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Abstract

We present new evidence from the lab on the outcomes resulting from collective and individual decisions over time. We combined static and longitudinal methods to test four conditions on individual and collective time preferences: impatience, stationarity, age independence, and dynamic consistency. The collective decision process was designed to favor coordination through initial communication over voting intentions. Our main results are the following. First, individuals were impatient and deviated from consistent behavior. On the other hand, groups made patient and highly consistent decisions. Our voting mechanism helped the groups to converge and make stable and dynamically consistent decisions.

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1 Introduction

1.1 Overview

Economic models usually assume that individuals and organizations are rational in their choices over time. Efficient decisions require that two central conditions on time preferences be satisfied: stationarity and dynamic consistency (Strotz, 1956; Bleichrodt et al., 2009). These conditions are necessary for consistent choices of an individual decision-maker as well as for a group of individuals coordinating on a joint intertemporal decision (Jackson and Yariv, 2012) or a policy maker (Caplin and Leahy, 2004). Households, boards, committees, teams of workers, are typical examples of groups that need to deliberate and coordinate their actions on important decisions with a time dimension. Examples of these types of decisions include retirement and saving decisions, education and health care, public good provision, investment decisions, effort provision, and reputation building.

Behavioral research on group decision-making has shown that groups are more likely to make rational choices, while individuals are more likely to act according to bounded rationality (Kagel and Cooper, 2005; Charness and Sutter, 2012; Maciejovsky et al., 2013). Therefore, it is expected that group intertemporal decisions should be more consistent and thus more efficient. For example, Charness and Sutter (2012) suggest that an individual subject to dynamic inconsistency in saving for retirement could achieve a better retirement outcome by participating in a group of decision-maker. Participation in a group results in a better intertemporal decision whose benefits might compensate the costs involved in delegating part of the decision.

The aforementioned view is still scarce. Nevertheless, there is a striking difference between this empirical scarcity and the numerous theoretical papers devoted to group decision-making and the aggregation of time preferences. The aggregation of time preferences predicts that there is little chance that a collective decision process will result in consistent choice over time, even if group members are individually consistent (Gollier and Zeckhauser, 2005; Jackson and Yariv, 2010). Empirical evidence on the aggregation of time preferences supports this view. For instance, Jackson and Yariv (2012) show that a large majority of subjects acting as social planners are present-biased and that only two percent of them exhibit consistent behavior.

In this paper, we present new lab evidence on the outcome resulting from collective and individual decisions over time. We combined static and longitudinal experimental methods to address the issue of stationarity and consistency of time preferences. Specifically, we tested four conditions on time preferences: impatience, stationarity, age independence, and dynamic consistency. For collective decisions, we designed a coordination mechanism based on majority voting preceded by a deliberation phase among the participants.

Our main results are as follows. In line with the existing literature on intertemporal choice, individuals were impatient and tended to deviate from consistent behavior. On the other hand, groups made patient and highly consistent decisions. Regarding the group decision process, we observed that our voting mechanism helped the groups to converge and make both stable and dynamically consistent decisions.

1.2 Literature Review

Two different and complementary streams exist in the literature on choice over time. First, there is a theoretical and normatively oriented literature on time preferences. Second, there is an empirical literature, mainly based on experimental findings. Following Samuelson (1937) and Fishburn and Rubinstein (1982), a large part of the theoretical literature on time preferences builds on discounted utility and additively separable functional forms that assume a separation between value and delay in evaluating temporal sequences of outcomes. A typical example is the exponential discounting utility model. The exponential discounting utility model assumes stationarity of time preferences and serves as the workhorse of many economic models. The representation of time preferences by the Discounted Utility model also has an advantage for empirical measurements. With an extra assumption on the linearity of utility, measures of discount factors and discount rates can be carried out through simple experimental methods (Thaler, 1981; Coller and Williams, 1999). Assuming nonlinear utility leads to more sophisticated but also more complex measurements (Andreoni and Sprenger, 2012; Abdellaoui et al., 2013). A possible difficulty of all the aforementioned measures is that they share the potential descriptive limitations of the discounted utility model. For instance, Rohde (2010) and Halevy (2012) show that several basic properties of time preferences can empirically be inferred from direct conditions on preferences without requiring a commitment to a specific functional representation of preferences. These basic properties include conditions on stationarity, dynamic consistency, and age independence. Our experiment follows that route and focuses on the basic conditions of choice over time without assuming any functional form.

Essentially, what emerges from the empirical literature on time preference is a great deal of heterogeneity among the elicited discount rates. Frederick et al. (2002) report elicited discount rates ranging from less than one percent (Thaler, 1981) to more than 1,000 percent (Holcomb and Nelson, 1992). Moreover, individuals often violate stationarity (Benzion et al., 1989; Bleichrodt and Johannesson, 2001; Kirby and Marakovic, 1995; Dellavigna, 2009), the key axiom underlying the standard constant discount rate hypothesis in the discounted utility model. Stationarity means that a decision made at one point in time does not change when the receipt periods are changed by the same delay. Stationarity should be distinguished from dynamic consistency. Dynamic consistency means that a decision for the future made at one point in time stays the same at another point in time. Consequently, a longitudinal experimental design is needed to test dynamic consistency. This requirement explains the relative scarcity of experimental studies devoted to dynamic consistency. Among the few existing experimental studies on dynamic consistency evidence is mixed. Gine et al. (2011) found 65 percent of the participants to be dynamically inconsistent in a framework were past choices where transparent. On the other hand, Sayman and Oncüler (2009) observed no evidence in favor of time inconsistency for short delays. Halevy (2012) reported that 48 percent of the subject were time-consistent.

Evidence on group choice over time suggests that groups are more patient than their individual members. For example, individuals are more patient when taking a joint decision with a partner than when taking a decision for themselves. This holds whenever the group consists of a couple of decision-makers (Abdellaoui et al., 2013; Carlsson et al., 2012) or an artificial experimental couple (Shapiro, 2010). Abdellaoui et al. (2013) and Carlsson et al. (2012) also found that couple decisions violate stationarity. For larger groups, collective patience has been found with groups of three to seven people (Shapiro, 2010; Denant-Boemont and Loheac, 2011).[1] Denant-Boemont and Loheac (2011) also found that unanimity generates more patience in collective choices than does majority voting. This points out that decision processes potentially condition the issue of collective decisions over time. The simplest decision rule, unanimity, is frequently used in experiments as a voting mechanism for collective choice. However, as shown by Gerardi and Yariv (2007), unanimity voting restrains the domain of possible outcomes that could be implemented compared to other intermediate voting rules, such as the simple majority voting rule. By eliminating some possible outcomes, the use of unanimity voting also restrains the domain of collective time preferences.

The pitfall of majority voting is that it may produce multiple voting equilibrium. For instance, anything that plays a focal role is known to help voters selecting a particular equilibrium. Goeree and Yariv (2011) built an experiment where collective deliberation could impact collective choice under various voting mechanisms. They observed that a free form deliberation made the issue of messages more important than that of voting. On the other hand, the absence of deliberation tended to make voters more strategic, making the issue of voting more contingent to institutional rules. These results suggest that a collective decision process organized under majority voting with initial communication over voting intentions may help participants to coordinate more effectively on a collective choice.

The structure of the paper is as follows. Section 2 presents the setting of the experiment and provides a theoretical background on time preferences. Section 3 focuses on collective decisions. Section 4 summarizes the experimental results.

[1] We are not aware of any experimental study to date that has evaluated stationarity and dynamic consistency in collective decisions.

Section 5 concludes.

2 Intertemporal Choice

The purpose of the experiment was to compare the results achieved by outcomes resulting from collective and individual decisions over time. In a protocol similar to the one used by Halevy (2012), we combined six indifference tasks to test four conditions on time preferences: impatience, stationarity, age independence, and dynamic consistency. We recruited 60 subjects from University of Rennes, France, and asked them to state their preferences between different pairs of timed outcomes in three regularly-spaced experimental sessions. Each pair of timed outcomes proposed a choice between a smaller-sooner option and a larger-later one. Half of the decisions were individual decisions and half of the decisions were collective decisions.

2.1 Experimental Tasks

We consider a decision-maker, either an individual or a group, who has to make a choice between timed outcomes. A timed outcome (t, x) results in the receipt of a positive monetary outcome $x \in X$ at date $t \in T$, where X represents the set of consequences and T the set of future dates. The purpose of the experimental tasks was to elicit indifference values between a smaller-sooner time outcome and a larger-later one. Indifference values were elicited through a series of choice questions in order to determine the sooner outcome (s, x) for which a subject was indifferent with a later outcome (ℓ, y). This procedure is known to yield more reliable indifference values than procedures that directly ask for values (Bostic et al., 1990, Noussair et al., 2004). In our design, a given indifference could have been elicited either by value equivalence (i.e., varying the sooner or the later outcome) or by delay equivalence (i.e., varying the delay associated with the sooner or the later outcome).

Following the literature (see Takeuchi, 2011 for a review), we elicited all indifferences by the value equivalence of the sooner outcome. Outcome y was kept constant during elicitation and across sessions, and was equal to €100 in individual decisions and €500 in collective decisions. For each pair of timed outcomes, subjects were faced with a choice between a series of timed outcomes, option A and option B. Option A always referred to the later outcome and option B always referred to the sooner one. Once a subject had switched between option A and option B, he/she was asked to express indifference between the two options. To that purpose, a scrollbar was displayed on the screen (see Appendix C), allowing the subject to specify the indifference point up to €1 precision level in individual decisions and €5 precision level in collective decisions. The elicitation process was repeated for each elicited indifference. Table 1, discussed in details later, shows the six indifferences elicited at the level of individual and of collective decisions across the three experimental sessions. Indifferences elicited for five-member groups were similar, except for the later outcome 100 that was multiplied by a factor 5. To control for order effects between individual and collective tasks, two-thirds of the sessions were implemented with an individual+group sequence, whereas the remaining one-third of sessions were implemented using the reverse order.

Session 1 (t)	Session 2 ($t+\Delta$)	Session 3 ($t+2\Delta$)
$(s, x_1^1) \sim_t (\ell, y)$	$(s+\Delta, x_2^1) \sim_{t+\Delta} (\ell+\Delta, y)$	$(s+2\Delta, x_3^1) \sim_{t+2\Delta} (\ell+2\Delta, y)$
$(s+\Delta, x_1^2) \sim_t (\ell+\Delta, y)$	$(s+2\Delta, x_2^2) \sim_{t+\Delta} (\ell+2\Delta, y)$	
$(s, x_1^3) \sim_t (\ell+\Delta, y)$		

Table 1: Elicited indifferences in each session, decision time in parenthesis. Each indifference is elicited by varying the sooner outcome until it reaches the indifference value. $y = 100$, $\Delta = \ell = 4$ weeks, $s =$ day of the first session. Payments were performed with a one-day delay.

Each subject was paid 20 euros for his/her participation in three experimental sessions. The show-up fee was paid at the end of the last session to ensure that participants would show up for all three sessions. In addition, we implemented a between-subject random-task incentive scheme by following a Becker-De Groot-Marshak (BDM) procedure. Before starting the experiment, subjects were informed that they might be selected to play one of their choices for real and could win a maximum of 100 euros per session depending on their choices. Thus, each subject could win a total amount of 300 euros over the three experimental sessions.[2] The probability of being selected in each session was i.i.d. and equal to one fifth. Selected subjects played their choice for real at the end of each experimental session. We used a front-end delay to minimize the possibility of perceived differences between the two payoff options with respect to (i) transactions costs and (ii) risk associated with future payments. The one day front-end delay was also compatible with the payment scheme. One difficulty for experiments based on a trade-off between immediate and future rewards is that subjects might not trust the experimenter with the timely provision of future rewards. To establish trustworthiness in the experiment and to ease their potential fear of manipulation, all future payments were warranted by the French Public Treasury. Each payment was transferred to the subject's bank account by the French Public Treasury.

2.2 Time Preferences

We assume that the decision-maker has preferences over the set of timed outcomes $X \times T$. Following Halevy (2012), we embed the decision-maker with a sequence $[\succsim_t]_{t=0}^{\infty}$ of complete and transitive binary relations defined over timed outcomes. We assume that preferences satisfy the usual continuity and monotonicity assumptions. We use conventional notation to express the preference of the decision-maker, letting $\succ_t$, $\succsim_t$, and $\sim_t$ represent the relations of strict preference, weak preference, and indifference between the sequences of timed outcomes at decision time t. Four conditions concerning time preferences are investigated in this paper: impatience, stationarity, age independence and dynamic consistency. Definitions follow.

Definition 1 *$\succsim_t$ exhibits impatience if for $x \leq y$ and every $t < s < \ell$,*

[2] We could not completely rule out wealth effects. For the individuals who get paid for real at $\ell + \Delta$, previous gains might have impacted behavior in Session 3. Since only three subjects satisfied this condition, we assume that wealth effects did not impact strongly our results.

$$(s, y) \succ_t (t, x).$$

Impatience is defined as the indifference at date t between a small outcome x received soon (at date s) and a larger outcome y received later (at date ℓ). Throughout the paper, s refers to the most immediate reward and ℓ to the most delayed reward, i.e when $s \leq \ell$. The experiment manipulates delay ℓ to measure the decision-maker's impatience.

Definition 2 *$\succsim_t$ is stationary if for x, y and every s, ℓ, Δ:*

$$(s, x) \sim_t (\ell, y) \iff (s + \Delta, x) \sim_t (\ell + \Delta, y).$$

Stationarity means that a decision made at date t does not change when the receipt periods are changed by a same delay. When stationarity holds the choice between two timed outcomes depends only on the time distance $\ell - s$ between them. Stationarity reflects constant impatience. It has been extensively investigated in the experimental literature (Frederick et al., 2002). Decreasing impatience is the prevailing individual violation of stationarity exhibited in this setting.

Violations of stationarity are not compatible with an exponential discount function and can be represented by a wide range of alternative discount functions. Hyperbolic discount functions are the most widely-used discount functions (Phelps and Pollack, 1968; Loewenstein and Prelec, 1992), but violations of stationarity can also be accommodated by more flexible non-hyperbolic discount functions (Bleichrodt et al., 2009).

The experimental literature on time preference often assumes linear utility. Under the discounted linear utility model, the value associated at date t with a timed outcome (ℓ, y) is given by the additively separable functional $V_t = \delta_t(\ell) \times y$, where $\delta_t(\ell)$ is the discount factor for delay ℓ evaluated at date t. The advantage of the linear utility model is that it allows for a direct measure of the discount factor through one indifference $\{x, 0\} \sim_t (\ell, y)$: $\delta_t(\ell) = x/y$.

For the left two columns in Table 1, a comparison of the first two lines provides a direct test of the stationarity condition stated by Definition 2 without assuming the discounted utility model. If preferences are stationary then one should observe $x_1^1 = x_1^2$ in column 1 and $x_2^1 = x_2^2$ in column 2. The farther from one the ratio x_j^2/x_j^1, $(j = 1, 2)$ is, the stronger the violations of stationarity.

Definition 3 $[\succsim_t]_{t=0}^{\infty}$ *satisfies age independence if for x, y and every s, ℓ, Δ:*

$$(s, x) \sim_t (\ell, y) \iff (s + \Delta, x) \sim_{t+\Delta} (\ell + \Delta, y).$$

Age independence means that a decision made a date t remains the same at date $t + \Delta$ if all receipts are delayed by the same amount of time. According to this condition, preferences are independent of calendar time. The experimental test of age independence manipulates the choice node by moving the choice date from t to $t + \Delta$ and the front-end delay from s to $s + \Delta$. In Table 1, for each line, between-column comparisons provides a direct test of the age-independence condition stated by Definition 3. If preferences satisfy age independence then one should observe $x_1^1 = x_2^1 = x_3^1$ in line 1 and $x_1^2 = x_2^2$ in line 2. The larger the absolute differences between the x's, the stronger the violations of age independence.

The last definition concerns dynamic consistency:

Definition 4 $[\succsim_t]_{t=0}^{\infty}$ *satisfies dynamic consistency if for x, y and every $t+\Delta < s, \ell$:*

$$(s, x) \sim_t (\ell, y) \iff (s, x) \sim_{t+\Delta} (\ell, y).$$

Dynamic consistency means that a decision made at date t for future timed outcomes remains the same for a given pair of timed outcomes when decision is taken at date $t + \Delta$. The experiment moves the choice date from t to $t + \Delta$ and keeps the delay s constant. Sayman and Oncüler (2009) and Read et al. (2012) have a similar design but use a different wording.[3] Both define dynamic consistency as longitudinal time consistency. In Table 1 within-diagonal comparisons for the first two lines provide a

[3]They call cross-sectional time consistency for stationarity.

direct test of dynamic consistency. If preferences satisfy dynamic consistency, then one should observe $x_1^2 = x_2^1$ and $x_2^2 = x_3^1$. The farther from one ratios x_1^2/x_2^1 and x_2^2/x_3^1 are, the stronger the violations of dynamic consistency.

Definitions are not independent from one another. Each pair of conditions implies the third. For example, stationarity and age independence imply dynamic consistency (Strotz, 1956). It follows that stationarity and dynamic consistency are equivalent if, and only if, age independence is satisfied. Definitions 2, 3 and 4 also show that time consistency and age independence together imply stationarity. Consequently, violations of dynamic consistency yield violations of stationarity, assuming that age independence is satisfied. If age independence is not satisfied, then violations of dynamic consistency do not necessary yield violations of stationarity. For example, age independence is violated if a person prefer one apple on his 21st birthday to two apples the day after, but in all other situations prefer two apples a day later. In such a case, the decision-maker exhibits dynamic consistency but not stationary.

2.3 Method

The indifference values elicited in both individual and collective tasks were designed to test the four conditions on time preferences defined above. The first information provided by a given elicited outcome is the amount of revealed impatience. According to Definition 1, if the elicited outcome (the sooner value) was strictly lower (equal) than the later outcome, then the decision-maker was classified as impatient (patient). The ratio between the elicited outcome and the later outcome provides a simple index of impatience. The lower the ratios, the higher the impatience for a given decision.

Definition 2 shows that the difference between $x_j^2 - x_j^1$, $j = 1, 2$ provides a test for violations of stationarity. A simple index of violations of stationarity can be constructed with the ratio x_j^2/x_j^1. The larger the deviations from one, the higher the violations of stationarity. The index can be computed either at date t (when $j = 1$) or at date $t + \Delta$ (when $j = 2$). Violations of age independence (Definition

3) are revealed by an index based on the ratio x_2^i/x_1^i, $i = 1, 2$. This index can be computed from date t (when $i = 1$) or from date $t + \Delta$ (when $i = 2$). A comparison between x_3^1 and x_2^1 provides an additional index of age independence. Violations of dynamic consistency (Definition 4) can be measured in a similar fashion, with an index based on the ratio between x_j^2 and x_{j+1}^1, $j = 1, 2$. Values larger (smaller) than one show standard (reverse) dynamic inconsistency.

In the results section, we test violations of stationarity, age independence and dynamic consistency using a conservative approach based on two-sided Student tests. The approach is conservative because it treats any deviation as symmetric. For example, both standard dynamic inconsistency and reverse dynamic inconsistency are treated as symmetric deviations from dynamic consistency. We check for robustness with Wilcoxon signed-rank tests.

The experimental tasks also allowed us to measure discount rates, but at an extra cost. The extra cost was to assume the linear discounted utility model. Under this assumption, any indifference $(s, x) \sim_t (\ell, y)$ yields the following equality: $\delta_t(\ell) = \delta_t(s)\frac{x}{y}$. Using two indifferences with different delay ℓ, the ratio between $\delta_t(\ell)$'s provides an index of the shape of impatience. According to the value of the ratio, the decision-maker reveals decreasing (constant, increasing) impatience.

3 Decision Processes

3.1 Group Decisions

In a given set of sessions, each subject participated in both individual and group decision making. For group decisions, participants were aware from the beginning that any group decision would be reached by a majority rule and lead to an equal sharing rule. Each subject was randomly matched with four other subjects at the beginning of the first session. Each group remained the same during the entire experiment, i.e. during the three successive sessions.[4] Before reaching a collective decision, group members were allowed to exchange information on their preferences.

[4]Such a design is usually referred to as a partner matching.

The procedure took the form of a sequence of four successive straw polls. At each step, each subject declared to the other members of the group his/her opinion on an indifference value x such that $(s, x) \sim_t (\ell, y)$. This indifference value corresponds to collective outcomes x and y to be equally shared among group members. At each step of the sequence, each subject was informed of all indifference values, resulting in a straw poll. Group members thus had four opportunities to indicate their favorite option. The information each subject received at the end of each sequence is displayed in Figure 1. The identity of each group's member was referred to by a color (brown, blue, purple, grey and beige). The colors remained the same for a given collective choice, but changed randomly from one vote process to the next. Random change was implemented to ensure anonymity and avoid any reputation effect.

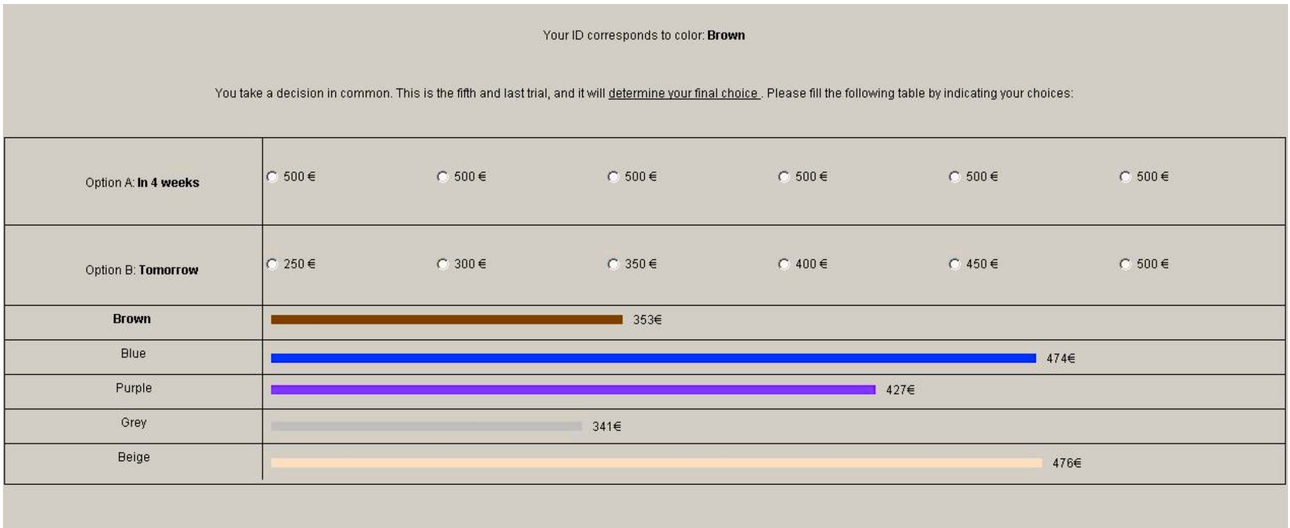

Figure 1: Information given about other member preferences during the group decision process.

In the last step of the collective decision process, subjects had to choose collectively. At that point, subjects had to reach an agreement by majority voting. Under majority rule, at the end of the fifth sequence, the indifference amounts for the most immediate reward were ranked from the lowest to the highest, and the median value was applied for the entire group, i.e., the option preferred by the majority of the group members was chosen for the entire group.

3.2 Coordination and Majority Voting

In our experiment, we adopted majority voting as a procedure for establishing a collective intertemporal choice. In our context, such a procedure corresponds to a coordination game among participants and theoretically leads to multiple equilibria. To help participants coordinating their choices on a unique equilibrium and avoiding dominated equilibria, we provided them with repeated public information over others' preferences by organizing successive straw polls before the actual collective choice.

Black's (1948) median voter theorem does not directly hold in our majority game for at least two reasons. First, more than two candidates exist in our majority voting game. Second, we could not rule out the possibility of strategic voting.[5] Applied to collective time preferences, majority voting on the most immediate reward x equivalent to a given delayed reward y results in multiple equilibria as long as the group is made up of more than three voters. Multiple equilibria also arise when agents have incomplete information about some of the characteristics of the structure of the game (Myerson and Weber, 1993). It follows that anything can happen in equilibrium for such multi-candidate elections (Palfrey, 2009). [6]

A simple way to facilitate coordination between voters on a given equilibrium is to provide them with public information. Forsythe et al. (1993) show that pre-vote communication helps groups to avoid selecting a Condorcet loser option as an equilibrium outcome. We followed that route and took the straw poll on indifference values x as public information. We then used replay communication

[5] As shown by Plott (1967), a multiplicity of equilibria arise in the majority voting game (see, e.g., Besley and Coate, 1997; Dhillon and Lockwood, 2004). For instance, if all other voters but one vote for a given candidate, it is a best response for any voter to also vote for that candidate.

[6] This result raises the theoretical issue of using game refinements in order to solve potential multiplicity in equilibrium voting strategies, e.g., iterated elimination of weakly dominated strategies (Farquharson, 1969; Besley and Coate, 1997) or trembling-hand perfect equilibria (Messner and Polborn, 2007; Acemoglu et al., 2009).

as a coordinating device for collective time preferences. However, the presence of a sequence of straw polls does not eliminate per se multiple equilibria. If players vote strategically, any option that is not a Condorcet loser might still be selected as an equilibrium. A consequence is that some voters would be more likely to vote for a candidate which is not their favorite candidate and a bandwagon effect can appear.

In the experiment, each collective decision corresponded to an elicited indifference given in Table 1. The stability of the vote mechanism over the three sessions makes it very likely that the selected equilibrium will be identical. As a consequence, age independence should hold whatever the predictions associated with the vote. On the contrary, votes on elicited values x_j^1 and x_j^2, $j = 1, 2$ are no longer similar. Accordingly, there is no reason to believe that the selected equilibrium will be identical. Nothing here predicts that stationarity should be satisfied. As shown in Section 2, a direct consequence of this is that dynamic consistency is not a predictable outcome of the votes.

3.3 Analyses of Decision Processes

Three different methods can be used to analyze decision processes in collective choice. The first method evaluates straw polls as a coordinating device on a given equilibrium. This measure compares the final vote to the last message sent to the other group members and corresponds to the measure used by Forsythe et al. (1993) to test Myerson and Weber's (1993) voting equilibria.

The second method compares the final decisions reached by the group to the individual preferences. This method helps in understanding any cost of deviating from individual preferences. We also simulate the decision a benevolent planner aggregating individual indifferences would have taken for each collective decision.

Last, we classify individuals according to their voting behavior. Following Forsythe et al. (1993), we distinguish sincere voting from insincere voting. Sincere voting corresponds to a vote according to individual preferences. We also distinguish dominated voting from undominated voting. Dominated voting occurs when a voter casts a vote that could never change the collective decision in a way that the voter would prefer.

4 Results

4.1 Time Preferences

Impatience

Elicited indifference values provided a simple way to characterize behavior for both individuals and groups. 42.3 percent of individual decisions were patient. The proportion rose to 80.6 percent for groups. Group decisions were more patient than the equivalent individual decisions (binomial test, $p < 0.01$). In order to investigate the pattern of discounting behaviors more thoroughly, we classified individual and groups based on their answers. A decision-maker was classified as impatient (patient) if at least four out of six indifference values produced an impatient (patient) answer. If a decision-maker was classified neither as impatient nor patient, she/it was classified as mixed. The classification is presented in Table 2 and shows a picture similar to the one derived from individual decisions. A majority of individual decision-makers were impatient, while a significant minority (30.4 percent) were patient. On the other hand, a large majority (83.4 percent) of the groups were classified as patient: collective behavior based on majority voting did not mirror individual behavior.

	Impatient	Patient	Mixed
Individuals	55.4 %	30.4 %	14.2 %
Groups	8.3 %	83.4 %	8.3 %

Table 2: Classification of individuals and groups

Stationarity and Age Independence

Stationarity predicts the equality of the elicited values in the upper two rows in Table 1. Age Independence predicts the equality of the elicited values within rows. Table 3 shows the values of the index of violation of stationarity and age independence for both individuals and groups and their significance levels. The higher degree of patience for groups is associated with the absence of violation of stationarity and age independence. The vast majority of groups replicated the same patient decision in all of the decisions and acted as zero discounting maximizers. For individual decisions the picture was different. Individuals had a behavior that was incompatible with stationarity and age independence for half of the measures. In this respect, the minority of subjects with patient choices coexisted with a majority of impatient subjects violating both stationarity and age independence.[7]

	Stationarity		Age Independence		
measured	at t	at $t+\Delta$	from t (1)	from t (2)	from $t+\Delta$
Individuals	1.013	1.026**	1.033	0.990	1.045**
Groups	0.996	1.006	0.989	0.997	0.999

Table 3: Violations of stationarity and age independence for individuals and groups.
N.B.: (i) Average values of indexes (no violation corresponds to a value equals to one) and (ii) **: significant at 1 %.

Dynamic Consistency

Dynamic consistency predicts the equality of the elicited values only when the time of the decision changes. Table 4 presents the results for the index of dynamic consistency. We found violations of dynamic consistency in individual decisions but not in collective decisions. For groups, the results were compatible with the results

[7] Appendix A shows the distribution of the indexes of stationarity, age independence and dynamic consistency.

on stationarity and age independence, as the two conditions together imply dynamic consistency. In both cases, groups were highly time-consistent. For individuals, a comparison of Table 3 and Table 4 shows that both violations of stationarity and age independence also predicted violations of dynamic consistency. The difference between individual and group behavior became more evident when we applied the less conservative approach: individual violations of dynamic consistency became significant at 1 % whereas collective violations remained non-significant (one-tailed t-test).

	Dynamic Consistency	
measured	at $t+\Delta$	at $t+2\Delta$
Individuals	1.020	0.967^{**}
Groups	0.993	0.991

Table 4: Violations of dynamic consistency for individuals and groups.
N.B.: (i) Average values of indexes (no violation corresponds to a value equals to one) and (ii) **: significant at 1 percent.

4.2 Discount Factors

The comparison of discount factors for indifference values elicited at the same date for a delayed outcome with delays $\Delta = 4$ weeks and $2\Delta = 8$ weeks provides information on the shape of impatience in our experiment. If the discount factor for a 8-week delay was proportionally higher than (equal to, lower than) the elicited discount factor for a 4-week delay, then the decision-maker showed decreasing (constant, increasing) impatience. Decreasing impatience is the usual finding in the experimental literature. Table 5 shows a classification of individuals and groups based on these three possible shapes of impatience.[8]

[8] In the classification, a patient decision-maker is characterized by constant impatience. Assuming linear utility, a patient decision-maker revealed a monthly discount rate lower than 1.21 percent, which corresponds to a large higher bound for market interest rates.

	Increasing Impatience	Constant Impatience	Decreasing Impatience
Individuals	15.0 percent	26.67 percent	58.33 percent
Groups	8.3 percent	91.7 percent	0 percent

Table 5: Classification of individuals and groups in terms of shape of impatience

Decreasing impatience was dominant for individual decisions. We also observed a proportion of choices characterized by increasing impatience. Constant impatience was, on the contrary, dominant for collective decisions.

4.3 Decision Processes

Efficiency of Straw Polls

The efficiency of straw polls in achieving coordination was assessed by comparing the final vote with the last message sent to the other group members. Overall, efficiency was high. 87.5 percent of the final votes were strictly identical to the intentions declared in the last straw poll. Efficiency decreased between experimental sessions from 92.8 percent in session 1 to 81.9 percent in session 2 and 82.1 percent in session 3. In any case, we found no differences between the values cast as final votes and the intentions declared in the last straw poll (all $p > 0.22$, t-tests). Figure 2 shows the relation between values casted in the last straw poll and the final votes: only a minority of votes were above (7.7 percent) or below (4.8 percent) the value cast in the last straw poll.

Distance to Individual Preferences

In order to compare collective decisions and individual preferences, we first evaluated the distance between the outcome of collective decisions and the elicited individual values. Overall, 35.8 percent of the final decisions were identical to the individual decisions. This percentage was stable across sessions. It suggests that reaching a collective decision in choice over time can have a non-negligeable cost

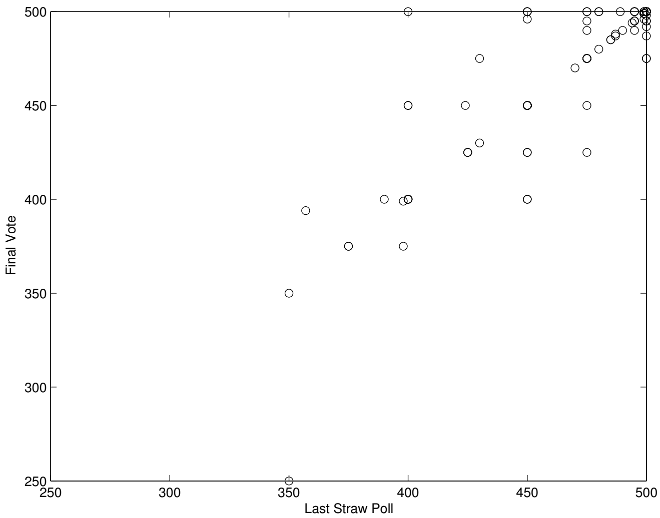

Figure 2: Efficiency in coordination: cast values x in last straw poll and final votes

when compared to individual preferences. Among the final decisions, 97 percent corresponded to patient choices. Despite this fact, votes differed from individual values (all $p < 0.01$). For most choices (54 percent), the collective decision imposed a more patient decision than the corresponding individual decision. For a minority of choices (8 percent), the collective decision imposed a more impatient decision on the individual than his/her corresponding individually preferred decision. Using the classification of individuals from Table 2, 78 percent of patient individuals obtained more than 4 out of 6 final decisions in line with their individual preferences. This percentage was zero for impatient individuals.

A second way to measure the distance to individual preferences is to simulate the equivalent values a benevolent planner would select for each decision. The simulation assumes that the planner can perfectly observe the elicited values at the individual level and aggregate them at the group level.[9] The results are shown in Table 6. We found that the planner would implement a decision incompatible with stationarity and age independence on half of the measures. Dynamic consistency

[9]In sessions 2 and 3 two subjects did not show up. Moreover, in session 3, two other subjects didn't show up. These missing data prevented us from simulating an utilitarian criterion for three of the groups. Consequently, results from the simulation are only given for 9 groups out of 12.

was also violated by simulated choices of this type. All three violations became highly significant when we applied the less conservative approach based on absolute deviations. These results replicate Jackson and Yariv's (2012) findings that experimental social planners do not make consistent choices. The results were highly consistent with individual results and showed that collective decisions were different from a decision based on a criterion summing up indifferences. Moreover, these results showed that the composition of each group did not affect the extent of the violations of stationarity, age independence and dynamic consistency.

	Stationarity		Age Independence			Dynamic Consistency	
measured	at t	at $t+\Delta$	from t (1)	from t (2)	from $t+\Delta$	at $t+\Delta$	at $t+2\Delta$
Planner	1.010	1.028*	1.017	0.987	1.035*	1.008	0.961*

Table 6: Violations of stationarity, age independence and dynamic consistency: utilitarian planner.

NB: (i) Average values of indexes (no violation corresponds to a value equals to one) and (ii) *: significant at 5 %.

Voting Behavior

In order to better understand the voting behavior at the individual level, we used a classification of votes separating first, sincere, and insincere voting and second, dominated, and undominated voting. Most votes were associated with undominated strategies: dominated votes accounted for only 17 percent of total votes. Among them only 2.5 percent were sincere. The undominated votes were both sincere (43.5 percent) and insincere (39.5 percent).[10] In order to investigate the pattern of voting behaviors more thoroughly, we classified individuals based on their answers. An individual was classified as sincere (insincere) if at least four out of six votes were sincere (insincere). An individual was classified as dominated (undominated) if at

[10]Most of the patient votes were undominated patient votes and account for 39.6 percent out of the 43.5 percent of undominated sincere votes.

least four out of six votes were dominated (undominated). Otherwise, the individual was classified as mixed. Table 7 shows the results of the classification. Results are consistent with Forsythe et al. (1993): dominated behavior was rare and most decisions were undominated.

	Dominated	Undominated	Mixed	Total
Sincere	0	20	0	20
Unsincere	4	25	1	30
Mixed	1	5	4	10
Total	5	50	5	60

Table 7: Classification of individuals according to their voting behavior

Finally, we consider the dynamic effects of the straw poll coordination on voting behavior. To test this, we identified subjects who were median voters after the first straw poll. Without the observed voting dynamics, these subjects should have obtained a collective decision in line with the values they cast. 85.6 percent of the subjects who were median voters in the first straw poll stuck to the value they cast in the final vote. Among these subjects, 62 percent were patient. The fact that patient choices made coordination easier was not only valid for groups where at least three subjects agreed upon the highest value from the beginning. The conditional probability of getting a patient collective choice if exactly two subjects had agreed upon a patient value on the first message was high and equal to 0.36.[11] This provides additional evidence that the values cast by other influenced votes towards more patience and consistency in collective time preferences.

[11] In comparison, the conditional probability of getting a patient collective choice if strictly more than two subjects agreed upon a patient value on the first messages was 0.74.

5 Discussion and conclusions

This paper presents a laboratory experiment on collective time preferences based on the elicitation of indifference values. We are the first to study four properties of time preferences- impatience, stationarity, age independence, and dynamic consistency- for individuals and groups. In addition, we designed a collective mechanism that helped groups to achieve a decision. We found that (i) individuals were impatient and tended to deviate from rational behavior, (ii) groups took patient and highly consistent decisions, and (iii) the decision process made subjects converge to dynamically consistent decisions, which satisfied both stationarity and age independence. The patient decisions taken by groups also show that the discount factors for groups are more in line with market interest rates than the discount factor for individuals.

The results could be in part explained by a selection bias. In our experiment, as in any experiment involving longitudinal measures, subjects were supposed to commit to three sessions over a time span of eight weeks. Here, a specificity of our subjects is probably their abilities to commit and schedule (Frederick, 2005; Perez-Arce, 2011; Dohmen et al., 2010). The proportion of dynamically consistent individual choices we found are no higher that found in the literature though.[12] Moreover, we were mainly interested in comparisons. It is plausible that the selection bias impacted all decision to a similar extent, thus we have no big effect on our comparisons. Finally, nearly all individuals moved toward a patient vote regardless of the composition of their groups and regardless of their own preferences.

The experimental design we implemented could also have influenced the main results. One usual drawback in the experiments that elicit time preferences is the possible uncertainty of future payoffs (Halevy, 2012; Augenblick et al., 2013). Having uncertain prospects could raise the impatience levels for subjects as they have the potential of adding a risk premium component to pure time preference (Halevy, 2008;

[12]Gine et al.(2011) found that 50 percent of the choices satisfied stationary and 35 percent of choices satisfying dynamic consistency. Sayman and Oncüler (2009), study 1, observed no evidence in favor of time inconsistency: 58 percent of the choices were dynamically consistent. Halevy (2012) reported 48 percent of time-consistent subjects and 56 percent of subjects satisfying stationary preferences.

Epper et al., 2011; Baucells and Heukamp, 2012; Epper and Fehr-Duda, 2012). We controlled for a possible uncertainty effect by using both high monetary payoffs and a guarantee of the future payments through bank transfers by the French Public Treasury. We are aware that these two controls could have induced more patient behavior, but the benefits of using this incentive structure seemed to us to be more important than this cost.

Finally, our coordinating device allowed groups to quickly converge towards a given decision. In this respect, our results have implications of the way boards and committees can achieve consistent decisions. Of course, the consequences of our device is that we observe deviations from individual preferences. Almost all deviations were towards more patience. This suggests the possible individual economic costs of the mechanism we used. It also suggests that collective decisions over time are subject to a bandwagon effect (Myerson and Weber, 1993). It is remarkable that, from an economic efficiency point of view, the most frequent collective decisions produced a consistent sequence of preference relations over time.

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Appendix A Indexes

This Appendix shows the distribution of the indexes of violation of stationarity (Figure 3), age independence (Figure 4) and dynamic consistency (Figure 5). Each Figure shows the distribution of the indexes for individuals (left panel) and groups (right panel). In each case, no violation corresponds to a unitary value. For the sake of comparison, the x-axis are identical on the left and right panels.

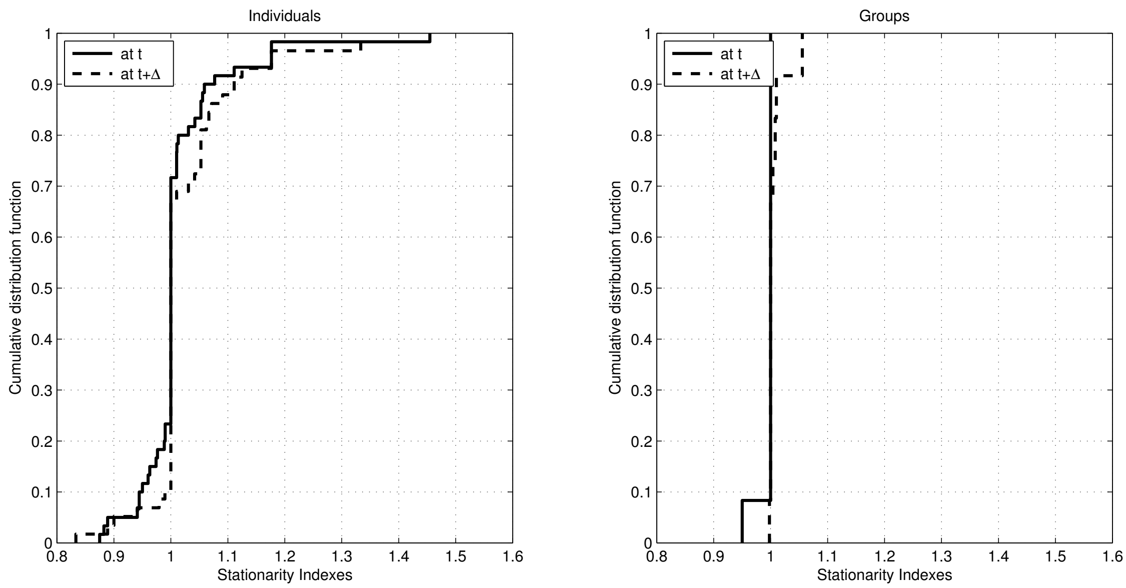


Figure 3: Distribution of Stationarity Indexes

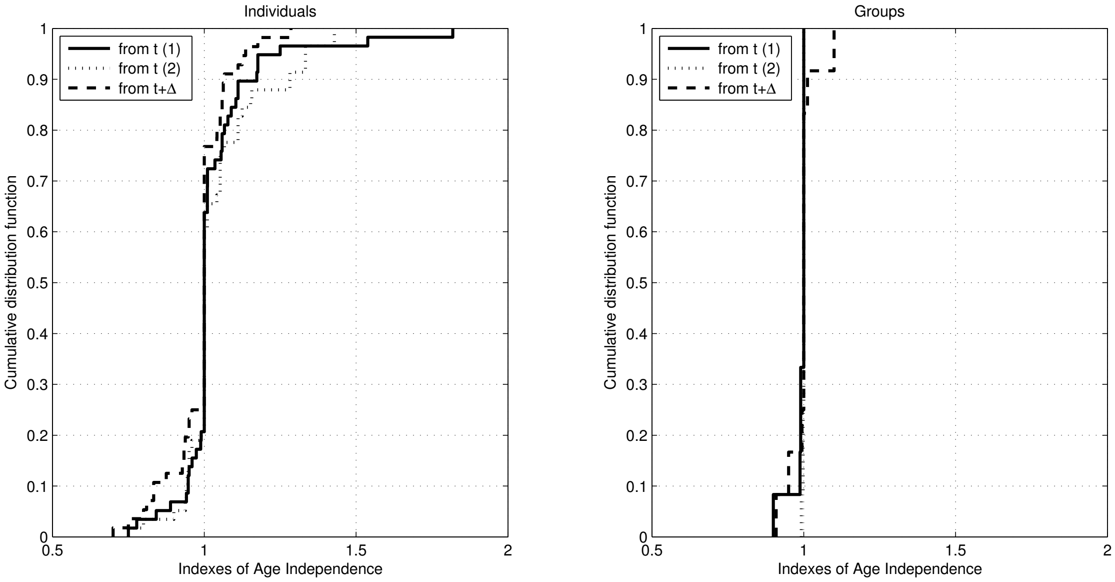


Figure 4: Distribution of Indexes of Age Independence

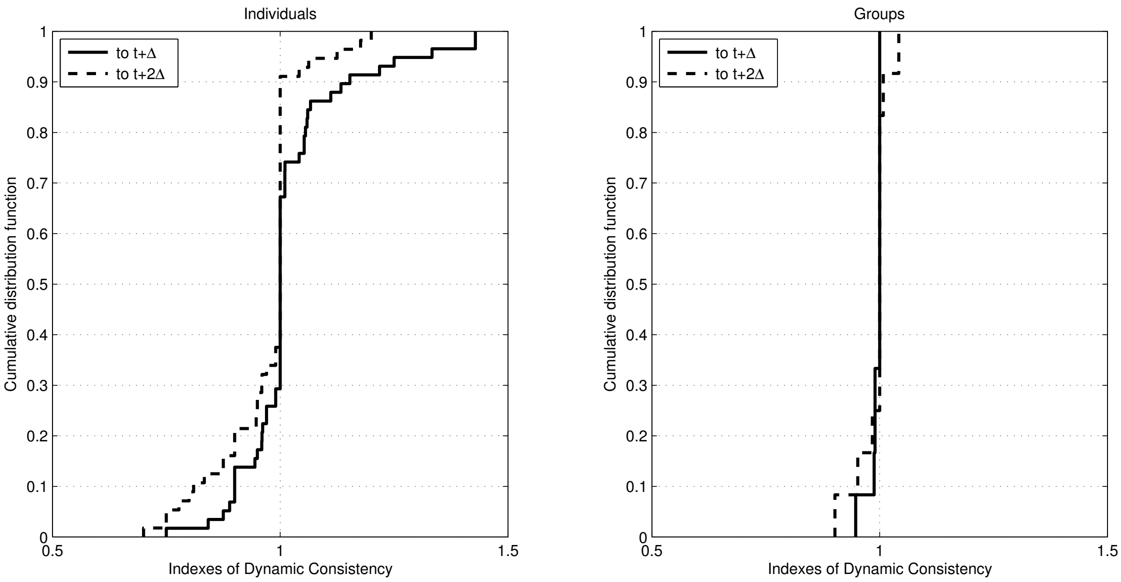


Figure 5: Distribution of Indexes of Dynamic Consistency

Appendix B Experimental Instructions

The experiment was conducted at Labex-em, the experimental lab of the University of Rennes between January and March 2012. Subjects were recruited using the ORSEE (Greiner 2004) software and the experiment was run using a purpose-written software coded in Z-tree (Fischbacher, 2007). In the recruitment phase, subjects were informed that they would have to participate in three successive experimental sessions, scheduled at regular intervals (4 weeks). Before entering the lab, subjects had to confirm that they are willing to commit themselves to the complete set of three experimental sessions. The instructions were the following.

General Instructions

Thank you for participating in our experiment. During this experiment, you will have to take decisions involving various amounts of money. If you follow the instructions, you could win a quite a large amount of money. All your responses will be converted into anonymous data after the experiment. During the experiment, you will have to answer a series of choice questions. There are no right or wrong answers to these questions. We are interested in your preferences: the only right answer to a choice task is the choice you prefer.

Twenty people will participate in this experimental session. During the session, you will have to take decisions individually and collectively. Therefore, you will decide alone on some decisions and will interact with other participants on other decisions. For reasons of anonymity, you will not have access to the other participants' identities.

The experiment consists of 2 parts:

- In a first (second) part, you will decide as an individual;
- In a second (first) part, you will have to take a decision in common as a member of a group of 5 people, i.e. you and four other people.

Gains and Payment

Your final payment will be determined by the choices you made during the experiment. Your final payment will depend on one single decision, selected at random by the computer. The code used to select the random decision is available from the experimenter upon request. If you obtain a payment, it will be paid to you by a transfer to your bank account. The payment order will be given today, or in 4 weeks or in 8 weeks time and will be realized with a one-day delay.

For your participation, you will receive a show-up fee of 20 euros. The show-up fee is conditional on your participation in the three experimental sessions. The show-up fee will be paid at the end of the third experimental session only if you attend all three of the sessions.

During the experiment, you will have to answer a series of choice questions regarding different amounts of money available at different dates. The display represented on Figure 6 shows an example of a series of questions. Option A offers a fixed amount of 100 euros to be obtained in 4 weeks time. Option B offers a series of 6 amounts equally ranged between 50 euros and 100 euros to be obtained tomorrow. For each of the 6 amounts, you will be asked to indicate whether you would like to choose option A or option B. Once you have switched between option A and option B, a scrollbar will appear on the screen. The scrollbar allows you to refine the amount of money at which you switch your choice from choice A to choice B. For instance, suppose you switch at 72 euros.

If you switch at 72 euros, do you agree that you prefer to choose option B at a higher amount than 72 euros? (Y/N). Do you agree that you prefer to wait 4 weeks and get option A at prices lower than 72 euros? (Y/N). If you have any questions, please feel free to ask the experimenter.

The payment will be implemented as follows: at the end of each experimental session, 4 participants will be selected at random from among the 20 participants attending the session. For each of these participants, the computer will select one decision at random. For that decision, the computer will select one possible choice at random. Let's take the decision represented on Figure 6 as an example. For that

decision, an integer between 50 and 100 will be selected at random.
If the computer draws 63, the selected choice is between 63 euros tomorrow and 100 euros in 4 weeks time. Do you agree? (Y/N). If you chose 72 euros as a switching point, your selected choice is therefore 100 euros in 4 weeks time and you will receive your payment directly by bank transfer from the French Treasury in 4 weeks time. Do you agree? (Y/N).
On the other hand, if the computer draws 83, the selected choice is between 83 euros tomorrow and 100 euros in 4 weeks time. Do you agree? (Y/N). If you chose 72 euros as a switching point, your selected choice is therefore 83 euros tomorrow and you will receive your payment directly by bank transfer from the French Treasury tomorrow. Do you agree? (Y/N).
If you have any questions, please feel free to ask the experimenter. At the end of the experimental session, you will get a receipt from the University of Rennes 1 for the payment.

Individual Decisions

For these decisions, you will have to reply alone to a series of choice questions regarding different amounts of money available at different dates. The display represented on Figure 6 shows an example of a series of questions. Option A offers a fixed amount of 100 euros to be obtained in 4 weeks time. Option B offers a series of 6 amounts equally ranged between 50 euros and 100 euros to be obtained tomorrow. For each of the 6 amount, you will be asked to indicate whether you would like to choose option A or option B. Once you will have switched between option A and option B, a scrollbar will appear. The scrollbar allows you to refine the amount of money at which you switch your choice from choice A to choice B.
Once you will have selected a switching point, you can continue by clicking on "OK". You can also cancel your choice. When you click on "OK", a confirmation screen will appear and you can proceed with the next decision.

Collective Decisions

For collective decisions, you will have to reply in groups of 5 to a series of choice questions regarding different amounts of money available at different dates. For these decisions, a display similar to the one represented on Figure 1 will appear. This display will allow you to communicate with the other members of the group before taking decision as a group. All the collective amounts will be shared equally among the members of the group. For collective decisions, the majority rule will apply: for each choice, whenever three out of five members agree on a choice, the choice will be adopted by the group. The decision will be taken after four successive displays of voting intentions for each group member and a final vote. Groups will remain the same for all decisions: in other words, you will take a group decision with the same people each time. For reasons of anonymity, you will be identified by a color for each decision. Colors will be reshuffled randomly between each decision. For the first trial, you will be presented with a display similar to the one represented in Figure 7. Option A offers a fixed amount of 500 euros to be obtained by the group in 4 weeks time. Option B offers a series of 6 amounts equally ranged between 250 euros and 500 euros to be obtained by the group tomorrow. For each of the 6 amount, you will be asked to indicate whether you would like the group to choose option A or option B. Once you have switched between option A and option B, a scrollbar will appear. The scrollbar allows you to refine the amount of money at which you switch your choice from choice A to choice B. Suppose you switch at 350 euros.

If you switch at 350 euros, do you agree that you prefer the group to choose option B at a higher amount than 350 euros? (Y/N). Do you agree that you prefer the group to wait 4 weeks and choose option A at a lower amount than 350 euros? (Y/N). If you have any questions, please feel free to ask the experimenter.

Once you have selected a switching point, you can continue by clicking on ”OK”. When you click on ”OK”, your opinion will be sent to the other members of the group and you will get their opinions.

The results of the trial will be displayed along with the next decision to be taken

(Figure 1).The display will enable you to see the opinions of the other members of the group. The results of the previous trial will show you whether the decision reaches majority or not, for each possible decision between Option A and Option B. After four successive trials, the decision you take will be the final vote for your group. After that decision, the result of the vote will appear (Figure 8). The screen shows you the votes of each member, the group switching point and your share. Suppose that the decision of your group led to a switching point at 349 euros.

If your group switches at 349 euros, do you agree that a majority of members prefer to choose option B at a higher amount than 349 euros? (Y/N). If the selected choice is a choice between Option A and Option B at a lower amount than 349 euros amount, you would get your share which is 100 euros in 4 weeks times?. Do you agree that a majority of the members would prefer to wait 4 weeks and get option A at a lower amount than 349 euros? (Y/N). Do you agree that if the selected choice is a choice between Option A and Option B with an amount equal to 472 euros (higher than 349 euros), you would get your share, which is 83.6 euros tomorrow? If you have any questions, please feel free to ask the experimenter.

Once your group has taken a decision, you can proceed with the next decision.

Appendix C Displays

This Appendix shows the typical displays used in the experiment. Figure 6 shows the multiple choice list used to elicit indifferences points. Figure 7 shows the equivalent multiple choice list used to elicit indifferences points for the first straw poll. Figure 8 shows the final screen presented to the subject after a vote.

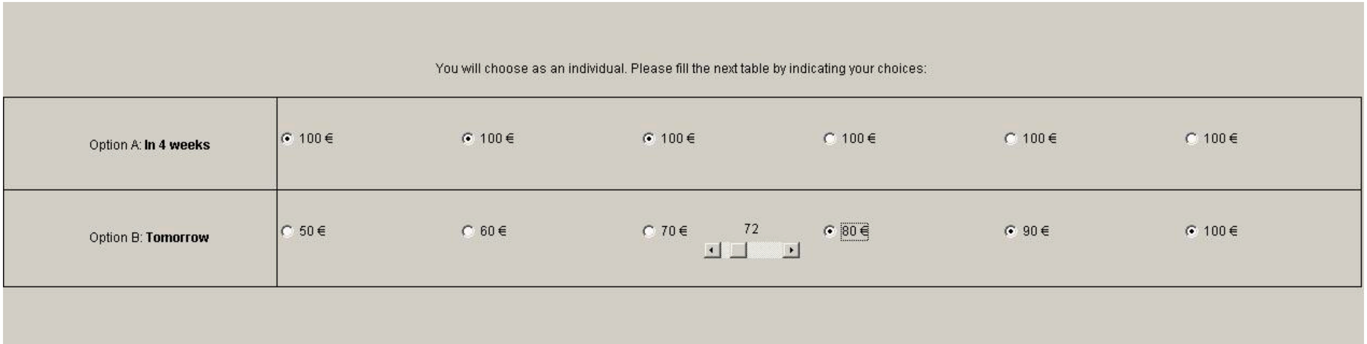


Figure 6: Presentation of Choice List in Individual Decisions

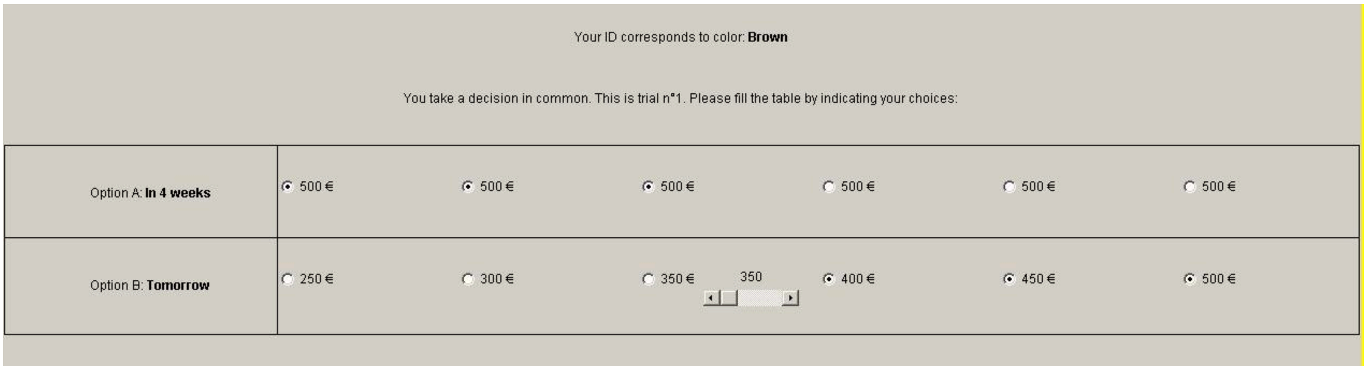
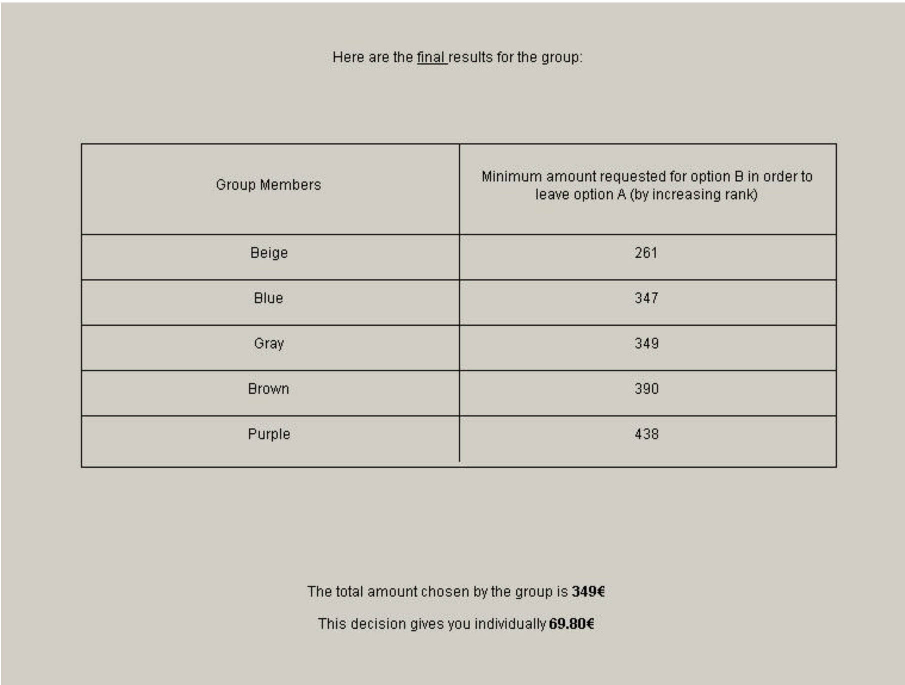


Figure 7: Presentation of Choice List in Collective Decisions: First Straw Poll



Here are the final results for the group:

Group Members	Minimum amount requested for option B in order to leave option A (by increasing rank)
Beige	261
Blue	347
Gray	349
Brown	390
Purple	438

The total amount chosen by the group is **349€**

This decision gives you individually **69.80€**

Figure 8: Presentation of a Collective Decision