Bargaining and Time Preferences: An Experimental Study*

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Abstract

We provide the first experimental test of the Rubinstein (1982) model of bargaining, where the cost of disagreement is payoff delay. Our design has all bargaining take place within a single session, but exogenously and transparently varies the payoff delay per round of disagreement at the individual level (week/month, with/without front-end delay), where delayed payments are conveniently implemented using a popular mobile payment service. We formally derive the basic theoretical predictions under exponential discounting (immediate agreement, proposer advantage, basic delay advantage, and front-end delay neutrality) and the differential predictions under present bias (qualified basic delay advantage and front-end delay advantage), and we purposefully design our treatments to test these. In contrast to prior experiments that did not implement actual payoff delay, we obtain strong behavioral support for the theory with present bias.

Keywords: Alternating-Offers Bargaining, Time Preferences, Present Bias, Laboratory Experiments

JEL Classification: C78, C91, D03

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1 Introduction

How will two parties to a transaction divide the economic surplus that it creates? As fundamental as this strategic problem is, it was not until Rubinstein (1982) that economic theory offered a useful answer to it as such, i.e., a tractable strategic model with a clear prediction based on the parties’ individual preferences. His disciplined model of the bargaining process as one of indefinitely alternating offers constitutes the core of modern non-cooperative bargaining theory, and it has been extended in many directions and applied to various settings.\(^1\)

The central driving force of this theory is the parties’ individual costs of the *delay* that results whenever they disagree, i.e., their time preferences. These determine their bargaining power. Not surprisingly, given the model’s importance, several studies have experimentally tested its predictions; however, rather than as payoff delay, the costs of disagreement in all of these studies have been implemented either as a reduction in monetary surplus or as a risk of exogenous breakdown. Hence, whether actual time preferences behaviorally affect the bargaining outcome as predicted remains an open question.

In this paper, we introduce a novel experimental design that directly addresses this question. In contrast to the prior experimental literature, we find strong behavioral support for all fundamental predictions of the theory, once we account for present bias. Quite remarkably, this is in line with the large body of empirical studies that directly measure time preferences and document present bias as the most important qualitative deviation from exponential discounting (e.g., Frederick, Loewenstein, and O’Donoghue, 2002; Augenblick, Niederle, and Sprenger, 2015; O’Donoghue and Rabin, 2015).

Our key innovation, both theoretically and experimentally, is to disentangle the timing of payoffs from the timing of bargaining rounds. Theoretically, we generalize the classic Rubinstein (1982) model to arbitrary payoff delays per round of disagreement and general time preferences, with the only substantial assumption that preferences are dynamically consistent. We establish and characterize the unique (subgame perfect Nash) equilibrium of this game, which is in history-independent strategies and has immediate agreement in every round. When the delay between any two rounds of bargaining is negligible—i.e., offers are frequent, so that bargaining is essentially instantaneous—preferences are dynamically consistent in this game by design. Our theory therefore covers also any “naturally” dynamically inconsistent time preferences such as quasi-hyperbolic and hyperbolic discounting, but without confronting any issues of *intra-*personal conflict or naïveté that arise when decisions are made over a significant time horizon.

The game we experimentally implement exploits this theoretical observation: All bargaining takes place within a single session with frequent offers, whereas actual payoffs are subject to significant delay.

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\(^1\)The books by Osborne and Rubinstein (1990a) and Muthoo (1999) provide overviews. Relatedly, Binmore, Rubinstein, and Wolinsky (1986) show how the model provides a non-cooperative foundation to the Nash bargaining solution (Nash, 1950), which has been a major modeling device used in applied theory and empirical work (for a recent example, see Ho and Lee, 2017).
per round of disagreement.\textsuperscript{2} Thus, we avoid the major concern with actual longitudinal designs (e.g., Sprenger, 2015) that attrition may be systematically related to time preferences.\textsuperscript{3}

While the theory parsimoniously focuses on time preferences and assumes these are common knowledge, it is well understood that people’s preferences include also other relevant concerns—in particular, fairness and risk—and are highly heterogeneous, so that strategic interaction is inherently subject to incomplete information. We employ a novel experimental approach, recently introduced by Kim (2019b) as effective discounting procedure,\textsuperscript{4} to control for various preference “confounds” and establish a setting in which time preferences nonetheless translate into clear comparative statics predictions to be tested between subjects. The procedure randomly assigns participants their individual length of payoff delay—either a week or a month per round of disagreement, and either including a front-end delay or not—and thus creates groups of bargainers that are similar in terms of their underlying general preferences but differ in their effective time preferences. The payoff delay profiles that bargainers individually face, their “types,” are made common knowledge within any bargaining match.

Our experimental treatments correspond to particular matchings of such bargainer types. We implement three of these: Treatment \textit{WM} matches bargainers whose payoff gets delayed by one week per round of disagreement (“weekly bargainers”) with bargainers for whom this is one month (“monthly bargainers”); Treatment \textit{WM2D} is similar, except that every bargainer’s payoff comes with an additional front-end delay of one week (even in case of immediate agreement, and we call these bargainers “delayed”); Treatment \textit{WW1D} matches two weekly bargainers of whom exactly one faces such a front-end delay. Within each treatment, participants play ten games under random rematching (subject to the treatment condition), with their individual type fixed throughout. In every such game, which type gets to make the initial proposal is determined randomly, so we observe both versions of the alternating-offers game for any type match in a treatment.

Under symmetry in terms of underlying preferences, assumptions on time preferences translate our type manipulation into differences in bargaining power. These comparative statics predictions in time preferences are our main focus, and we test them by comparing cumulative distribution functions of behavioral measures of interest for first-order stochastic dominance. Though conservative, we deem this appropriate in view of the fact that our manipulation is supposed to effectively “shift” the entire distribution of time preferences.

The natural benchmark is constant/exponential discounting (EXD), for which our model reduces exactly to that of Rubinstein (1982). Under EXD, the first two treatments are equivalent, and the

\textsuperscript{2}Our study is thereby tightly linked to the experimental evidence on time preferences elicited from binary choices between various time-dated monetary rewards. Given the indefinite strategic interaction, to ensure the credibility of our experiment, we additionally impose a commonly known 25\% chance of random exogenous termination. Though this probability is held constant across all rounds of all games in all treatments, strictly speaking, time preferences should therefore be interpreted as including this risk here.

\textsuperscript{3}Kim (2019a) indeed finds that patience and present bias measured at the beginning of his experiment well predicted how long participants would take part in his longitudinal study.

\textsuperscript{4}We thank John Duffy for helping coin this term.
third treatment is symmetric because a front-end delay is strategically irrelevant, akin to a sunk cost. Besides the general predictions of immediate agreement and a proposer advantage, EXD clearly implies that weekly bargainers obtain a greater share than monthly bargainers in the same initial role.\footnote{We find a very high degree of efficiency in our experimental bargaining games, as almost three quarters end in immediate agreement, without significant differences. We also confirm a proposer advantage.} Our data from Treatments $WM$ and $WM2D$ strongly confirm this basic delay advantage.\footnote{We also strongly confirm this prediction in a comparison of behavior across Treatments $WM$ and $WW1D$, which have the weekly bargainers (with no delay) as a common type. The other comparison across treatments for this prediction, namely $WM2D$ and $WW1D$, which have the delayed weekly bargainers as a common type, violates it, but see below for present bias and hyperbolic discounting.} However, in contradiction to EXD, we find that the two treatments are not equivalent behaviorally, and also behavior in Treatment $WW1D$ violates symmetry.

The leading alternative to EXD is quasi-hyperbolic discounting (QHD), which adds a single parameter to capture the empirically well-documented phenomenon of a present bias (Phelps and Pollak, 1968; Laibson, 1997). This model’s key implication is that a front-end delay is strategically advantageous to initial respondents.\footnote{Note that from Round 2 onwards all agreements have delayed payoffs, so present bias ceases to matter, and the initial proposer’s strategic advantage means that only the respondent’s such bias materializes in terms of equilibrium.} Relative to EXD, QHD therefore clearly breaks the symmetry in Treatment $WW1D$ in favor of the delayed (weekly) bargainers; our data from this treatment indeed strongly confirm this front-end delay advantage. Similarly, QHD also breaks the equivalence between Treatments $WM$ and $WM2D$ under EXD, in the direction of an advantage of respondents under the latter treatment, where they are delayed. While we find some support for this prediction when we compare those games where the initial proposer is a weekly bargainer, the opposite is true when we compare those games where the initial proposer is a monthly bargainer.

This latter finding, in turn, is consistent with hyperbolic discounting, which also features a present bias, but as an instance of uniformly diminishing impatience; QHD can be interpreted as a parsimonious approximation that focuses solely on present bias (see Frederick et al., 2002). Adding a front-end delay shifts all delays into the future and, under hyperbolic discounting, this therefore not only “removes” any present bias but effectively increases patience uniformly. In relative terms, this may increase bargaining power more for a monthly bargainer than a weekly bargainer. Indeed, a pronounced present bias together with hyperbolic discounting of future delays yields exactly those clear predictions from QHD that our data strongly confirm, while at the same time rationalizing also the behavioral findings that contradict QHD’s predictions.\footnote{To obtain clear predictions, we impose minimal structure on hyperbolic discounting satisfied by all commonly considered models of such discounting; see Loewenstein and Prelec (1992) for a general parametric family. Closely related are Halevy (2008) and Chakraborty, Halevy, and Saito (2020), relating present bias and hyperbolic discounting to the inherent uncertainty about future consumption and common violations of expected utility.} Considering that hyperbolic discounting and present bias are exactly the key qualitative properties of empirically measured time preferences across, as found across a huge number of studies eliciting them from individual decisions, we interpret our findings as a strong confirmation of the theory.

To summarize: Time preferences are certainly not all that matters in bargaining, but they do...
matter significantly, and in a manner that is theoretically predicted by and consistent with what we know from the large body of work that has researched them.

Especially with respect to the negative conclusions from prior experimental investigations of the Rubinstein (1982) model (to be discussed in the next section), our findings may therefore be regarded as an unprecedented behavioral success story for the basic model of non-cooperative bargaining theory, when extended to incorporate the key properties of real time preferences. With the latter qualification, they lend encouraging behavioral support to the large and important literature applying this model. Moreover, our finding that people seem to commonly understand and strategically respond to present bias not only supports the presumed prevalence of this bias, but also promotes (further) theoretical work on dynamic strategic interaction with present-biased individuals. Finally, viewed from a somewhat different perspective, our results may also be taken as a demonstration of the methodological value of the effective discounting procedure for further experimental work on the role of time preferences in various strategic settings.

The rest of this paper is organized as follows. The next section discusses the most closely related literature. We then present the general theoretical background for our study in Section 3. This is followed by our experimental design and the behavioral predictions for the most important classes of time preferences, as well as administrative details in Section 4. We report and discuss our experimental findings in the subsequent Section 5. Finally, Section 6 offers a brief conclusion. All proofs are relegated to Appendix A. Appendix B provides additional figures, and Appendix C has additional results on learning. Appendices D and E contain experimental instructions (for one exemplary experimental treatment) and selected screenshots, respectively.

2 Literature Review

Our review of the literature focuses on (1) theoretical analyses of time preferences in the canonical bargaining environment with an infinite horizon and alternating offers, and (2) experimental studies that investigate this bargaining model. There are large areas of work on bargaining that we do not cover, including the vast experimental literature on ultimatum bargaining and finite-horizon sequential bargaining, and the theoretical literature that extends the original Rubinstein (1982) model in several other directions, such as multilateral bargaining, bargaining with asymmetric/incomplete information, and endogenous proposer determination. For a recent review of the ultimatum bargaining literature, see Guth and Kocher (2014). For a comprehensive survey of non-cooperative bargaining theory during its most active period of research, see Binmore, Osborne, and Rubinstein (1992); for a more recent survey on bargaining theory focusing on incomplete information, see Ausubel, Cramton, and Deneckere (2002).

Theory. In his seminal paper, Rubinstein (1982) introduces the canonical bargaining model in which two players alternate in making offers to each other, for how to divide a given surplus, until they
reach agreement. Assuming exponentially discounted concave utility and perfect information, there is a unique subgame-perfect equilibrium. It is in stationary strategies that imply immediate agreement in any round, hence efficiency. Given impatience and that the burden of delay is with the player responding to an offer, a proposing player enjoys a strategic advantage. Moreover, ceteris paribus, the more patient a player is—in particular, the higher her discount factor for given utility—the greater is her bargaining power, in the sense of capturing a larger share of the surplus in the equilibrium agreement. With symmetric preferences, as offers become infinitely frequent and players approach perfect patience, the proposer advantage vanishes and the equilibrium outcome converges to an immediate equal split, as prescribed by the Nash (1950) bargaining solution.

Motivated by empirical evidence, several theoretical attempts have recently been made to generalize this model in terms of time preferences. Almost all of these have focused on “stable” preferences to maintain the game’s stationarity property that makes it tractable. In this case, any deviation from exponential discounting implies dynamic inconsistency, and Schweighofer-Kodritsch (2018) provides a comprehensive equilibrium characterization under minimal preference assumptions, when these preferences are common knowledge, implying “full sophistication” (for related work see also Ok and Masatlioglu, 2007; Noor, 2011; Pan, Webb, and Zank, 2015; Lu, 2016). He finds that with concave utility, a weak present bias is sufficient for a unique equilibrium similar to exponential discounting. However, as Akin (2007) and Haan and Hauck (2019) show for quasi-hyperbolic discounting, naiveté about present bias may lead to even perpetual disagreement.

We provide a hitherto overlooked alternative but formally equivalent interpretation to Rubinstein’s model as one where bargaining itself is essentially instantaneous, but payoffs nonetheless get significantly delayed with any disagreement. Based on this interpretation, we generalize the model to arbitrary delays upon any disagreement and general time preferences, under the sole substantial assumption of dynamic consistency. This is a special case of bargaining over a time-varying surplus, as considered and geometrically analyzed by Binmore (1987), where the variation in surplus derives from non-constant discounting (see also Coles and Muthoo, 2003). Relative to this prior work, our theoretical contribution consists in showing that under very mild assumptions on time preferences there is a unique equilibrium, and to provide an algebraic proof.

Experiments. Weg, Rapoport, and Felsenthal (1990) and Rapoport, Weg, and Felsenthal (1990) are the first experimental studies of an infinite-horizon, alternating-offers bargaining game. Both implement a within-subjects shrinking-pie design and compare two conditions, equal and unequal “discount factors,” which correspond to the rates at which the players’ value of the pie shrinks over bargaining rounds. To prevent their experiments from lasting too long, they program the computer to terminate the bargaining once the number of rounds exceeds 20, whilst informing their participants only that a game would be terminated by the experimenters if it lasted “too long.” Analyzing their experimental data on final agreements, initial offers, the number of rounds to reach an agreement and

9Rapoport et al. (1990) actually implement fixed costs per round of disagreement rather than constant shrink rates.
the characteristics of counteroffers, they reject most basic predictions of the Rubinstein (1982) model and argue for the importance of fairness concerns. In particular, they observe no significant proposer advantage nor any significant cost advantage.

Zwick, Rapoport, and Howard (1992) experimentally study an environment in which the number of bargaining periods is unlimited and the pie’s value is fixed, but where bargaining is subject to exogenous random termination. This takes the form of a constant and commonly known breakdown probability. They implement three different such probabilities of breakdown in a between-subjects design. Based on their experimental results, they also reject basic predictions of the Rubinstein (1982) model; e.g., average Round-1 demands are the same under a breakdown probability of 1/10 as under a breakdown probability of 5/6. However, they also reject the equal split solution.

Like Weg et al. (1990) earlier, Binmore, Swierzbinski, and Tomlinson (2007) employ a shrinking-pie design with unequal discount factors. They also adopt a similar forced termination procedure: Participants are only informed that there will be exogenous termination, but not the exact rule. In fact, the computer intervenes and terminates the game after a randomly drawn number of rounds, varying from 3 to 7. These authors find some behavioral support for basic predictions of the Rubinstein (1982) model, especially for a proposer advantage. Unlike any of the above studies, and also unlike ours, however, they have a long and incentivized training/conditioning phase, where participants play against a robot programmed to a specific strategy; they also do not implement the deterministic alternating-offers protocol but instead a random proposer protocol, where the proposer of any round is always randomly chosen from the two players with equal probability; moreover, the pie in their experiment consists of lottery tickets.

Notably, none of these studies features any payoff delay. The domain of outcomes over which preferences are defined is either that of immediate monetary rewards or lotteries thereover. Hence, none of these studies speaks directly to the question of whether time preferences matter in bargaining; in particular, by their design, they cannot address whether patience is a source of bargaining power, which is the focus of our study where we implement significant delays to payoffs. Another distinctive feature of our study is that we focus on general comparative statics predictions under different theories of time preferences rather than testing particular point predictions against each other.

Regarding our basic question of whether time preferences matter in bargaining, the most closely related work is an unpublished experiment by Manzini (2001). Her design and also her conclusion are radically different from ours. She first elicits participants’ limit prices for avoiding a delay of one and two months, respectively, of a given monetary prize otherwise paid the next day, via a variation of the

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10Somewhat relatedly, Andreoni and Sprenger (2012) conclude from their experimental findings that “risk preferences are not time preferences.”

11Of course, it is straightforward to provide assumptions under which the games thus implemented are formally equivalent to special cases of the Rubinstein (1982) model with exponentially discounted utility. This only means that one may appeal to this equivalence in order to obtain the predictions from that original model, under these (more or less stringent) assumptions. It does not mean that one learns anything about how time preferences affect the bargaining outcome, however; as an analogy, one obviously could not measure time preferences without having any delayed options.
BDM (Becker, DeGroot, and Marschak, 1964) procedure. Then, she pairs the participants for a single bargaining game with alternating offers over just two rounds, so the second round is an ultimatum game. Immediate agreement results in payment the subsequent day, whereas delayed agreement results in payment with a month’s delay.\textsuperscript{12} Providing the bargainers with information on their respective limit prices for a month’s delay, these turn out to have no significant correlation with the opening offers.\textsuperscript{13} Hence, she concludes that time preferences do not matter in bargaining, and she suggests that the task of bargaining distracts attention completely away from time considerations.

Whilst very carefully designed, the negative conclusion from this work hinges crucially on two assumptions, both related to the participants’ incomplete information regarding their opponent’s preferences. First, it assumes that participants trust the measure of their opponent’s time preference, which includes trust that the opponent understood the elicitation procedure. Second, it assumes that participants’ preferences involve no other concerns confounding time preferences, in particular fairness concerns. We consider these very strong assumptions, unlikely to hold in the interaction. Indeed, we ascribe our very different findings to the way our design, in which we transparently manipulate effective time preferences, deals with incomplete information; this procedure appears very successful in establishing a setting in which both individuals share an understanding of who is “more patient,” and translate this into bargaining power.

3 Theoretical Background

We now present the bargaining game that we implement in our experiment, characterize its unique equilibrium under full generality with regards to time preferences, and show how it is a generalization of the classic Rubinstein (1982) model. In doing so, we highlight two alternative interpretations of the latter in terms of the timing of offers versus the timing of payoffs, and point out how each of these relates to assumptions about time preferences. All formal proofs are in Appendix A.

3.1 The Model

Consider two individuals \(i \in \{1, 2\}\) deciding on how to share a fixed monetary amount via indefinite alternating-offers bargaining, as in Rubinstein (1982). For simplicity, normalize the amount to one, so divisions correspond to shares, and assume it is perfectly divisible. In any round \(n \in \mathbb{N}\), one individual \(i\) proposes a division \(x \in \{(x_1, x_2) : x_1 \in [0, 1] \text{ and } x_2 = 1 - x_1\}\) to the other individual \(j = 3 - i\) (we will use this convention for \(i\) and \(j\) throughout), who can then either accept or reject. If the proposal is accepted, there is agreement and the game ends; if it is rejected, then the game continues to round

\textsuperscript{12}Indeed, this is the only other bargaining study we know of that implements delayed payoffs.

\textsuperscript{13}She also studies two additional treatments implementing shrinking pies in a way that is comparable to the treatment with delayed payments. For both of these, she finds much higher correlations of opening offers with the opponent’s cost of disagreeing.
\(n + 1\), where this protocol is repeated with reversed roles, so \(j\) proposes and \(i\) responds. Player 1 makes the proposal in round 1, and the game continues until a proposal is accepted. Denoting by \(r_n\) the responding player of round \(n\), \(r_n = 2\) for \(n\) odd, and \(r_n = 1\) for \(n\) even.

We assume consequentialist individuals that distinguish outcomes only according to whether there is agreement, and if so, how much they obtain at what point in time. Importantly, we decouple rounds and delays, which is the key innovation of our experimental design. While bargaining itself takes essentially no time because offers are so frequent that there is negligible delay between rounds, any disagreement nonetheless entails a significant payoff delay. For the general model, we allow this payoff delay to be arbitrary and to differ between individuals and rounds. Therefore, we specify the domain of individual \(i\)’s preferences as any \((q, n) \in ([0, 1] \times \mathbb{N}) \cup \{(0, \infty)\}\), where \((0, \infty)\) subsumes any infinite history (perpetual disagreement). We assume these preferences to have a utility representation \(U_i\) that satisfies general discounted utility; i.e., for each individual \(i \in \{1, 2\}\), there exist a delay discounting function \(d_i\) and an atemporal utility function \(u_i\) such that

\[
U_i(q, n) = d_i(n - 1) \cdot u_i(q),
\]

and which satisfy the following three properties:

1. (Delay Discounting) \(d_i(0) = 1 > d_i(n) > d_i(n + 1) > 0 = d_i(\infty)\) for all \(n \in \mathbb{N}\);

2. (Atemporal Utility) \(u_i: [0, 1] \to [0, 1]\) is continuous and strictly increasing from \(u(0) = 0\) to \(u(1) = 1\);\(^{14}\)

3. (Intertemporal Utility) there exists \(\alpha_i < 1\) such that for all \(n \in \mathbb{N}\), and for all \(q \in [0, 1]\) and \(q' \in (q, 1]\),

\[
\delta_i^{-1}(\delta_i(n) \cdot u_i(q')) - \delta_i^{-1}(\delta_i(n) \cdot u_i(q)) \leq \alpha_i \cdot (q' - q),
\]

where \(\delta_i(n) \equiv d_i(n) / d_i(n - 1)\).

The discounting function \(d_i(n - 1)\) gives the discount factor for the total payoff delay associated with agreement being reached in round \(n\), i.e., after \((n - 1)\) rounds of disagreement. The expression \(\delta_i(n)\) is the discount factor for the specific period of payoff delay caused by disagreement in round \(n\); by property 1, it lies between zero and one. Note that \(d_i(n) = \prod_{m=1}^{n} \delta_i(m)\) holds true, subject to the convention that the “empty product” equals one.

Properties 1 and 2 define the bargaining problem: On the one hand, any round of disagreement causes (further) payoff delay, which is costly to both individuals because they are impatient, and on the other hand, each of them always wants more of the cake for herself.

Property 3 guarantees uniqueness of equilibrium by ensuring that backwards-induction dynamics are well-behaved. It says that \(i\)’s willingness to pay to avoid another round’s delay is always increasing.

\(^{14}\)The assumption that \(u(1) = 1\) is a mere normalization and without loss of generality.
in the amount that she would obtain in case of this delay. This property extends what has been termed “increasing loss to delay” (see the axiomatic formulation of Rubinstein, 1982, and its treatment in Osborne and Rubinstein, 1990b) or “immediacy” (see the utility formulation of Schweighofer-Kodritsch, 2018) to the non-stationary setting studied here, and it is implied by standard assumptions; e.g., \( u_i \) concave and \( \sup_n \delta_i(n) < 1 \).

To see that the Rubinstein (1982) model is a special case, simply let \( \delta_i(n) \) be a constant for each individual \( i \). Given exponential discounting, this means that the payoff delay associated with any round of disagreement is of the same length.

### 3.2 Equilibrium

Our equilibrium notion for this extensive-form game of perfect information is that of subgame perfect Nash equilibrium (SPNE). SPNE outcomes of a more general version of this game, where bargaining is over a general time-varying surplus, are geometrically analyzed by Binmore (1987), who shows that the extreme utilities are obtained in history-independent SPNE. Coles and Muthoo (2003) establish existence for a version of that game, which also contains our model. We contribute here a uniqueness and characterization result, for general discounted utility where non-stationary discounting is the source of time-varying surplus, and we provide algebraic proofs.

**Lemma 1.** There exists a unique sequence \( x_n \) such that, for all \( n \in \mathbb{N} \),

\[
x_n = 1 - u^{-1}_r(\delta_r(n) \cdot u_r(x_{n+1})).
\]

**Proposition 1.** There exists a unique equilibrium. This unique equilibrium is in history-independent strategies that imply immediate agreement in every round. It is characterized by the unique sequence \( x_n \) of lemma 1 as follows: In round \( n \), the respective proposer demands share \( x_n \), and the respective respondent accepts a demand \( q \) if and only if \( q \leq x_n \).

Proposition 1 delivers a general characterization of SPNE. In the special case where the model reduces to Rubinstein’s, which will also serve as our benchmark, the infinite sequence in (3.1) reduces

\[\text{for any } \delta < 1. \text{ Moreover, if } u(q_0) = \delta u(q_1), \text{ then } u(q_0 + \varepsilon) > \delta u(q_1), \text{ and upon substituting for any given } n; \sup_n \delta_i(n) < 1 \text{ ensures boundedness away from equality across all } n \text{ by ruling out that } \lim_{n \to \infty} \delta(n) \to 1.\]

\[\text{Denoting } q = q_1 \text{ and } q' = q_1 + \varepsilon, \text{ and applying this to individual } i's \text{ preferences, the third assumed property follows for any given } n; \text{ the property follows for any given } n; \sup_n \delta_i(n) < 1 \text{ ensures boundedness away from equality across all } n \text{ by ruling out that } \lim_{n \to \infty} \delta(n) \to 1.\]

Even when it reduces to that of Rubinstein (1982), the model is not susceptible to the “smallest-units” critique of van Damme et al. (1990), because despite the frequent offers, any disagreement still entails substantial payoff delay.
to two equations:

\[
x_1 = 1 - u_2^{-1} (\delta_2 \cdot u_2 (x_2)),
\]

\[
x_2 = 1 - u_1^{-1} (\delta_1 \cdot u_1 (x_1)).
\]

We generate several behavioral predictions from this exponential-discounting benchmark for our concrete experimental treatments, and we employ the general characterization to also derive the behavioral predictions from various alternative forms of discounting (in particular, quasi-hyperbolic discounting capturing a present bias). We present all of these theoretical predictions in Section 4, after defining our specific treatments.

### 3.3 Dynamic Consistency and Alternative Interpretation

With frequent offers, the time that passes between decisions is negligible. Hence, preferences are “trivially” dynamically consistent. Essentially, a single self of the individual makes all the strategic decisions, whereby only this one temporal snapshot of preferences matters (sometimes called “commitment preferences”). This affords our model full generality in terms of time preferences, as it avoids any of the strategic complications arising from dynamic inconsistency that actually manifests itself throughout the game.\(^\text{17}\)

In fact, dynamic consistency is the only substantial restriction our model imposes: Each individual’s preferences over various outcomes \((q, n)\) are represented by a single utility function \(U_i\) as above, and at any point in the game she consistently decides to maximize this utility.\(^\text{18}\) This means that our model really allows not only for arbitrary (though costly) payoff delays upon any disagreement but also delays between rounds. As stressed before, when the latter is negligible, preferences are dynamically consistent by the game’s design. However, under the assumption that preferences are truly dynamically consistent, the model accommodates also any setting where bargaining takes a significant amount of time and payoffs may get delayed by the process of bargaining itself. In particular, we may replace rounds \(n\) with actual time \(t\), so that there is a significant delay between rounds of bargaining and payoffs occur immediately upon agreement. This is the usual formulation and interpretation of the Rubinstein (1982) model. From this perspective, our model generalizes this classic model from exponential discounting to any dynamically consistent discounting.\(^\text{19}\)

\(^{\text{17}}\)For an analysis of dynamically inconsistent but stable time preferences when bargaining itself does take significant time and is therefore subject also to intra-personal conflict, see Schweighofer-Kodritsch, 2018. The general model here can, however, even accommodate dynamically inconsistent preferences that are time-varying, because any variation over time is negligible for the strategic interaction with frequent offers; e.g., an individual may discount utility exponentially at every point in time, but on one day exhibit a higher discount factor than on another day. For the purposes of our game, her preferences satisfy exponential discounting, even though across calendar time they are dynamically inconsistent.

\(^{\text{18}}\)We focus on the separable case of discounted utility merely to notionally ease the exposition. It is relatively straightforward to formulate the three assumed properties for non-separable preferences, and to then generalize our uniqueness and characterization result, using the same line of proof.

\(^{\text{19}}\)Non-exponential but dynamically consistent discounting means that discounting may vary with absolute (calendar)
To summarize: The bargaining game we implement in our experiment may appear somewhat artificial, but it has several important practical advantages for our experimental investigation over the usual interpretation of alternating-offers bargaining, with significant delay between rounds of offers (see our introductory discussion in Section 4 below). Moreover, under the assumption of dynamic consistency (or a mere common belief in such consistency), it is also equivalent to a game with the usual interpretation. Proposition 1 and any behavioral predictions derived from it then directly extend to the usual setting where bargaining itself takes time. This applies in particular to the special case of our model with exponential discounting, which is equivalent to Rubinstein (1982), and which will therefore serve as our benchmark.

4 Experimental Design and Behavioral Predictions

In this section, we first introduce our general experimental approach to testing predictions of the bargaining theory based on time preferences. We then describe our concrete experimental design and subsequently present the behavioral predictions for the specific treatments that we test. We conclude by providing further administrative details.

4.1 General Approach

The theory of bargaining developed here focuses on time preferences as strategic determinant of bargaining outcomes. When it comes to testing its predictions experimentally, a researcher first of all faces the challenge that she does not know the participants’ preferences. Equation (3.1) demonstrates that the theory’s point prediction is potentially influenced by an infinite number of discounting parameters together with the shape of the atemporal utility functions, whose elicitation would not be practically feasible. Moreover, preferences most likely include concerns other than time preferences, in particular fairness concerns (as demonstrated by the ultimatum game, see Güth, Schmittberger, and Schwarze, 1982). For this reason, we design our experiment to test comparative statics predictions regarding time preferences, rather than point predictions. In other words, we ask whether time preferences matter as predicted, despite various other possible concerns.

Second, and in contrast to the theory, also the players themselves do not know their opponent’s (time, risk, social) preferences. Put simply, the basic goal of our design is to establish a setting where both individuals have a shared understanding of who is more “patient,” which we would argue is the setting to which the theory is really meant to apply. Our key innovation towards this goal is to randomly assign participants their individual payoff delay structure and to make this assignment time but not the passage of time; e.g., an individual’s discount factor for the first week of January 2022 may differ from her discount factor for the second week of January 2022, but both of these discount factors are the same regardless of when the individual considers these delays. See Halevy, 2015, for further elaboration and experimental investigation of the relationship between stationarity, dynamic consistency and time invariance (and their respective violations).
commonly known within each matched bargaining pair. Thus, we create groups of individuals with the same distribution of general preferences (including various concerns) but effectively different time preferences. Assumptions on the structure of underlying time preferences then translate into shifts in relative bargaining power, via shifts in patience, and making both individuals’ “types” common knowledge then implies common beliefs about who will be at an advantage in terms of their effective time preferences. We derive such comparative statics predictions for the most important classes of time preferences, without any parametric assumptions, and we test them by comparing the associated distributions of behavioral outcome measures for different types.

4.2 Experimental Design

Table 1 presents our experimental design, which contains three experimental treatments. Each treatment corresponds to a particular pairing of “bargainer types,” where this type corresponds to the exogenously imposed payoff delay that an individual faces for any possible agreement. To implement meaningful payoff delay, we relied on the popular mobile payment system Venmo.\footnote{Venmo is a service provided by PayPal that allows account holders to transfer funds to others via a mobile phone app. It handled $12 billion in transactions in the first quarter of 2018 (https://en.wikipedia.org/wiki/venmo). For more information, please visit https://help.venmo.com/hc/en-us/articles/210413477. When recruiting our participants, we clearly announced that those without a Venmo account are not eligible for participating in the experiment. At the end of the experiment, participants were asked to report their account information for payment, including user name and email address. The fact that no one had any reporting error or difficulty in providing this information suggests that all our participants are sufficiently familiar with Venmo in their daily lives.}

In Treatment WM, one bargainer faces one week of delay per round of disagreement whereas the other faces one month of such delay. In Treatment WM2D, this is similar, except that both additionally face a front-end delay of one week; i.e., now also immediate agreements result in one week of payoff delay. In Treatment WW1D, both bargainers face the same delay of one week per round of disagreement, but one of them additionally faces such a front-end delay of one week. In the rest of the paper, we will call the bargainer whose payment window is weekly/monthly/delayed a weekly/monthly/delayed bargainer.

Within a given treatment, all games are played by a particular pair of different types, say A and B, and everyone anonymously plays ten games. Participants are always randomly rematched, subject to the treatment condition. Moreover, the initial proposer is always determined by chance, so we observe both versions of the game in terms of which type is the initial proposer. For instance, in every game of Treatment WM, a weekly bargainer plays against a monthly bargainer, and half of the games have a weekly bargainer as the initial proposer, with a monthly bargainer as initial respondent, and the other half have a monthly bargainer as the initial proposer, with a weekly bargainer as initial respondent. We can compare these two kinds of games within treatments to measure and test for a basic proposer advantage.

Our focus is on testing comparative statics with respect to time preferences, however, and we
now sketch how our treatments deliver such tests. Details and formal derivations of the behavioral predictions to be tested follow below, in Section 4.3.

Whenever a weekly and a monthly bargainer are matched, one transparently faces a longer delay and therefore greater cost of disagreement than the other, for all commonly considered time preferences. Thus, we can test whether effectively greater patience translates into a strategic advantage in terms of a more favorable bargaining outcome. Introducing a front-end delay additionally allows us to test the prediction from exponential discounting that only “marginal” delay but no “fixed” delay matters—akin to marginal v. fixed/sunk cost—against the alternative of present bias, or also future bias. Observe here that our treatments produce such tests not only within treatments (there, across the two kinds of games) but also across treatments (weekly bargainers appear in both $WM$ and $WW1D$, and delayed weekly bargainers appear in both $WM2D$ and $WW1D$).

In the following, we highlight the key components of our experimental design and compare them with the conventional designs used in the related literature. The full experimental instructions for Treatment $WM$ can be found in Appendix D.

Table 1: Experimental Treatments

<table>
<thead>
<tr>
<th>Bargainer 1</th>
<th>Bargainer 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly with D</td>
<td>Monthly with D</td>
</tr>
<tr>
<td>Weekly with D</td>
<td>$WM2D$</td>
</tr>
<tr>
<td>Weekly</td>
<td>N/A</td>
</tr>
</tbody>
</table>

*Note: Delay (D) = 1 Week

Effective Discounting Procedure and Payoff Delay. Unlike with the shrinking-pie design, the size of surplus in our experiment is fixed as $50 (500 tokens), and we use the novel experimental manipulation proposed by Kim (2019b), the “effective discounting procedure,” to control time preferences and implement payoffs over a potentially long period of time.\footnote{Kim (2019b) develops the design to investigate the effect of time preferences on cooperative behavior in an infinitely repeated game.} More precisely, we exogenously control the effective discounting of our participants by changing the payment delay of bargaining payoffs at the individual level, which is either a week or a month per round to agreement and may include an additional front-end delay of one week. For instance, in Treatment $WM$, the weekly bargainer receives the payoff from an agreement in Round $n$ in $(n - 1)$ week(s) from the day of the experiment; the monthly bargainer receives her payoff in $(n - 1)$ month(s) from the day of the experiment. Table 3 in Appendix D illustrates how the payment schedule is presented to participants for this treatment. With the additional front-end delay in Treatment $WM2D$, the now delayed weekly and monthly bargainers receive their payoff in $n$ week(s) and in $(n - 1)$ month(s) plus one week, respectively. Assuming $(\beta, \delta)$-discounting (i.e., quasi-hyperbolic discounting), any present (or near-future) bias will vanish with such
a front-end delay, and this will be true also with more general forms of such a bias.\textsuperscript{22}

**Fixed Types and Random Rematching.** To minimize any potential confusion among participants regarding their incentives and payment schedule, we randomly assigned every participant their “bargainer type” at the beginning of the session and fixed it throughout the entire experiment. Participants then played multiple games, as usual, where they were randomly rematched after each game, subject to the particular treatment’s pairing specification. Within any match, the types of both players were made common knowledge at the very beginning of the game, see the screenshots in Appendix E.

**Probabilistic Termination.** In addition to payoff delay, we also implemented exogenous termination with a fixed, commonly known termination probability of 25\%. By contrast, previous studies of the Rubinstein (1982) model, such as Zwick et al. (1992), have employed probabilistic termination as the sole cost of disagreement and studied the effects of varying the termination probability on outcomes.\textsuperscript{23} Importantly, in our experiment, the same 25\% termination probability was transparently applied to all rounds of all games in all treatments. As a result, even if risk attitudes enter preferences, they could not be a significant source of behavioral differences we observe. This design choice serves two related purposes. First, it ensures that every bargaining game, while still indefinite, is expected to end after a reasonable amount of time and, upon its conclusion, to also be promptly followed by the next one, which is important for the credibility as well as smooth running of our experiment. Second, it theoretically keeps bargainers further away from possible indifference to delay, as required by property 3 of our preference assumptions. Of course, in terms of our model, discounting should therefore be viewed as also including this constant risk (assuming expected utility).\textsuperscript{24}

**Deterministic Roles.** At the beginning of the first round of every bargaining game, the initial proposer/responder roles were randomly determined, which in turn determined the individuals’ roles for all subsequent rounds via the alternating-offers protocol. This is in contrast to experiments studying random-proposer bargaining protocols, where the proposer is randomly determined in every round; Binmore et al., 2007 is the most closely related such experiment.

\textsuperscript{22}There is no consensus on how long this delay needs to be to make any present/future bias negligible. In his related experiment on the repeated Prisoners’ Dilemma, Kim (2019b) finds that the cooperation rate is significantly higher in a treatment with a payoff delay of one month per round than in a treatment with no payoff delay, suggesting that a month may be an upper bound.

\textsuperscript{23}See also Dal Bò and Fréchette (2018) for the use of the probabilistic termination in infinitely repeated games.

\textsuperscript{24}With expected utility, a constant probability of breakdown simply proportionally reduces each \( \delta_i(n) \) by this fraction, whereby it is captured by our model. It should be noted, however, that certain violations of expected utility yield dynamic inconsistency even across rounds, in contrast to our model. In particular, Halevy (2008) argues that the future is inherently uncertain and shows how empirically plausible non-linear probability weighting of future consumption risk provides a foundation of present bias and diminishing impatience. Since Schweighofer-Kodritsch (2018) finds that this form of dynamic inconsistency does not upset any of the qualitative equilibrium predictions of the benchmark under dynamic consistency, we abstract from risk as a potential source of dynamic inconsistency.
4.3 Behavioral Predictions

We now employ Proposition 1 to derive the behavioral predictions that our experiment is designed to test. These concern the basic theoretical implications of the most important classes of time preferences with regards to efficiency and distribution. Efficiency of bargaining (immediate agreement) is a general implication. The distribution of surplus (bargaining power) depends on who gets to be the initial proposer (proposer advantage) and on the two bargainers’ specific time preferences (“patience advantage”) on the other hand. All formal proofs are in Appendix A.

We begin by establishing the important and influential benchmark predictions from exponential discounting, as in Rubinstein (1982), and subsequently highlight the differential predictions under the most important alternative forms of discounting, as they have been observed empirically – in particular, present bias as in quasi-hyperbolic discounting. In each case, to capture the implied “typical” behavior, we impose preference symmetry, i.e.: Both individuals have the same atemporal utility function, \( u_1 = u_2 = u \), and, for the same future delay \( \Delta_{t,t'} \) from some given date \( t > 0 \) to some later date \( t' > t \), discount utility with the same discount factor \( \delta_{t,t'} \). Note that by implementing idiosyncratic payoff delays (bargainer types), our effective discounting procedure nonetheless induces variation in the cost of disagreement within and across matches/treatments.

**Exponential Discounting (EXD).** Since any given bargainer type faces the same payoff delay from any round of disagreement, the stationarity property of EXD implies that any such delay is discounted with the same discount factor, irrespective of any front-end delay. Let then \( \delta \in (0,1) \) be the (common) discount factor for a weekly delay, and let \( \phi \delta \) be the (common) discount factor for a monthly delay, where \( 0 < \phi < 1 \).\(^{25}\) Using notation \( \phi_i \in \{\phi, 1\} \) with \( \phi_i = 1 \) if and only if bargainer \( i \) is a weekly bargainer, any bargainer \( i \)’s type is fully captured by \( \phi_i \), determining her preferences over agreements as \( U_i(q,n) = (\phi_i \delta)^{n-1} u(q) \). Both WM and WM2D correspond to pairing \( \{1, \phi\} \), and WW1D corresponds to pairing \( \{1, 1\} \).

**Prediction 1.** Symmetric EXD implies:

1. **Efficiency:** There is always immediate agreement.

2. **Proposer Advantage:** In every treatment, a given bargainer type obtains a greater share as initial proposer than as initial respondent.

3. **Basic Delay Advantage:** For a given initial role (proposer or respondent):

   3a. In both of Treatments WM and WM2D, the weekly bargainer obtains a greater share than the monthly bargainer.

\(^{25}\)If we take a month to equal four weeks, then \( \phi \delta = \delta^4 \) pins down \( \phi = \delta^3 \).
(3b) Across Treatments WM and WW1D, the weekly bargainer obtains a greater share against the monthly bargainer (WM) than against the delayed weekly bargainer (WW1D).

(3c) Across Treatments WM2D and WW1D, the delayed weekly bargainer obtains a greater share against the delayed monthly bargainer (WM2D) than against the non-delayed weekly bargainer (WW1D).

(4) **Front-End Delay Neutrality:**

(4a) In Treatment WW1D, the bargaining outcome is the same, irrespective of which type is the initial proposer.

(4b) Across Treatments WM and WM2D, the bargaining outcome is the same, both when the initial proposer is a weekly bargainer and when it is a monthly bargainer.

**Quasi-Hyperbolic Discounting (QHD).** Present bias, the excessive weight put on immediate rewards relative to delayed rewards, is the most important deviation from EXD. By adding a single parameter $\beta \in (0, 1)$, the model of quasi-hyperbolic discounting captures this empirically well-established phenomenon. Since all offers are made at the same date, there is no room for dynamic inconsistency across rounds, however, and the bias may play a role only in the first round. Moreover, it will do so only when the initial respondent faces no front-end delay. Upon failing to agree immediately, all possible payoffs lie in the future, the proposer’s discounting of the first round’s delay is irrelevant, and a front-end delay for the respondent would push any immediate-agreement payoffs into the future as well. Keeping the earlier exponential-discounting notation and additionally introducing $\beta_i \in \{\beta, 1\}$ with $\beta_i = 1$ if and only if bargainer $i$ is not delayed, any bargainer $i$’s type is fully captured by $(\phi_i, \beta_i)$ determining her preferences over agreements as $U_i(q, n) = \beta_i^{\chi\{1\}(n)} \left(\phi_i \delta\right)^{n-1} u(q)$, where $\chi\{1\}(n)$ equals one if $n = 1$ and zero otherwise. WM2D corresponds to pairing $\{(1, \beta), (\phi, \beta)\}$, WM corresponds to pairing $\{(1, \beta), (\phi, \beta)\}$, and WW1D corresponds to pairing $\{(1, 1), (\phi, 1)\}$.

**Prediction 2.** Symmetric QHD implies: (1) and (2) as under EXD, and

(3’) **Qualified Basic Delay Advantage:** (3a,3b) as under EXD, and

(3c’) Across Treatments WM2D and WW1D, the delayed weekly bargainer obtains a greater share against the delayed monthly bargainer (WM2D) than against the non-delayed weekly bargainer (WW1D) as initial respondent, but *may obtain a smaller share as initial proposer.*

(4’) **Front-End Delay Advantage:**

(4a’) In Treatment WW1D, the *delayed weekly bargainer obtains a greater share*, both as initial proposer and as initial respondent.

(4b’) Across Treatments WM and WM2D, the *initial proposer obtains a greater share in WM than in* WM2D, both when it is a weekly bargainer and when it is a monthly bargainer.
**Other Forms of Discounting.** Due to the tractability they afford, EXD and QHD are, by far, the most important models of time preferences for theoretical analyses. However, empirical studies, especially from psychology, suggest hyperbolic discounting—which also known as diminishing impatience, which also implies present bias—as a universal form of discounting. At the same time, experimental studies from economics also document the “opposite” of present bias, namely (near-) future bias. We now discuss the implications of these alternatives.

First, consider hyperbolic discounting, where $\delta_i(n)$ is increasing in $n$. Since it implies a present bias, a front-end delay increases such a discounter’s bargaining power as respondent. However, disagreement in round $n$ adds a shorter payoff delay to a shorter delay for a weekly bargainer than a monthly bargainer, meaning that for $n$ large enough a monthly bargainer may in general become more patient than a weekly bargainer. This would resonate through the entire recursion of equation (3.1), thereby affecting the equilibrium outcome. Based on our intuition that discounting for the same additional delay would not change fast with the preceding delay (except for the immediate present), and given the sizeable termination probability that also enters discounting, we assume that the effect of pushing delays further into the future does not outweigh the effect of longer delays in determining the immediate equilibrium agreement. Notably, the leading models of hyperbolic discounting are all special cases of discounting function $d(t) = (1 - \alpha \cdot t)^{-\beta/\alpha}$ (with $\alpha, \beta > 0$), proposed by Loewenstein and Prelec (1992), and for any such discounting our design ensures that the cost of disagreement is always lower for a weekly bargainer than for a monthly bargainer (also when both are delayed). Loosely speaking, hyperbolic discounting then remains sufficiently similar to constant discounting for any delay that starts in the future, such that, by continuity, the only important difference from EXD is a present bias, and the qualitative behavioral predictions under hyperbolic discounting are then identical to those for QHD for within-treatment predictions. Regarding predictions across treatments, hyperbolic discounting still introduces another possibility, however: Even the general functional form does not restrict whether the weekly (with no delay) or the delayed monthly bargainer type is more patient (though one can show that they can always be ordered). The fact that both is possible renders hyperbolic discounting altogether permissive with respect to Predictions (3c/3c’) and (4b/4b’).

Finally, consider also near-future bias. Somewhat loosely, this means that the discounting function is initially concave (hump-shaped), in contrast to the convex discounting functions under EXD, QHD or hyperbolic discounting. While empirically documented, it is neither known how prevalent this bias is (hence, whether it could be reasonably expected to guide typical behavior) nor how far the “near” future extends from the immediate present (hence, whether a week’s front-end delay could be reasonably expected to mute it). In view of these open issues, we omit a detailed analysis, except for

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26 The reason is that the different delays per round have a constant ratio, which also equals the ratio of total delays the two bargainers face in any agreement. Measuring time $t$ in the unit that is the shorter delay per round and letting the corresponding type be type $A$, $A$’s discount factor for round $n$ is $\delta_A(n) = [(1 - \alpha \cdot n)/(1 - \alpha \cdot (n - 1))]^{-\beta/\alpha}$; letting the longer delay be $k > 1$ times the shorter delay with corresponding type $B$, $B$’s discount factor for round $n$ is $\delta_B(n) = [(1 - \alpha \cdot kn)/(1 - \alpha \cdot k(n - 1))]^{-\beta/\alpha}$. Basic algebra yields $\delta_A(n) > \delta_B(n)$, and it is straightforward to check that the same holds true if both $A$ and $B$ face the same front-end delay.
noting that if a near-future bias operates like “inverted” present bias in QHD—i.e., \(1 < \beta < 1/\delta\)—then it would simply yield the mirror image of the differential predictions of QHD from EXD, because a front-end delay would then make the initial respondent weaker rather than stronger.\(^{27}\)

**Summary.** Immediate agreement and a proposer advantage are fundamental theoretical implications for bargaining. While our experiment is set up to test these as well, its main innovation and focus is on the comparative statics in time preferences. The idea that patience is power in bargaining becomes somewhat intricate with any violation of EXD, since there is then no simple measure of patience to apply at every stage of bargaining. As argued, under mild restrictions, a basic delay advantage in the sense of prediction (3a) may be considered a fundamental theoretical implication as well. Focusing on QHD as parsimoniously capturing the key empirical deviation from EXD (among all forms of present-biased discounting), the major distinctive implication for our experiment to test is that a front-end delay increases an initial respondent’s bargaining power (rather than having no effect), which underlies all of its differential predictions. Under minimal restrictions, hyperbolic discounting maintains the fundamental predictions together with the key distinctive prediction of QHD, but is otherwise more permissive.

### 4.4 Administrative Details

Our experiment was conducted using z-Tree (Fischbacher, 2007) at the University of California, Irvine. A total of 348 subjects who had no prior experience of our experiment were recruited from the graduate and undergraduate student population of the university. Upon arrival at the laboratory, participants were instructed to sit at separate computer terminals. Each of them received a copy of the experiment’s instructions. To ensure that the information contained in the instructions is induced as public knowledge, these instructions were read aloud, and the reading was accompanied by slide illustrations followed by a comprehension quiz.

Each session studied a single treatment, and we conducted 6 sessions for each treatment, for a total of 18 sessions (6 sessions \(\times\) 3 treatments). In all sessions, participants played 10 games under the corresponding treatment condition, matching bargainer types A and B, say. At the beginning of the experiment, one half of the participants were randomly assigned to be type A and the other half to be type B. Individual participants’ types remained fixed throughout the session. We used the random-matching protocol (across matches, subject to the treatment condition). Each session had 16–20 participants and hence involved 8–10 simultaneous games.

We illustrate the instructions with those for Treatment WM. The full instructions for this treatment can be found in Appendix D. For each game, one Type A participant and one Type B participant

\(^{27}\)Specifically, rather than qualifying prediction (3c), which would then carry over from EXD, such bias would qualify (3b) to not necessarily holding anymore for the weekly bargainer as initial proposer, and it would change “greater” to “smaller” in predictions (4a’) and (4b’).
were randomly matched. At the very beginning of Round 1, one of the two was randomly chosen to be the proposer, and the other to be the responder. The proposer then proposed how to split 500 tokens (worth $50) between the two of them as:

“_______ tokens for yourself and _______ tokens for the other person.”

After observing the split proposed, the respondent decided whether to accept or reject it. If the respondent accepted the proposed split, both participants received their proposed amount in tokens, and the match was terminated. If the respondent rejected the proposed split, then the match proceeded to the next round of bargaining with a 75% chance and was terminated with a 25% chance. If a match was terminated after the rejection of a proposed split, both participants received zero tokens for the match. If the match proceeded to the next round, then the participant who was the proposer in the previous round became the respondent, and the participant who was the respondent in the previous round became the proposer. At the end of the experiment, one of the 10 matches was randomly selected for payment. For the selected match, if agreement was reached, the delay of the participant’s payment depended on (1) his/her bargainer type and (2) the round in which the proposed split was accepted.

After all ten matches were over, we measured participants’ time preferences by using the BDM (Becker, DeGroot, and Marschak, 1964) method. We elicited their switching points between sooner and later money amounts. One decision was randomly selected for actual payment.28

The tokens our participants earned in the selected match were converted into US dollars at a fixed and known exchange rate of $0.1 per token. In addition to these earnings, participants received a show-up payment of $10. Any amount a participant was due to receive was paid electronically via Venmo, including immediate payments. Earnings were $37.90 on average, and the average duration of a session was approximately 1.5 hours.29

28 We measured participants’ time preferences in 4 sessions for each treatment. The main purpose of this measurement was to offer a check whether the random assignment was successfully implemented in terms of participants’ time preferences. Indeed, we find no significant differences in the distribution of choices between treatments. In line with Manzini (2001), we find no significant correlations of these measures with behavior in our experiment. The measures are not only naturally noisy, but time preferences may also be correlated with other behaviorally relevant preference characteristics like fairness concerns, and with beliefs about others’ (the opponents’) preferences, which are crucial for equilibrium behavior. Our exact procedure was as follows. In cases where participants were asked to switch from sooner to later payments, up to the chosen switching point, all sooner payment options were automatically selected, and below the switching point, all later payment options were automatically selected. Thus, we did not allow multiple switching points, which are usually regarded as irrational. Participants made decisions for 8 blocks that differed as follows: (1) different time horizons for sooner and later payments and (2) the money amount was increasing only for one date (either sooner or later), for the other it was fixed.

29 We conducted 6 sessions in May and June, 2018, and 12 sessions in October and December, 2018. The longest delay among the matches selected for payment was 7 months and the corresponding amount was paid on May 17, 2019.
5 Experimental Results

This section presents our experimental results regarding Predictions 1 and 2. First, we take a look at the basic efficiency property of bargaining outcomes and present empirical evidence regarding the proposer advantage. Then, we investigate the key predictions regarding any advantage created from the basic delay and front-end delay manipulation. In the body of this paper, we mainly focus on the data from the second half the experiment, after some learning has taken place. In line also with the literature, we conduct our tests based on comparisons of initial proposals, as capturing the bargainers’ perception of relative bargaining power. We have these data for every bargainer type in every treatment, and every participant with a given type played both versions of the game against the treatment’s given opponent type (i.e., as initial proposer and as initial respondent). Notably, the vast majority of agreements were reached immediately or with only one round of delay, with highly similar rates across all treatments. In any case, we do find similar results for the first half of the experiment, and when comparing actual immediate agreements; Appendix B has the supporting supplementary figures. Finally, we summarize and discuss our findings.

5.1 Efficiency, and Proposer Advantage

Figure 1: The Proportions of Agreements over Rounds – Last 5 Matches

Figure 1 depicts the proportions of agreements made in Rounds 1, 2, 3, and 4 or after, based on the last 5 matches data. The basic picture does not change if we instead use the first 5 matches only or all 10 matches. In Treatment WM, the vast majority of matches result in agreement reached with
no delay (72.5%) or one round of delay (12.5%). In Treatments WM2D and WW1D, the broad picture is highly similar. For all rounds, the proportions of agreement before random termination are 91.8%, 89.3% and 90.5% for Treatments WM, WM2D, and WW1D, respectively.

In all pairwise comparisons between treatments, the acceptance rates in Round 1—i.e., the rates of immediate agreement—do not significantly differ between treatments (one-sided Fisher’s exact test, \( p \)-values > 0.18). Figure 10 in Appendix B shows that these rates also do not differ significantly across the two versions of the game within any treatment.

These observations establish that immediate agreement is the rule rather than the exception, and they suggest that failures to agree are unrelated to the specific pairing of bargainer types and effective time preferences. Of course, participants make their decisions based on incomplete information, but this does not seem to cause much delay and inefficiency. The fact that the average number of rounds for agreement is only slightly above 1.3 also supports that, on average, bargaining achieved very high levels of efficiency.\(^{31}\)

Finally, considering agreements only (recall the risk of exogenous termination) and averaging also over all treatments, more than 75% are immediate agreements, and approximately 17% are agreements with a delay of only one round. We summarize this as follows.

**Result 1 (Efficiency).** *In every treatment, the vast majority of agreements is reached immediately or with only one round of delay.*

We next explore the proposer advantage in our data, based on initial proposals. Figure 2’s left panel reports the average share for proposers and respondents of each type in each treatment over the last 5 matches. For every type, the average share for proposers is significantly larger than that for respondents (Kolmogorov-Smirnov test, \( p \)-values < 0.01).\(^{32}\) Moreover, the differences are substantial in their magnitudes (25–40 tokens).

Of course, not all proposals are accepted, and we would naturally expect more rejections for proposals that leave less to respondents. Hence, we also consider actually accepted proposals, see figure 2’s right panel for the last 5 matches, which confirm the advantage of initially proposing.\(^{33}\) These observations firmly support the predicted proposer advantage in bargaining when the cost of disagreement is delay.

**Result 2 (Proposer Advantage).** *In every treatment, given any bargainer type (weekly, monthly, delayed), the average share as proposer is significantly and substantially larger than that as respondent.*

\(^{30}\)For a robustness check to control for the size of proposals in Round 1, we also run probit regressions in which a treatment dummy variable and the respondents’ share are independent variables, and the standard errors are clustered at the session level. For all pairwise comparisons over the last 5 matches, the difference in acceptance rates is insignificant except for being only marginally significant in the comparison of Treatments WM and WW1D (\( p \)-value = 0.059). For all matches, no pairwise comparison results in a significant difference (\( p \)-values > 0.153).

\(^{31}\)The average number of rounds for agreement does not differ across treatments (Mann-Whitney test, \( p \)-values > 0.5).

\(^{32}\)Qualitatively the same patterns are observed for the first 5 matches.

\(^{33}\)We find a similar confirmation for the first 5 matches, and also for actual payoffs, see appendix B.
5.2 Basic Delay and Front-End Delay Advantages

To maximize the amount of data for our analyses, we focus on initial proposals, thereby treating them as equilibrium proposals. Contrary to the equilibrium assuming perfect information, not all of them are accepted, of course, due to preference heterogeneity and incomplete information. However, as shown, most of them are, and at very similar rates across conditions. This suggests that proposers did generally attempt to reach agreement immediately, and that the effect of incomplete information is “constant” across conditions. Moreover, we obtain similar results when considering actually agreed shares, see Figures 17 through 19 in Appendix B.

Our manipulation is supposed to effectively shift the distribution of time preferences between the randomly selected groups of bargainer types. We therefore conduct our comparisons based on the entire observed distributions of initial proposals in terms of the proposer’s claimed share.\textsuperscript{34} Specifically, we always examine the cumulative distribution functions (CDFs) for first-order stochastic dominance, and we use appropriate uni-directional Kolmogorov-Smirnov (KS) tests for statistical significance in this strong sense. Note that in contrast to comparisons of means, which are always ordered, nothing guarantees such order here.

Recall that our design produces tests of all predicted comparative statics on within-treatments data, which we consider first, and on across-treatments data, which follows second.

\textsuperscript{34}The CDF figures that follow below are censored by the given range of [250, 310] for ease of graphical representation. It contains, on average, more than 95% of the observations in the data. Such truncation does not apply to any of the statistical analyses.
5.2.1 Within Treatments

Within treatments, we test for the basic delay advantage according to Prediction (3a), which is common to both EXD and QHD and concerned with Treatments WM and WM2D: In each of these treatments, proposals by weekly bargainers are predicted to exceed those by their monthly counterparts in terms of the proposer’s own share. The other within-treatment test is that of front-end delay neutrality under EXD, Prediction (4a), v. front-end delay advantage under QHD, Prediction (4a’), and it is concerned with treatment WW1D: Whereas both bargainer types are predicted to make identical proposals under EXD, under QHD the delayed type is predicted to claim a larger share of the surplus.

Note that, if a type A’s initial proposals have a larger proposer share than a type B’s proposals, this is equivalent to type A’s being offered a larger respondent share than type B. Hence, within each treatment, a single comparison covers the entire respective prediction.

![CDF of Round 1 proposals in WM](image)

(a) First 5 Matches  
(b) Last 5 Matches

Figure 3: Round-1 Proposals in Treatment WM

Figure 3 presents the CDF of Round-1 proposals in Treatment WM aggregated over the first 5 matches (Figure 3(a)) and over the last 5 matches (Figure 3(b)), by bargainer type. The solid line indicates the CDF for the weekly proposer, and the dotted line indicates that for the monthly proposer. A few observations are immediate. First, consistent with prior findings, fairness concerns seem to be an important factor in bargaining.\(^{35}\) Approximately 50% of proposals are equal (250-250) splits. Second, the CDF of proposals by weekly bargainers clearly lies below that for monthly bargainers already for the first 5 matches (KS test, \(p\text{-value} = 0.046\)). This difference remains statistically significant and becomes even more substantial in magnitude in the last 5 matches (KS test, \(p\text{-value} < 0.01\)). We therefore strongly confirm the general Prediction (3a) for Treatment 3. Both matched types act in accordance with a shared understanding that longer delay increases the cost of disagreement and

\(^{35}\)In fact, this does not require the proposers to be fair-minded; it could be that they have “selfish” preferences but believe that they are facing a fair-minded respondent.
weakens bargaining power.

**Result 3** (Basic Delay Advantage in Treatment WM). *In Treatment WM, the initial proposals by weekly bargainers significantly exceed and first-order stochastically dominate those by monthly bargainers.*

![CDF of Round 1 proposals in WM2D](image)

(a) First 5 Matches  
(b) Last 5 Matches

Figure 4: Round-1 Proposals in Treatment WM2D

Figure 4 presents the CDF of Round-1 proposals in Treatment WM2D by bargainer type. The solid line indicates the CDF for the (now delayed) weekly proposer, and the dotted line indicates that for the (now delayed) monthly proposer. Again, close to 50% of proposals are equal splits. Unlike in Treatment WM, the distributions of proposals are quite obviously not significantly different initially (KS test, \( p \)-value = 0.726). However, behavior gravitates towards the theoretical prediction as the participants gain more experience. In the comparison for the last 5 matches, we observe the predicted first-order stochastic dominance, although it remains statistically non-significant (KS test, \( p \)-value = 0.262). Restricting attention to proposals that are strictly greater than 250 (meaning that the proposer claims more than half the surplus), the predicted first-order stochastic dominance relationship becomes marginally significant (KS test, \( p \)-value=0.078). Altogether, these findings also support the general Prediction (3a), though relative to Treatment WM, the front-end delay in Treatment WM2D significantly mitigates the basic delay advantage. In other words, it is less clear that the two bargainer types perceive the longer delay as significantly weakening bargaining power. This observation is consistent with diminishing impatience, so that adding a front-end delay shifts bargaining power somewhat to the bargainer with longer delays.

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36 Excluding the observations with equal shares does not harm our analysis for Treatment WM2D because the frequencies of equal-split proposals by weekly and monthly bargainers are not statistically different (Fisher’s exact test (one-sided), \( p \)-value = 0.378).
**Result 4** (Basic Delay Advantage in Treatment WM2D). *In Treatment WM2D, the initial proposals by delayed weekly bargainers and those by delayed monthly bargainers are not significantly different in their distributions. We observe first-order stochastic dominance of the former in the last 5 matches, where the difference is statistically more significant, especially upon excluding equal splits.*

While Treatments WM and WM2D pair two types that differ solely in their payoff delay per round of disagreement and therefore permit a straightforward test of the basic delay advantage, Treatment WW1D is symmetric in this respect. The only asymmetry between types consists here in the fact that one of them is facing a front-end delay, while the other is not. Under EXD, this “fixed cost” asymmetry is irrelevant, while it is an advantage under QHD (present bias).

![CDF of Round 1 proposals in WW1D](image)

**Figure 5: Round-1 Proposals in Treatment WW1D**

Figure 5 shows the CDF of Round-1 proposals in Treatment WW1D by bargainer type. The solid line indicates the CDF for the weekly proposer (facing no front-end delay), and the dotted line indicates that for the delayed weekly proposer. Whereas EXD predicts no difference, it is clear to see that the distribution of proposals by delayed weekly bargainers first-order stochastically dominates that of the weekly bargainers without front-end delay throughout, as alternatively predicted under QHD. This difference is highly significant both in the first and the last 5 matches (KS test, *p*-value < 0.01 and *p*-value = 0.046, respectively). Hence, the front-end delay neutrality Prediction (4a) for Treatment WW1D is strongly rejected in favor of the alternative Prediction (4a’) of a front-end delay advantage, as under QHD (or any present bias). Instead of perceiving no difference in their bargaining power, the two types act in accordance with a shared understanding that a front-end delay confers an advantage due to present bias.

**Result 5** (Front-End Delay Advantage in Treatment WW1D). *In Treatment WW1D, the initial proposals by delayed weekly bargainers significantly exceed and first-order stochastically dominate those by weekly bargainers without delay.*
5.2.2 Across Treatments

We now turn to testing the predictions of a basic delay advantage and front-end delay neutrality v. advantage across treatments. Here, we generally exploit the feature of our design that we observe the same bargainer types against different opponent bargainer types. In contrast to the within-treatment comparisons, we therefore have to separately consider predictions for the “common type” as initial proposer and as initial respondent. Throughout, we focus on the data from the last 5 matches for these comparisons. Recall here that the rates of immediate agreement are similar across any two treatments.

First, we consider the basic delay advantage according to general Prediction (3b), common to both EXD and QHD: Fixing the initial role, the weekly bargainer is predicted to obtain a greater share against a monthly bargainer (in Treatment WM) than against a delayed weekly bargainer (in Treatment WW1D). The weekly bargainer (with no delay) is here the common type, and we have to consider two comparisons here, each comparing behavior across the two different opponent types (treatments): One for the weekly bargainer as initial proposer, and another one for the weekly bargainer as initial respondent. The two pairs of CDFs of initial proposals—by and to weekly bargainers, respectively—are shown in Figure 6.

![Figure 6: Response to Different Types by Weekly – Last 5 Matches](image)

(a) Weekly Proposer in WM v. WW1D  (b) Weekly Respondent in WM v. WW1D

Figure 6(a) compares Round-1 proposals by weekly bargainers to monthly bargainers, as in Treatment WM (solid), and to delayed weekly bargainers, as in Treatment WW1D (dashed), for the last 5 matches. Consistent with Prediction (3b), the former distribution clearly first-order stochastically dominates the latter. The difference is highly significant statistically (KS test, $p$-value < 0.01). This finding demonstrates that weekly bargainers perceive themselves in a much stronger initial proposing position against monthly bargainers than delayed weekly ones, in strong confirmation of Prediction (3b).\(^{37}\)

Figure 6(b) compares Round-1 proposals to weekly bargainers by monthly bargainers, as in Treatment WM (solid), and by delayed weekly bargainers, as in Treatment WW1D (dashed), for the last 5 matches. Notably, this finding contradicts near-future bias, see footnote 27.

\(^{37}\)Notably, this finding contradicts near-future bias, see footnote 27.
5 matches. Again, consistent with Prediction (3b), the former distribution quite obviously first-order stochastically dominates the latter, and this difference is also highly significant statistically (KS test, \( p \)-value < 0.01). What is remarkable here is that much of this difference is due to the fact that about 60% of monthly bargainers propose a weekly bargainer an equal split, whereas only 40% of delayed weekly bargainers do so. This finding in turn demonstrates that, against the same weekly bargainer type, the monthly bargainers perceive their initial proposing position to be weaker than the delayed weekly ones perceive theirs, providing further strong confirmation of Prediction (3b).

**Result 6 (Basic Delay Advantage across Treatments WM and WW1D).** The initial proposals by weekly bargainers to monthly bargainers in Treatment WM significantly exceed and first-order stochastically dominate those to delayed weekly bargainers in Treatment WW1D. The initial proposals to weekly bargainers by delayed weekly bargainers in Treatment WW1D significantly exceed and first-order stochastically dominate those by monthly bargainers in Treatment WM.

Next, we turn to Prediction (3c) under EXD and its more permissive qualification (3c’) under QHD, concerning another instance of basic delay advantage. Here, the common type is the delayed weekly type, and we compare this type’s outcomes against the delayed monthly type (Treatment WM2D) and against the weekly type with no delay (Treatment WW1D). Figure 7 provides the pairwise comparisons.

![CDF of Round 1 proposals of weekly with delay](image1.png)  
![CDF of Round 1 proposals against Weekly with delay](image2.png)

(a) Del. Weekly Proposer WM2D v. WW1D  
(b) Del. Weekly Respondent WM2D v. WW1D

**Figure 7: Response to Different Types by Delayed Weekly – Last 5 Matches**

Figure 7(a) compares Round-1 proposals by delayed weekly bargainers to delayed monthly bargainers, as in Treatment WM2D (solid), and to weekly bargainers (with no delay), as in Treatment WW1D (dashed). In this case, EXD predicts an unambiguously greater advantage against delayed monthly bargainers, whereas QHD implies that weekly bargainers with no delay may also be the weaker respondents, if their present bias is sufficiently strong to outweigh their delay advantage in later rounds. The EXD Prediction (3c) is here rejected, since neither is there any qualitative first-order dominance relationship between the CDFs, nor is there any statistically significant difference between them (KS test, \( p \)-value = 0.349). In other words, delayed weekly bargainers perceive their initial proposing position
to be roughly equally strong against both of these opponent types. This is consistent with Prediction (3c’) under QHD (or a strong present bias).

Figure 7(b) compares Round-1 proposals made to delayed weekly bargainers by delayed monthly bargainers, as in Treatment WM2D (solid), and by weekly bargainers (with no delay), as in Treatment WW1D (dashed). Since an initial proposer’s present bias is irrelevant to equilibrium, both EXD and QHD imply that weekly bargainers should claim more than delayed monthly ones from the same opponent type, here a delayed weekly bargainer. Our data reject this, however. There is a marginally significant difference with the opposite first-order stochastic dominance order (KS test, $p$-value = 0.09). Delayed monthly bargainers perceive their initial proposing position against delayed weekly ones to be somewhat stronger than weekly ones do, in contradiction to both Predictions (3c) and (3c’).38

Result 7 (Basic Delay Advantage across Treatments WM2D and WW1D). The initial proposals by delayed weekly bargainers to delayed monthly bargainers in Treatment WM2D and those to weekly bargainers (with no delay) in Treatment WW1D are not significantly different in their distributions, and we observe no first-order stochastic dominance relationship. The initial proposals to delayed weekly bargainers by delayed monthly bargainers in Treatment WM2D marginally significantly exceed and first-order stochastically dominate those by weekly bargainers (with no delay) in Treatment WW1D.

Finally, we turn to Predictions (4b) and (4b’), concerning front-end delay neutrality under EXD, v. front-end delay advantage under QHD (present bias). We investigate this by comparing Treatments WM and WM2D, which are strategically identical under EXD, but not under QHD, because a front-end delay lowers the initial respondent’s cost of delay, thereby increasing bargaining power. Recalling that the initial proposer’s present bias is irrelevant, the differential prediction under QHD is that Round-1 proposals by weekly bargainers (delayed or not) should claim a greater share in Treatment WM than Treatment WM2D; and similarly for the initial proposals by monthly bargainers.

![Figure 8: Response to Different Types by Front-End Delay – Last 5 Matches](image)

(a) Weekly Proposers in WM v. WM2D  
(b) Monthly Proposers in WM v. WM2D

38Near-future bias also makes Prediction (3c), which is here strongly rejected; see footnoteNFB.
Figure 8(a) compares Round-1 proposals by weekly bargainers to monthly bargainers, as in Treatment $WM$ (solid), and by delayed weekly bargainers to delayed monthly bargainers, as in Treatment $WM2D$ (dashed). Under EXD, these are predicted to be the same, whereas under QHD, they should be larger in Treatment $WM$ without front-end delay. The visual comparison suggests first-order stochastic dominance supporting the QHD prediction. However, there are somewhat more very high proposals (i.e., proposers claiming a very high share for themselves) in Treatment $WM2D$, and the difference in distributions is not statistically significant (KS test, $p$-value = 0.48). EXD’s Prediction (4b) cannot explain the particular shape of CDFs, yet cannot be rejected. Granting that our distributional test may be somewhat conservative, there is some though limited support for QHD’s alternative Prediction (4b’).

Figure 8(b) compares Round-1 proposals by monthly bargainers to weekly bargainers, as in Treatment $WM2D$ (solid), and by delayed monthly bargainers to delayed weekly bargainers, as in Treatment $WM2D$ (dashed). In contrast to both Predictions (4b) and (4b’), the latter proposals first-order stochastically dominate the former, and this difference is highly significant statistically (KS test, $p$-value < 0.01). Delayed monthly bargainers claim more from delayed weekly ones than monthly bargainers do from weekly ones. Predictions (4b) and (4b’) are overall rejected.

**Result 8** (Front-End Delay Advantage Across Treatments $WM$ and $WM2D$). The initial proposals by weekly bargainers to monthly bargainers in Treatment $WM$ tend to first-order stochastically dominate those by delayed weekly bargainers to delayed monthly bargainers in Treatment $WM2D$, but they are not significantly different statistically. The initial proposals by delayed monthly bargainers to delayed weekly bargainers in Treatment $WM2D$ significantly exceed and first-order stochastically dominate those by weekly bargainers to monthly bargainers in Treatment $WM$.

### 5.3 Summary and Discussion

Overall, we obtain rather strong support for the theoretical predictions under QHD (present bias). This is true above all in our within-treatment comparisons. The two failures—one part of the effective-delay advantage Prediction (3c’) and one part of the front-end-delay advantage Prediction (4b’)—occur in the naturally tougher comparisons across treatments, which may develop their own “cultures” for non-obvious reasons. Remarkably, however, both occur with proposals by the same type in the same treatment: The delayed monthly bargainers in Treatment $WM2D$ claim “too much” from their opponents, the delayed weekly bargainers; i.e., they perceive their position as “too strong.” Indeed, if we exclude all comparisons involving Treatment $WM2D$, thereby focusing on within-treatment Predictions (3a,$WM$) and (4a), as well as across-treatment Prediction (3b), then the behavioral support for the theory under QHD (present bias) is overwhelming: Our participants here convincingly demonstrate a shared understanding that a longer basic delay makes a bargainer weaker (both as initial respondent and as initial proposer) and a front-end delay makes a bargainer stronger (as initial respondent).
What might explain then the theoretically surprising findings that, as initial proposer, delayed monthly bargainers exert greater bargaining power against their delayed weekly opponents than (i) weekly bargainers (with no delay) do against the same opponent types, and than (ii) monthly bargainers do against weekly bargainers (neither with delay)? As pointed out in our discussion of the behavioral implications of other time preferences, hyperbolic discounting can permissively explain these features, whilst at the same time predicting the same as QHD where its predictions are strongly confirmed. From this perspective, we find evidence for present bias together with hyperbolic discounting. Still, QHD arguably captures the key features of behavior very well, whilst being parametrically parsimonious and tractable.

As expected, we also find evidence for social preferences. Overall, more than 45% of proposals correspond to an equal split. There are, however, notable difference across treatments and bargainer types, as can be seen in the within-treatment comparisons. Indeed, the predictions’ confirmations in terms of first-order stochastic dominance all come with correspondingly sizeable differences in the fraction of proposed equal splits. Relatedly, Treatment WM2D is the only one in which this fraction is almost identical for both types. The strong confirmation of Prediction (4a) via Treatment WW1D, a front-end delay advantage, could also be explained by social preferences for equalizing utility, given the treatment’s asymmetry in terms of the payoff timing of immediate agreements. However, the difference we find concerns the entire distribution and is substantial, which suggests that the contribution of social preferences is only partial. The fact that in both other treatments immediate agreements come with no payoff delay difference and we still find a strong effect confirms this interpretation.

Overall, roughly 3 out of 4 proposals are accepted immediately. While this means a great amount of efficiency, a fair number of proposals are still rejected, however. It seems clear that information is in fact incomplete, because preferences are heterogeneous, and this causes such rejections. However, our experimental procedure has arguably proven to be rather successful in establishing a common understanding of relative bargaining power based on time preferences, as intended. As part of this procedure, we made the different individual payoff delays within a match very salient. If some of the predictions’ confirmations appear to be “obvious” consequences of this, in spite of incomplete information about preferences (time, risk, social), then this is exactly the point to make: When two bargainers share a common understanding of who is more patient, then their behavior will reflect this in terms of greater bargaining power.39

6 Concluding Remarks

Our findings confirm that patience is a source of bargaining power. We obtain this confirmation via contributing a novel between-subjects design that randomly manipulates time preferences at the individual level. As argued, we consider the behavioral success of the theory in our experiment—

39This is also confirmed by our analysis of learning in Appendix C.
certainly relative to prior related studies—a consequence of how our design controls the inherently incomplete preference information that the participants and also we as researchers have. Since this issue arises importantly in many settings, we interpret this paper’s results also as a demonstration of our method’s wider usefulness.

This paper speaks to the large body of theoretical analyses of dynamic strategic interaction, where time preferences—with few exceptions, this means simply “the discount factor”—are a key driver of behavior. The general observation that time preferences matter in ways predicted by equilibrium, here established for the classic such setting of indefinite alternating-offers bargaining, contributes a very positive message. It confirms a necessary condition for the empirical validity of basic theoretical exercises.

At the same time, beyond exponential discounting, patience becomes a more complicated notion; there is no longer simply “a” discount factor, but there are potentially many. We obtain strong evidence for a present bias, as parsimoniously captured by the quasi-hyperbolic discounting model. The fact that people seem to share a common understanding of this bias and strategically respond to it is encouraging and even calls for further theoretical analyses of dynamic strategic interaction with present-biased individuals.

At a more detailed level, however, we also obtain evidence for present bias as a feature of diminishing impatience, i.e., hyperbolic discounting. Our design offers a rare instance to investigate the strategic role of time preferences at such detail. While largely unexplored in strategic interaction (though see Obara and Park, 2017, for a notable exception in the context of repeated games), our result may also inspire future work in this direction, both empirical and theoretical. For instance, we suspect that diminishing impatience could also contribute towards explaining the frequently observed U-shaped agreement-time curves in bargaining settings with deadlines (i.e., disproportionately many agreements right at the beginning and just before the deadline) reported in the literature (e.g., Roth, Murnighan, and Schoumaker, 1988; Embrey, Fréchette, and Lehrer, 2014; Karagözoglu and Riedl, 2014; Karagözoglu, Keskin, and Özcan-Tok, 2019).
References


Haan, Marco A. and Dominic Hauck (2019), “Games with possibly naive hyperbolic discounters.”


Appendices

A Proofs

Lemma 1

Proof. Define, for each player $i$, the function $f_i : [0,1] \to [0,1]$ as $f_i(U) = 1 - u_i^{-1}(U)$. If player $j$ is respondent and could obtain a fixed utility $U$ by rejecting, then $1 - u_j^{-1}(U)$ is the maximal share of proposer $i$ so that $j$ is willing to accept. Equation (3.1) then says that $x_n = f_{r_{n+1}}(\delta_{r_n}(n) \cdot u_{r_n}(x_{n+1}))$, whereby any sequence $x_n$ corresponds to a history-independent equilibrium: In any round $n$, the proposing player offers the share $1 - x_n$, thus keeping $x_n$ for herself, and this is the smallest offer accepted by the responding player, who upon rejection would similarly capture $x_{n+1}$. (Note the indifference of the responding player, $u_{r_n}(1 - x_n) = \delta_{r_n}(n) \cdot u_{r_n}(x_{n+1})$.)

Take now any odd-numbered round $N$, in which player 1 is the proposer, and consider the two extreme cases for responding player 2’s continuation utility upon rejection: first, when it is minimal and equals zero, and second, when it is maximal and equals one. For each of these two cases compute the implied backwards induction solution for the thus truncated game. Clearly, it has immediate agreement in every round, and, starting from the respective extreme terminal values, it is characterized by the recursive equation (3.1) for all rounds up through round $N$. (The extreme shares $x_{N+1} = 0$ and $x_{N+1} = 1$ correspond to the extreme continuation utilities $U_2 = 0$ and $U_2 = 1$.) Define these two finite sequences as $a^N_n$ and $b^N_n$, and—using assumption 3 with $\alpha = \max\{\alpha_1, \alpha_2\}$—observe that

$$|a^N_N - b^N_N| = a^N_N - b^N_N$$
$$= f_1(0) - f_1(\delta_2(N))$$
$$= u_2^{-1}(\delta_2(N)) - u_2^{-1}(0)$$
$$\leq \alpha \cdot \delta_2(N)$$

$$|a^N_{N-1} - b^N_{N-1}| = b^N_{N-1} - a^N_{N-1}$$
$$= f_2(\delta_1(N-1) \cdot u_1(f_1(\delta_2(N)))) - f_2(\delta_1(N-1) \cdot u_1(f_1(0))))$$
$$= u_1^{-1}(\delta_1(N-1) \cdot u_1(f_1(0))) - u_1^{-1}(\delta_1(N-1) \cdot u_1(f_1(\delta_2(N))))$$
$$\leq \alpha \cdot (f_1(0) - f_1(\delta_2(N)))$$
$$\leq \alpha^2 \cdot \delta_2(N)$$

$$\vdots$$

$$|a^N_1 - b^N_1| \leq \alpha^N \cdot \delta_2(N).$$

Clearly, $|a^{2n-1}_1 - b^{2n-1}_1| \to_{n \to \infty} 0$ (recall that we use only odd-numbered rounds), and hence $\lim_{n \to \infty} a^{2n-1}_1 = \lim_{n \to \infty} b^{2n-1}_1$, which proves the claim, since $a^{2n-1}_1 \geq x_1 \geq b^{2n-1}_1$ for all $n$. \qed
Proposition 1

Proof. Consider any odd-numbered round $N$, in which player 1 is the proposer, and suppose the supremal equilibrium continuation utility of player 2 takes the highest possible value of 1. Then there exists an equilibrium with the outcome that players agree in round 1 and the proposing player 1 obtains share $a^N_1$, defined in the proof of lemma 1. Similarly, supposing the infimal equilibrium continuation utility of player 2 takes the lowest possible value of 0, there exists an equilibrium with the outcome that players agree in round 1 and the proposing player 1 obtains share $b^N_1$, defined in the proof of lemma 1. Now, any equilibrium utility value $U_1$ of player 1 (as of round 1) satisfies $u_1(a^N_1) ≥ U_1 ≥ u_1(b^N_1)$, whereby lemma 1 proves uniqueness. A similar argument proves uniqueness of player 2’s equilibrium utility. Both are uniquely obtained in the immediate-agreement equilibrium characterized by the sequence of lemma 1.

Prediction 1

Proof. Immediate agreement (1) is a general implication, irrespective of how players discount utility. The other predictions require proof. In preparation, note that defining $f(U) ≡ 1 - u^{-1}(U)$ for any $U ∈ [0,1]$, proposition 1 implies that the unique equilibrium is characterized by

$$x^E_1 = f(\phi_2 \delta u(f(\phi_1 \delta u(x^E_1))))$$ and $$x^E_2 = f(\phi_1 \delta u(x^E_1)). \quad (A.1)$$

where $x^E_i$ is the share that individual $i$ obtains in immediate agreement whenever she gets to propose. This share $x^E_i$ obtains as the unique (and interior) fixed point of the function $g_i(q) ≡ f(\phi_i \delta u(f(\phi_i \delta u(q))))$, defined for any $q ∈ [0,1]$. The characterization covers all matches of all treatments.

For the proposer advantage (2), simply observe that $x^E_1 > u^{-1}(\phi_1 \delta u(x^E_1)) = 1 - f(\phi_1 \delta u(x^E_1)) = 1 - x^E_1$.

For the delay advantage (3), observe that $\phi_1 > \phi_2$ implies $g_1(q) > g_2(q)$ for all $q ∈ [0,1]$, and therefore $x^E_1 > x^E_2$ (comparison of proposer shares), which is equivalent to $1 - x^E_2 > 1 - x^E_1$ (comparison of respondent shares). Given (4), this covers all parts.

Finally, (4) follows directly from exponential discounting, as explained earlier.

Prediction 2

Proof. Again, (1) requires no specific proof. For the remainder, note that the second-round continuation equilibrium is characterized by the shares $x^E_i$ solving the two equations (A.1). Backwards induction then yields immediate agreement in the first round, with the initial proposer’s share given by

$$x^Q_1 = f(\beta_2 \phi_2 \delta u(x^E_2)).$$

(2) follows straight from the corresponding proof for EXD, upon noting that $\beta_2 ≤ 1$ implies $x^Q_1 ≥ x^E_1$, since

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40 Our preference assumptions imply that each $g_i$ is continuous and increasing from $g_i(0) > 0$ through $g_i(1) < 1$, whereby a fixed point exists and any fixed point is interior. Moreover, by our third preference assumption, each $g_i$ has a slope less than one, so there is a unique fixed point.
\[ x_1^F > 1 - x_2^F = u^{-1}(\phi_1 \delta u(x_1^F)) \geq u^{-1}(\beta_1 \phi_1 \delta u(x_1^F)). \]

For (3a), first observe that WM has \( \beta_1 = \beta_2 = \beta \) and that the respondent’s continuation share is smaller for the monthly than the weekly bargainer, from EXD, whereby the initial proposer’s share \( x_1^Q \) is greater (equivalently, the initial respondent’s share \( 1 - x_1^Q \) is smaller) when this is the weekly bargainer (against the monthly bargainer) than when it is the monthly bargainer (against the weekly bargainer). Second, observe that WM2D has \( \beta_1 = \beta_2 = 1 \), whereby predictions are as under EXD.

For (3b), observe that the weekly bargainer’s continuation share is greater against the monthly bargainer (WM) than against the delayed weekly bargainer (WW1D), both as initial proposer and as initial respondent, from EXD. Hence, when the weekly bargainer is the initial respondent, \((\phi_2, \beta_2) = (1, \beta), 1 - x_1^Q \) is greater against the monthly bargainer, \((\phi_1, \beta_1) = (\phi, \beta)\), than against the delayed weekly bargainer, \((\phi_1, \beta_1) = (1, 1)\). Upon noting that when the weekly bargainer is the initial proposer, a responding delayed weekly bargainer is unaffected by present bias, whereas a responding monthly bargainer is additionally weakened by it, the implication follows also for the cross-treatment comparison of the weekly bargainer’s shares as initial proposer.

For (3c’), first observe that with the initial respondent’s type equal to \((\phi_2, \beta_2) = (1, 1)\), her continuation share—hence also \( 1 - x_1^Q \)—is smaller against the weekly than the monthly bargainer, as under EXD. Second, fixing \((\phi_1, \beta_1) = (1, 1)\), it should be clear from continuity that a violation of the prediction under EXD—meaning \( x_1^Q \) is smaller when \((\phi_2, \beta_2) = (\phi, 1)\) than when \((\phi_2, \beta_2) = (1, \beta)\)—obtains as \( \phi \) approaches one while \( \beta \) approaches zero.

For (4a’), observe that when the weekly bargainer is the initial proposer, then \( x_1^Q = x_1^F \), while when the weekly bargainer is the initial respondent, then \( x_1^Q > x_1^F \).

For (4b’), observe that in WM, under either assignment of roles, \( x_1^Q > x_1^F \), whereas in WM2D, under either assignment of roles, \( x_1^Q = x_1^F \).
B Additional Figures

Efficiency

Figure 9: The Proportions of Agreements over Rounds – First 5 Matches

Figure 10: The Proportions of Immediate Agreements – All Matches
Proposer Advantage: First 5 Matches Proposals and Accepted Proposals

Figure 11: Proposer Advantage – First 5 Matches Proposals
Proposer Advantage: Final Payoffs incl. Random Termination

Figure 12: Final Payoffs (All) – First and Last 5 Matches

Proposer Advantage: Final Payoffs excl. Random Termination

Figure 13: Final Payoffs (excl. Random Terminations) – First and Last 5 Matches
Basic Delay and Front-End Delay Advantages: Proposals over Matches

Figure 14: Round-1 Proposals over Matches in Treatment $WM$

Figure 15: Round-1 Proposals over Matches in Treatment $WM2D$

Figure 16: Round-1 Proposals over Matches in Treatment $WW1D$
Basic Delay and Front-End Delay Advantages: Accepted Proposals

Figure 17: Accepted Proposals in Treatment $WM$ – First and Last 5 Matches

Figure 18: Accepted Proposals in Treatment $WM2D$ – First and Last 5 Matches

Figure 19: Accepted Proposals in Treatment $WW1D$ – First and Last 5 Matches
C Learning

We explore here whether and how their bargaining outcome in the previous match affects the proposers’ behavior in the subsequent match. Table 2 reports the regression results in which the dependent variable is the proposer’s proposed (own) share in Round 1 of each match (excluding the very first one, which has no history).

Table 2: Learning

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<td>Match 6-10</td>
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<td>(0.036)</td>
<td>(0.056)</td>
</tr>
<tr>
<td>Round 1 Accept</td>
<td>-41.723**</td>
<td>-104.134**</td>
</tr>
<tr>
<td></td>
<td>(16.823)</td>
<td>(36.187)</td>
</tr>
<tr>
<td>Round 1 Accept × Round 1 Share</td>
<td>0.160*</td>
<td>0.338**</td>
</tr>
<tr>
<td></td>
<td>(0.080)</td>
<td>(0.126)</td>
</tr>
<tr>
<td>Constant</td>
<td>215.125***</td>
<td>169.088***</td>
</tr>
<tr>
<td></td>
<td>(27.188)</td>
<td>(32.635)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.043</td>
<td>0.102</td>
</tr>
<tr>
<td>Observations</td>
<td>615</td>
<td>796</td>
</tr>
</tbody>
</table>

Notes: OLS regression with the Proposer’s proposed (own) share in Round 1 as dependent variable. The independent variable “Accepted Share” is one’s own share that was accepted in Round 1 of the previous match. “Accepted Round” represents the number of the round in which the proposal was accepted in the previous match. “Round 1 Share” is one’s own share that was proposed in Round 1 of the previous match. “Round 1 Accept” is the dummy variable taking the value of 1 if and only if the proposal was accepted in Round 1 of the previous match. Clustered standard errors at the session level are reported in parentheses. *Significant at 10%; **Significant at 5%; ***Significant at 1%

Overall, our participants were more likely to offer higher shares to respondents as they gained experience. In columns (1) and (2), we restrict our attention to proposals that were accepted in the previous match. A higher share in the previous match meant that a participant became more likely to claim a higher share as proposer in Round 1 of the subsequent match. The magnitude of this association became stronger in the later part of the experiment. An agreement reached only in later rounds also made the proposals in Round 1 more aggressive, but this is significant only in the later matches.

We also look at all proposals in the previous match in columns (3) and (4), with a particular focus on whether proposals were accepted in Round 1. The fact that a proposal was rejected in Round 1 of the previous match led proposers to make less aggressive proposals in the subsequent match. Interestingly, the tendency of higher shares in the previous match to lead to more aggressive proposals is significantly stronger for accepted proposals than for rejected proposals. In sum, participants’ learning from their past experiences made them behave more consistently with the theoretical predictions.
D Experimental Instructions - Treatment WM

INSTRUCTION

Welcome to the experiment. Please read these instructions carefully; the payment you will receive from this experiment depends on the decisions you make. The amount you earn will be paid through Venmo.

Your Payment Type and Match

At the beginning of the experiment, one-half of the participants will be randomly assigned to be Payment Type A, and the other half will be Payment Type B. Your payment type will remain fixed throughout the experiment. Your payment type will affect when you will be paid, which will be explained below.

The experiment consists of 10 matches. At the beginning of each match, one Type A participant and one Type B participant are randomly paired. The pair is fixed within the match. After each match, participants will be randomly repaired, and new pairs will be formed. You will not learn the identity of the participant you are paired with, nor will that participant learn your identity—even after the end of the experiment.

Your Decisions in Each Match

Round 1: At the beginning of Round 1, one participant will be randomly assigned to the role of a proposer and the other participant to the role of a responder. Each participant in a match has a 50-50 chance to be the proposer and to be the responder regardless of his/her payment type.

The proposer is then asked to propose how to split 500 tokens (= $50) between the two participants as:

“_______ tokens for yourself and _______ tokens for the other person.”

After observing the split proposed by the proposer, the responder decides whether to accept or reject the proposed split.

Outcome, Termination, and Transition to Next Round: The outcome of Round 1 depends on whether the split proposed by the proposer is accepted or rejected.

1. If the responder accepts the proposed split, both participants will receive the amount of tokens proposed, and the match will be terminated.

2. If the responder rejects the proposed split, then the match will proceed to the next round with a 75% (3/4) chance or was terminated with a 25% (1/4) chance. This is as if we were to roll a 100-sided die and continue if the resulting number is less than or equal to 75 and end if the number obtained is larger than 75.

(a) If a match is terminated after a rejection of a proposed split, both participants will receive 0 tokens for the match.
(b) If the match proceeds to the next round, then the proposer-responder roles are alternated. That is, the participant who is the proposer in the current round will become the responder in the next round, and vice versa. The number of tokens the participants receive will be determined by the outcome of the subsequent rounds.

**Round** $K > 1$: In Round $K > 1$, the participant who was the proposer in Round $(K - 1)$ becomes the responder, and the participant who was the responder in Round $(K - 1)$ becomes the proposer. The proposer is then asked to propose how to split 500 tokens (= $50) between the two participants. After observing the split proposed by the proposer, the responder decides whether to accept or reject the proposed split.

The rest of the procedures determining the outcome, termination of the round, and transition to the next round are the same as those in Round 1.

**Information Feedback**

- At the end of each **round**, you will be informed about the proposal made by the proposer and the accept/reject decision made by the responder.
- At the end of each **match**, you will be informed **when and how much** you are going to be paid.

**Your Monetary Payments**

At the end of the experiment, one match out of 10 will be randomly selected for your payment. Every match has an equal chance to be selected for your payment so that it is in your best interest to take each match seriously. Participants will receive the amounts of tokens according to the outcome from the selected match with the exchange rate of 1 token = $0.1.

**When** you are going to be paid depends on (1) your payment type and (2) the round in which the proposed split is accepted.

If you are **Type A**, you may be paid today or in a few **weeks**. If a proposed split is accepted in Round 1, you will be paid today right after the experiment. If a proposed split is accepted in Round 2, you will be paid in one week. If a proposed split is accepted in Round $K > 1$, you will be paid in $(K - 1)$ weeks.

If you are **Type B**, you may be paid today or in a few **months**. If a proposed split is accepted in Round 1, you will be today right after the experiment. If a proposed split is accepted in Round 2, you will be paid in one month. If a proposed split is accepted in Round $K > 1$, you will be paid in $(K - 1)$ months.

The following table summarizes the schedule of payment for each type:

- Any amount you are supposed to receive will be paid electronically via Venmo.

In addition to your earnings from the selected match, you will receive a **show-up fee of $10** through Venmo, right after the experiment.

**A Practice Match**
<table>
<thead>
<tr>
<th>If a proposed split is accepted in</th>
<th>Type A will be paid</th>
<th>Type B will be paid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round 1</td>
<td>Today</td>
<td>Today</td>
</tr>
<tr>
<td>Round 2</td>
<td>In 1 week</td>
<td>In 1 month</td>
</tr>
<tr>
<td>Round 3</td>
<td>In 2 weeks</td>
<td>In 2 months</td>
</tr>
<tr>
<td>Round 4</td>
<td>In 3 weeks</td>
<td>In 3 months</td>
</tr>
<tr>
<td>Round 5</td>
<td>In 4 weeks</td>
<td>In 4 months</td>
</tr>
<tr>
<td>......</td>
<td>......</td>
<td>......</td>
</tr>
<tr>
<td>Round K</td>
<td>In ((K - 1)) weeks</td>
<td>In ((K - 1)) months</td>
</tr>
</tbody>
</table>

Table 3: Schedule of Payment

To ensure your comprehension of the instructions, you will participate in a practice match. The practice match is part of the instructions and is not relevant to your cash payment; its objective is to get you familiar with the computer interface and the flow of the decisions in each round of a match. Once the practice match is over, the computer will tell you “The official matches begin now!”

**Rundown of the Study**

1. At the beginning of the experiment, your payment type will be randomly determined. Your payment type will remain fixed throughout the experiment.
2. At the beginning of each match, one Type A participant and one Type B participant are randomly paired.
3. At the beginning of Round 1, one participant will be randomly assigned to the role of a proposer and the other to the role of a responder.
4. The proposer then proposes how to split 500 tokens (= $50).
5. If the responder accepts the proposed split, both participants will receive the amounts of tokens as proposed, and the match will be terminated.
6. If the responder rejects the proposed split, then the match will proceed to the next round with 75% (3/4) chance or be terminated with 25% (1/4) chance. If a match is terminated after the rejection of a proposed split, both participants will receive 0 tokens for the match.
7. If the match proceeds to the next round, then the proposer-responder roles are alternated.
8. At the end of the experiment, one of 10 matches will be randomly selected for payment. For the selected match, the timing of your payment depends on (1) your payment type and (2) the round in which the proposed split was accepted. All your earnings will be paid to you through Venmo.
9. For Type A, you may be paid today or in a few weeks. For Type B, you may be paid today or in a few months.
10. In addition to your earnings from the selected match, you will receive a show-up fee of $10 right after the experiment.

**Administration**

Your decisions, as well as your monetary payment, will be kept confidential. Remember that you have to make your decisions entirely on your own; please do not discuss your decisions with any other participants. Upon finishing the experiment, you will be asked to sign your name to acknowledge your receipt of the payment. You are then free to leave. If you have any question, please raise your hand now. We will answer your question individually.
E Selected z-Tree Screen-shots

Figure 20: Proposer’s Screen

Figure 21: Responder’s Screen