you will receive the $5 in two weeks. The other person was not told anything about when you will be paid and was only told that he or she would be paid today.
>
> *Stag-Hunt*:
> If this task is randomly selected for payment, the person you are matched with will receive all of his or her money today. If you select Blue you will receive the $4.50 today. However, if you both select Grey you will receive the $10 in two weeks. The other person was not told anything about when you will be paid and was only told that he or she would be paid today.

The Hybrid player is paid in the future, so his own discount factor will influence his choice. The Hybrid player should realize, however, that his opponent is unaware of the temporal aspect of the game and will not incorporate the opponent's discount factor into his decision. By comparing the behavior of Treatment $1'$ to the Hybrid treatment, we can isolate the effect that one's own discounting has on behavior. By comparing the behavior of the Hybrid treatment to Treatment 3 of our earlier study, we can effectively infer how others' discount factors (along with any higher order beliefs) influence behavior. If the cooperation rates in Treatment $1'$ and the the Hybrid treatment are equal, it would mean that the reduction in cooperation associated with pushing payments into the future is not due to own discounting, but rather to the belief one has regarding the discount factor of others. If, on the other hand, the cooperation rates in Treatment $1'$ and the Hybrid treatment are different, it would mean that the reduction in cooperation associated with pushing the payments into the future is due to one's own discounting, and that beliefs do not matter much.[15]

Results

A total of 81 new subjects participated in Study 2. There are $N = 77$ usable responses for the individual discounting task and $N = 74$ usable responses for the belief-elicitation

task could involve future payments.

[15] To the degree that both own discounting and beliefs about others matter we would expect to see Hybrid behavior fall between the extremes of Treatments 1 and 3.

task because some participants either left the task blank or their responses were inconsistent. The results are described in Table 2. The first column denotes the row in which a participant switched from choosing the today payment to choosing the future payment; it is used to identify the range of each person's discount factor. If a person never chose the future payment, it was assumed that they would switch in the next row giving their discount factor a range between $0.5 \leq \delta \leq 0.6$. Only two people were this impatient. Overall, 61% of individuals (47 out of 77) chose to have \$5 in two weeks rather than \$4.50 immediately. If each individual is assigned a discount factor that is the midpoint between their range, the average two-week discount factor for the entire sample can be computed as $\bar{\delta} = 0.88$ (with std. error = 0.02).[16] This is comparable to the estimate of Deck and Jahedi (2013b) which found a one-week $\bar{\delta} = 0.86$ using a similar methodology.

Table 2: **Distribution of Individual and Others Predicted Discount Parameters.**

Row	Range of Discount Factor	Number	Actual	Avg. Prediction
1	$1.0 \leq \delta \leq 1.1$	5	6.5%	1.3%
2	$0.9 \leq \delta \leq 1.0$	47	61.0%	9.5%
3	$0.8 \leq \delta \leq 0.9$	5	6.5%	17.6%
4	$0.7 \leq \delta \leq 0.8$	13	16.9%	39.2%
5	$0.6 \leq \delta \leq 0.7$	2	2.6%	20.3%
6	$0.5 \leq \delta \leq 0.6$	3	3.9%	12.2%
$\oslash$	$0.4 \leq \delta \leq 0.5$	2	2.6%	0%

The final column of Table 2 reveals what individuals believe the average patience level of others to be. For each of the money now vs. money later choices, participants were asked to predict the fraction of other subjects that chose the immediate option. Using this information, we computed each individual's predicted distribution of discount rates. We utilized the change in percentage guess from subsequent rows to calculate the implied fraction massed at each discount factor. If there was a positive number in the final row, we assumed that the remaining fraction were massed at $0.4 \leq \delta \leq 0.5$. If the first row contained a number less than 100%, it was assumed that the residual percentage had $1.0 \leq \delta \leq 1.1$. For each person, the average prediction of others' discount factor was then computed using the midpoint of each range as the appropriate discount factor. We found that the average prediction of the discount factor was lower for all but ten individuals. The estimated belief

[16] Using the lower bound of the δ range would yield an estimate of $\bar{\delta_L} = 0.83$ while the upper bound yields an estimate of $\bar{\delta_H} = 0.93$. The estimate is invariant to the Prisoner's Dilemma or Stag-Hunt treatment the subject experienced.

of others' average discount factor is $\bar{\delta}_j = 0.75$ (with std. error $= 0.01$), which is significantly smaller than the average own discount factor (p-value < 0.001).

There are $N = 79$ usable responses overall for both the Prisoner's Dilemma and the Stag-Hunt tasks as two participants left those tasks blank. The results are described in Table 3. The shaded columns in the middle present the cooperation rates in the Prisoner's Dilemma and Stag-Hunt games in Study 2 while the first and last column recapitulate the results from the first study. For Treatments 1 and $1'$ where players receive their payments that day, cooperation rates for the Prisoner's Dilemma game are quite similar (two-sided p-value $=$ 0.749). There are no difference in the cooperation rates between those treatments for the Stag-Hunt game (two-sided p-value $= 0.841$) as well. Therefore, we combine data from these two treatments. Combining these data sets strengthens the statistical tests comparing today and future payments presented previously. For the Prisoner's Dilemma game the combined (60.6%) cooperation rate differs statistically (one-sided p-value $= 0.06$) from the Treatment 3 cooperation rate (45.2%). For the Stag-Hunt game, the combined (72.7%) cooperation rate differs statistically (one-sided p-value $= 0.01$) from the Treatment 3 cooperation rate (50.0%). Given the similarity in behavior between Treatments 1 and $1'$, this is hardly surprising.

Table 3: **Summary of Experimental Results.**

	Treatment 1 Study 1	Treatment $1'$ Study 2	Hybrid Study 2	Treatment 3 Study 1
% Cooperate in Prisoner's Dilemma	63% (0.09)	59% (0.08)	50% (0.08)	45% (0.08)
% Cooperate in Stag-Hunt	74% (0.09)	72% (0.07)	83% (0.06)	50% (0.08)

We now turn to behavior in the Hybrid treatment. As in the previous section, the appropriate statistical tests are one-sided given the anticipated ordering of behavior among treatments. In the Prisoner's Dilemma, cooperation rates in the Hybrid treatment fall between the combined Treatments 1 and $1'$ and Treatment 3. Statistically, the Hybrid treatment differs neither from the combined Treatments 1 and $1'$ (one-sided p-value $= 0.145$) nor from Treatment 3 (one-sided p-value $= 0.336$). However, in the Stag-Hunt game, cooperation rates in the Hybrid treatment are not different from the combined Treatments 1 and $1'$ (one-sided p-value $= 0.873$) but do differ significantly from Treatment 3 (one-sided p-value $= 0.001$). These results are more supportive of beliefs about others discounting driving strategic behavior than own discounting.[17]

[17]Three of the four statistical comparisons are consistent with this explanation whereas only one of the

Table 4: **Cooperation and Discount Factors**

Dependent Variable = Cooperation in PD or Coordination in SH games				
	Prisoner's Dilemma		**Stag-Hunt Game**	
	Treatment 1′	Hybrid	Treatment 1′	Hybrid
	b/se	b/se	b/se	b/se
Own Discount Factor	0.718	-0.640	-0.273	-0.553
	[1.015]	[0.652]	[0.926]	[0.528]
Belief of Others' Discount Factor	-0.841	-0.706	-0.520	0.078
	[1.035]	[0.954]	[0.944]	[0.773]
Constant	0.521	1.605**	1.346*	1.225**
	[0.828]	[0.667]	[0.755]	[0.540]
R^2	0.024	0.080	0.025	0.038
Observations	34	36	34	36

* significance at 10%, ** significance at 5%, *** significance at 1% (one-sided test)

As further evidence that one's own discount rate is not affecting behavior in the Prisoner's Dilemma and Stag-Hunt games in the Hybrid treatment, we present results from a regression analysis in Table 4. A linear probability model is estimated looking at the effect that the discount factor of oneself and one's belief about the average discount rate of others has on cooperation in both Treatment 1′ and the Hybrid Treatment for each game. Absent any correlation between impatience and cooperation, the discount factor of oneself and one's beliefs about others should not be influential in determining behavior in Treatment 1′ because they are irrelevant to the decision maker. Columns 1 and 3 of the Table are consistent with this prediction as neither coefficient is statistically significant. Columns 2 and 4 are the main regressions of interest; they show that one's own discount factor in the Hybrid treatment does not statistically influence cooperation rates. These columns also show that one's belief about others' discount rates also does not affect behavior, which substantiates our notion that subjects understood the information that was available to other subjects.[18]

four comparisons is consistent with the own discounting explanation.

[18]The results in Table 4 do not substantially differ if one runs a Probit regression rather than OLS. Furthermore, the results do not change if the regressions are run with one independent variable at a time rather than both variables together.

5 Discussion

A preponderance of evidence, accumulated mainly from individual choice experiments, has found individuals behave impatiently in the short-run. This study investigates whether individuals behave just as impatiently in environments involving strategic interaction. While one might be inclined to believe that impatience should apply constantly across all intertemporal situations, this is not necessarily so. In fact, Deck and Jahedi (2013b), the one experimental study examining discounting in a strategic setting, find no evidence of impatience in a Tullock contest, despite the fact that they do observe discounting in an individual choice experiment with the same subject pool.

In order to explore whether discounting occurs across strategic settings, this paper reports the results of a study that considers four tasks: a Prisoner's Dilemma game, a Stag-Hunt game, a First Price Auction, and a Second Price Auction. For each task, treatments are implemented that either reduce the rewards or delay the payment of the reward relative to a baseline condition. In all four cases, reducing the rewards has the anticipated effect. This effects is also found by delaying the reward in all four tasks. On their own, the results appear to suggest that the impatience that has been found in individual choice experiments extends to strategic games. However, in all four of these strategic settings there is the possibility that the belief that others are impatient could be driving observed behavior. This belief about the patience levels of others is inconsequential to the predicted bidding strategy in Deck and Jahedi (2013b), and thus offers a potential reconciliation between the seemingly contradictory findings.

Our second study is designed to disentangle the behavior due to one's own discounting from behavior due to the beliefs about others' impatience levels. We conduct an experiment using a subset of the games from the first study, but with one player's payoff delayed while his opponent is unaware of this fact. Our results suggest that people are individually patient in these strategic settings, but react to an incorrect belief that others are overly-impatient. This is further bolstered by directly comparing discount rates elicited from individual choice experiments with elicited beliefs about others' discount rates. To our knowledge, this is the first study to examine whether people have accurate beliefs regarding the discount factors of other individuals. Indeed, they do not. Participants own discount factor of $\delta = 0.88$ is nearly 13% higher than their belief regarding the discount factor of others. That is, people tend to believe they are more patient than other people.

Our findings have important implications. In many strategic situations, it is critical to accurately predict the discount factor of others to react optimally. In a bargaining game, for example, if a person predicts that others are more impatient than they are, he may propose an offer that is too low. The other player, in turn, might reject the offer and counter with a bid that is likewise too small; the belief being that the first person is more impatient than he actually is. This can lead to inefficiencies, confusion, and resentment towards the unreasonable behavior of the other person. Correspondingly in a war of attrition, one might mistakenly expect a rival to drop out precipitately if one overestimates the rival's impatience. Other noteworthy applications may include auctions. It is possible, for instance, that in auctions where there is a delay between when the auction is conducted and when delivery is completed that bidders may reduce their bid in anticipation that other bidders are going to act impatiently. With incorrect beliefs regarding others' discount factors, the revenue equivalence theorem would not hold making some auctions better than others. Lastly, the findings here can affect the external validity of laboratory experiments. If the naturally occurring phenomenon that is being studied in the lab has temporal components, failure to incorporate this aspect of the problem in the lab may bias results. Ultimately, we believe that further research is necessary to more fully understand how and when own discounting and beliefs about the impatience of others affects economic decision making.

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A Appendix

Experiment Instructions

This is an experiment in economic decision making. You will earn a cash payment based in part on what choices you make, so it is important that you understand these directions completely. If you have any questions, please raise your hand and a researcher will come to you. Otherwise, please do not talk or communicate with anyone else in this experiment.

This experiment involves four tasks that you will complete. After all of the response forms are collected, one task will be randomly selected by rolling a die and you payment will be based upon that task. You will receive your payment in the accompanying white envelope at the end of class, so please make sure you legibly print your name on it. Please do this now.

Color Tasks - You and the person you are matched with each have to choose a color.

1. Color Task A
Selecting Green pays you $2.
Selecting Black pays the other person $4.

This means that if…
both of you pick Green you both receive $2.
both of you pick Black you both receive $4.
you pick Green and the other person picks Black you receive $6 and the other person receives $0.
you pick Black and the other person picks Green you receive $0 and the other person receives $6.

My choice is Green or Black (circle one)

2. Color Task B
Selecting Blue pays you $4.50.
Selecting Grey pays you $8.00 if the other person selects Grey and $0 if the other person selects Blue.

This means that if…
both of you pick Blue you both receive $4.50.
both of you pick Grey you both receive $8.00.
you pick Blue and the other person picks Grey you receive $4.50 and the other person receives $0.00.
you pick Grey and the other person picks Blue you receive $0.00 and the other person receives $4.50.

My choice is Blue or Grey (circle one)

Auction Tasks – You and the person you are matched with each receive $6.00. You both have the opportunity to bid on a fictitious item. Two values were drawn randomly from the interval $0.00 to $6.00 to determine your value and the other person's value for the fictitious item. Your value is listed below and the other person's value is unknown to you. The *higher bidder* will win the auction and receive their value for the fictitious item minus the price plus the $6.00. The *lower bidder* will only receive the $6.00. How the price is determined differs for the two auction tasks.

3. Auction Task C - The price will equal the **higher** bid.
example: If the two bids are $2.25 and $3.50, the person bidding $3.50 will win the auction and pay the price of $3.50.

My Value is $4.80. My bid is ___________ (maximum of $6.00)

4. Auction Task D - The price will equal the **lower** bid.
example: If the two bids are $2.25 and $3.50, the person bidding $3.50 will win the auction and pay the price of $2.25.

My Value is $4.80. My bid is ___________ (maximum of $6.00)

By completing this form, I acknowledge that I have read the accompanying information regarding this study, am at least 18 years of age, and am voluntarily agreeing to participate in this study.

Name________________________________ Signature ____________________________________
UA ID__________________Total Payment (completed by researcher)__________________________

Experiment Instructions

This is an experiment in economic decision making. You will earn a cash payment based in part on what choices you make, so it is important that you understand these directions completely. If you have any questions, please raise your hand and a researcher will come to you. Otherwise, please do not talk or communicate with anyone else in this experiment.

This experiment involves four tasks that you will complete on the front and back of this sheet. After all of the response forms are collected, one task will be randomly selected by rolling a die and your payment will be based upon that task. You will receive your payment in the accompanying white envelopes at the end of class on the appropriate day, so please make sure you legibly print your name on both of them. Please do this now.

Color Tasks - You and the person you are matched with each have to choose a color.

1. Color Task A

Selecting Green pays you $2.
Selecting Black pays the other person $5.

This means that if…
both of you pick Green you both receive $2.
both of you pick Black you both receive $5.
you pick Green and the other person picks Black you receive $7 and the other person receives $0.
you pick Black and the other person picks Green you receive $0 and the other person receives $7.

If this task is randomly selected for payment, the person you are matched with will receive all of his or her money today. If you select Green you will receive the $2 today. However, if the other person selects Black you will receive the $5 in two weeks. The other person was not told anything about when you will be paid and was only told that he or she would be paid today.

My choice is Green or Black (circle one)

2. Color Task B

Selecting Blue pays you $4.50.
Selecting Grey pays you $10.00 if the other person selects Grey and $0 if the other person selects Blue.

This means that if…
both of you pick Blue you both receive $4.50.
both of you pick Grey you both receive $10.00.
you pick Blue and the other person picks Grey you receive $4.50 and the other person receives $0.00.
you pick Grey and the other person picks Blue you receive $0.00 and the other person receives $4.50.

If this task is randomly selected for payment, the person you are matched with will receive all of his or her money today. If you select Blue you will receive the $4.50 today. However, if you both select Grey you will receive the $10 in two weeks. The other person was not told anything about when you will be paid and was only told that he or she would be paid today.

My choice is Blue or Grey (circle one)

Time Tasks

3. Time Task A

For each of the six questions below, check the box next to the option that you like the best.
If this task is randomly selected for payment, a 6-sided die will be rolled in the front of class. The choice you made on the question number that corresponds to the die roll will determine your payoff.

For example, suppose the result of the die roll is a 3. If you checked the first box for question 3 below, then you will receive $4.00 today. If you checked the second box for question 3 below, then you will receive $5 in two weeks. If you did not check either box, you will receive nothing.

Please check your decision for each of the 6 rows in this table.

If you roll number (1):	Would you like to receive	☐	**$5.00 today**	or	☐	**$5.00 in two weeks**
If you roll number (2):	Would you like to receive	☐	**$4.50 today**	or	☐	**$5.00 in two weeks**
If you roll number (3):	Would you like to receive	☐	**$4.00 today**	or	☐	**$5.00 in two weeks**
If you roll number (4):	Would you like to receive	☐	**$3.50 today**	or	☐	**$5.00 in two weeks**
If you roll number (5):	Would you like to receive	☐	**$3.00 today**	or	☐	**$5.00 in two weeks**
If you roll number (6):	Would you like to receive	☐	**$2.50 today**	or	☐	**$5.00 in two weeks**

4. Time Task B

In the previous task you were asked a series of questions about receiving various amounts of money today or $5 in two weeks. In this task you are predicting how the other people in this experiment, excluding you, answered those questions. For each question, you should write down the percentage of people (between 0% and 100%) you think checked the box to receive money *today*. If this task is randomly selected for payment, a 6-sided die will be rolled in the front of class. The choice you made on the question number that corresponds to the die roll will determine your payoff in the following way: Your payment in two weeks equals $5 minus (the difference between the actual percentage and your prediction)^2/2000. Because of the way this equation is structured, the closer your guess is to what others did, the higher your payoff will be. Therefore, you should provide your best guess as to what others did.

Please provide your prediction (between 0 and 100) for each of the 6 rows in this table.

If you roll number (1):	What % of the other participants preferred **$5.00 today** over **$5.00 in two weeks?**_________
If you roll number (2):	What % of the other participants preferred **$4.50 today** over **$5.00 in two weeks?**_________
If you roll number (3):	What % of the other participants preferred **$4.00 today** over **$5.00 in two weeks?**_________
If you roll number (4):	What % of the other participants preferred **$3.50 today** over **$5.00 in two weeks?**_________
If you roll number (5):	What % of the other participants preferred **$3.00 today** over **$5.00 in two weeks?**_________
If you roll number (6):	What % of the other participants preferred **$2.50 today** over **$5.00 in two weeks?**_________

By completing this form, I acknowledge that I have read the accompanying information regarding this study, am at least 18 years of age, and am voluntarily agreeing to participate in this study.

Name____ Signature ______________________________________

UA ID________________________Total Payment (completed by researcher)_________________________