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EMPIRICAL ARTICLE

# Group collaboration reduces delay discounting of intertemporal choices and its duration

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**Abstract**

Many real-world intertemporal decisions involve a group of two or more individuals making consensual decisions through group collaboration. Here, we ask how group collaboration affects intertemporal choices. In two experiments, participants completed intertemporal choices individually first (the precollaboration phase). Then, participants were placed into groups of two or three and completed a similar intertemporal task, with the group arriving at a consensual decision on each trial (the group collaboration phase). Finally, participants once again completed the intertemporal choices individually (the postcollaboration phase). Results showed that after group collaboration, the delay discounting significantly decreased compared to before collaboration both at group level and at individual level. The effect of group collaboration on individual intertemporal choices was no longer discernible by 1 week later. Therefore, the current research demonstrates the effectiveness of group collaboration and provides a way to nudge both groups and individuals to make farsighted choices.

## 1. Introduction

Intertemporal choice refers to a decision that involves tradeoffs between immediate and delayed rewards (Chen & He, 2021; Frederick et al., 2002; Loewenstein & Elster, 1992; Ren et al., 2015), such as spending money now or saving it to spend later. In real life, many important intertemporal decisions are made by groups of decision-makers rather than by individuals, for example, boards of directors deciding upon their firms' investment strategies, household members collectively deciding on savings or educational choices, and real estate heirs jointly deciding on decoration investments.

In intertemporal choices, people are usually asked to make a series of choices between a smaller-sooner (SS) reward and a larger-later (LL) reward. People usually prefer an immediate payoff against a delayed one with the same amount. This phenomenon is called *delay discounting*, as the value of the payoff declines as its fulfillment is delayed into the future (Bickel et al., 2007; Frederick et al., 2002; Green & Myerson, 2004; Kirby et al., 1999; Madden & Bickel, 2010). The higher the delay discounting, the more people prefer the SS reward, while the lower the delay discounting, the more people prefer the LL reward.

Previous studies showed that discounting rates can be affected by interventions. An overview of behavioral trainings and manipulations that have been developed to reduce delay discounting in human participants aged 12 years or older indicated that delay discounting can be decreased, showing that delay discounting is profoundly context-dependent and changeable (Scholten et al., 2019). For example, the episodic future thinking, which is the act of vividly imagining one's future, reduces delay discounting by increasing the salience of future events or response outcomes that would otherwise not be considered (Dassen et al., 2016; Rung & Madden, 2018). Individuals' delay discounting decreased by introducing decoys that are similar but inferior to delayed rewards (Kowal & Faulkner, 2016). In addition, the delay discounting would also be influenced by surrounded environments. Geng et al. (2022) asked participants to make intertemporal choices under blue or red light and found that people under blue light chose the delayed but larger payment more than those under red light.

Currently, researchers have mostly focused on the individuals' intertemporal choice (Akin, 2012; Chen & He, 2021; Lindner & Rose, 2017). However, it is not yet clear whether group collaboration reduces the delay discounting and how long this effect would last. Previous studies on group collaboration have found that group collaboration can lead to risky shift; that is, individuals' opinions are often influenced by group collaboration and are usually more risky than previous individual decisions (Kogan & Wallach, 1967; Stoner, 1961, 1968; Wallach et al., 1962, 1964). One important reason is that risky behavior is considered more valuable by society (Brown, 1965) and group members choosing risky choices are more influential (Teger & Pruitt, 1967). It is similar for group-collaborated intertemporal decisions. Long-term vision is considered more valuable by society in Chinese culture (Hofstede, 2011). Hence, it is possible that the more farsighted choices would exert more of an influence on other group members during group collaboration in Chinese culture because farsighted choices are more consistent with social norms in Chinese culture. In addition, farsighted choices are more convincing because it complies with the principle of rationality. Thus, group collaboration might lead to more far-sighted choices. The current research addressed these questions by examining the effect of group collaboration in intertemporal choices and its duration in Chinese culture.

### *1.1. Intertemporal choices in group context*

Based on our knowledge, research on intertemporal choices in group context can be classified into two different types, i.e., making decisions for hypothetical groups or collaborative decision-making with real groups. In the former group context, previous studies found that the delayed discounting for groups was lower than that for individuals (Charlton et al., 2011; Loya et al., 2018; Yi et al., 2020). For example, Charlton et al. (2011) examined the effect of group context on intertemporal decision-making. They asked participants to first make an intertemporal decision for themselves and then to make the decision for groups of 10 people (including the participants themselves), with the benefits of this decision being equally distributed among these 10 people. The delayed discounting for groups was lower than that for individuals. Loya et al. (2018) further found that the delay discounting was smaller when making intertemporal decisions for groups of 10 people than for groups of 2 people. Yi et al. (2020) also found that when decision outcomes were shared among group members, groups had a lower delay discounting than when the outcomes were only for the decision maker.

In contrast, for the collaborative decision making with real groups, previous research findings of group collaborative intertemporal decision-making were inconsistent. Some research found that group collaboration did not significantly reduce delay discounting compared to precollaboration individual decision-making (Bixter et al., 2017; Bixter & Rogers, 2019). However, other research found that groups were more patient and had lower delay discounting than individual intertemporal decisions (Denant-Boemont et al., 2017; Glätzle-Rützler, Lergetporer, & Sutter, 2021; Shapiro, 2010). Specifically, Bixter et al. (2017) first asked each participant to make intertemporal decisions for themselves individually (precollaboration phase), then asked participants to form a group to make intertemporal decisions together through collaboration (group collaboration phase), and finally asked each participant to make intertemporal decisions individually for themselves again (postcollaboration

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phase). The goal of group collaboration was to discuss every choice until every member of the group was satisfied with the amount. Also, even though they made judgements as a group, the rewards would be received individually. That is, if one of the reward items is $60 to be received in 4 months, that $60 would not be divided amongst the group but would be received individually. They found that group collaboration did not significantly decrease delay discounting. However, Glätzle-Rützler et al. (2021) asked participants to make intertemporal decisions individually first, and then make intertemporal decisions by three people as a group, with the benefits equally distributed among the three members, and found that group decisions were more patient and had a smaller delay discounting than individual decisions. Denant-Boemont et al. (2017) compared individuals' intertemporal choices to groups of five people making intertemporal decisions together and found that group decisions were more patient and had a smaller delay discounting than individual decisions. Also, a study by Shapiro (2010) found similar results that groups were more patient and had a smaller delay discounting than individuals in intertemporal decision making. Thus, the previous studies show inconsistent results on whether group collaboration decreases delay discounting or not, some (e.g., Bixter et al., 2017; Bixter & Rogers, 2019) say yes, others (e.g., Denant-Boemont et al., 2017; Glätzle-Rützler and Sutter, 2021) say no.

Even though Bixter et al. (2017) and Bixter and Rogers (2019) found convergent effect, i.e., postcollaboration phase converging toward their respective group, which suggested individuals' delay discounting would be affected by group collaboration. Because the absolute delay of discounting differences between group collaboration and pre-/post collaboration was used in their research, convergent effect could not tell us whether group delay discounting decrease or increase after group collaboration. Based on previous inconsistent findings, further testing is needed to help identify the circumstances under which (and reasons why) group collaboration might reduce delay discounting. In addition, previous research did not examine the duration of this effect of group collaboration. Therefore, further investigation of the effect of group collaboration on individuals' intertemporal choices and its duration is needed.

### *1.2. Mechanisms of group collaborative intertemporal choices*

Intertemporal decision-making and risk decision-making have similarities in theoretical development, behavioral effects, and neural basis (Zhou et al., 2019). Although collaborative intertemporal choices have not been studied intensively, we can draw on previous studies on group collaborative risk decision-making. Previous studies on group collaboration on risk decision-making have found that group collaboration can lead to risky shift; that is, individuals' opinions are often influenced by group collaboration and are usually more risky than previous individual decisions (Kogan & Wallach, 1967; Stoner, 1961, 1968; Wallach et al., 1962, 1964). Specifically, the risk-taking level of group decision-making is higher than the average risk-taking level of individual decision-making. There are two main explanations for risky shift, i.e., social comparison and persuasive argumentation or the information influence model. According to social comparison, when individuals in a group give their own opinions about decisions, they often have to compare with the opinions of others. Since risk-taking is more valuable (Brown, 1965), an individual would feel uneasy and worry about the negative evaluation by other members if their levels of risk-taking were lower than the average of the other members of the group (Teger & Pruitt, 1967). As a result, individuals would adjust their choices to be riskier in order to gain positive evaluations from other group members. In contrast, persuasive arguments are like the right answer in group problem-solving, they are convincing, and the person holding the argument is so confident and persuasive that others are easily persuaded. Accordingly, the degree of risky shift depends on the quantity and quality of arguments provided by group members (Burnstein et al., 1973; Vinokur & Burstein, 1974). Thus, social comparison and persuasive argumentation occur in combination to produce risky shift, although the persuasive argumentation effects tend to be larger (Isenberg, 1986).

As one type of group decision-making, group intertemporal decision-making may also be influenced by social comparison and persuasive arguments. In group collaboration, members communicate with each other about their choices and the reasons for them. During this process, group members

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usually compare themselves. In the current research, all participants are Chinese. Chinese culture is a long-term-oriented culture (Hofstede, 2011). Previous study (Wang et al., 2016) showed that cultural factors as captured by the Hofstede cultural dimensions contribute significantly to the variation of time discounting, even after controlling for economic factors, such as GDP, inflation rate, and growth rate. In particular, higher degrees of long-term orientation (LTO) predict a stronger tendency to wait for larger payoffs. Therefore, farsighted choices would be more socially desirable in Chinese culture. Thus, individuals would change their choices to be more farsighted during group collaboration.

Also, from the perspective of persuasive arguments, once a member provides the benefit of choosing farsighted options, which are more rational and sufficiently persuasive, it would become a persuasive argument. Glätzle-Rützler et al. (2021) also found that just one very patient member of the group increased the patience of the group as a whole in intertemporal decision-making. They provided participants with an anonymous real-time chat to coordinate group decisions. For each of the 20 binary decision problems, they have to coordinate on whether to choose the immediate payoff, or the larger payoff in four weeks. Therefore, we can predict that under the influence of persuasive arguments, group collaboration will make group members fully be aware of the benefits of choosing farsighted options in intertemporal decision making, which will lead to decreased delay discounting.

Therefore, based on social comparison and persuasive arguments in group collaboration, we proposed the following hypotheses.

**Hypothesis 1:** The delay discounting of group collaboration will be significantly lower than the average individual members' delay discounting before collaboration.

**Hypothesis 2:** After group collaboration, individuals' delay discounting will be significantly lower than that before group collaboration.

## 2. Experiment 1

### *2.1. Method*

#### 2.1.1. Participants

One hundred and forty-two college students (49 males) were recruited from a university in China and randomly assigned into 71 dyadic groups, with a mean age of 21 and a standard deviation of 2.17.

#### 2.1.2. Procedure

Two participants entered the laboratory together and sat in separate seats (about 2 m apart). Participants were unaware of the collaboration in the second phase. The experimental procedure is shown in Figure 1.

First, they were asked to complete the intertemporal choices independently (Phase 1) before group collaboration. The intertemporal choices were measured by 7 choice options developed by Wang and Dvorak (2010) (see Table 1). Participants were asked to choose between receiving SS rewards and LL rewards, e.g., "Would you prefer ¥120 tomorrow or ¥450 in 31 days?" We took the delay discount rate, $k$, as the index of intertemporal preference, with lower values corresponding to higher levels of foresightedness. Delay-discounting refers to the reduction in the present value of a future reward as the delay to that reward increases (Kirby et al., 1999). In the present research, indifference between a smaller, earlier reward (tomorrow) and a larger, later reward (future) indicates the following hyperbolic discount parameter: $k = (\text{future ¥} - \text{tomorrow ¥})/((\text{delay(in days)} \times \text{tomorrow ¥}) - (\text{future ¥}))$.

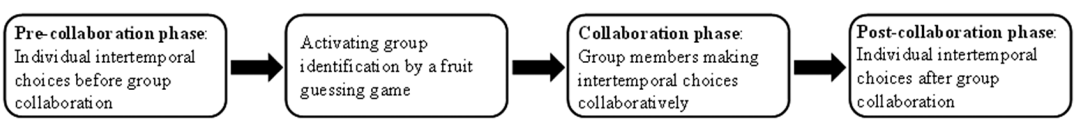


***Figure 1.*** *The procedure of Experiment 1.*

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***Table 1.*** *The intertemporal choices for precollaboration and group collaboration.*

| Order | Precollaboration | | | Group collaboration | | |
|---|---|---|---|---|---|---|
| | SS | LL | K at indiff. | SS | LL | K at indiff. |
| 1 | ¥120 tomorrow | ¥450 31 days | 0.10091743 | ¥150 tomorrow | ¥420 73 days | 0.02564103 |
| 2 | ¥390 tomorrow | ¥780 4 days | 0.5 | ¥270 tomorrow | ¥300 1112 days | 0.00010002 |
| 3 | ¥240 tomorrow | ¥330 939 days | 0.00039995 | ¥210 tomorrow | ¥360 448 days | 0.00160051 |
| 4 | ¥510 tomorrow | ¥660 18 days | 0.00161865 | ¥90 tomorrow | ¥480 16 days | 0.40625 |
| 5 | ¥570 tomorrow | ¥600 527 days | 0.00010007 | ¥540 tomorrow | ¥630 418 days | 0.00039984 |
| 6 | ¥450 tomorrow | ¥720 25 days | 0.02564103 | ¥480 tomorrow | ¥690 70 days | 0.00638104 |
| 7 | ¥180 tomorrow | ¥390 183 days | 0.00645161 | ¥420 tomorrow | ¥750 9 days | 0.10891089 |

As shown in Table 1, the choice sets presented before and after the collaboration task had identical distributions of associated *k*-values, ranging from 0.0001 to 0.5, but the specific monetary sums and delays were different. Choices over such a range reveal where one begins to prefer larger, later rewards. Individual discount parameters were computed as the geometric mean of the *k*-values bounding this preference switch (Kirby & Maraković, 1996). Following the literature (Kirby et al., 1999), the *k* values were normalized using natural log transformation because raw *k* values were skewed. The 7 k-values corresponding to 7 choices are listed from smallest to largest, in 4-fold increments.

Because participants' choices are not always perfectly consistent with any single value of delay discounting *k*, we calculated the consistency. The consistency measure represents the percentage of participants' choices that were consistent with their assigned discount rate. In other words, it represents the degree to which the respondents' selections are consistent with response patterns preceding, as well as following, the switch(es) from SS choices to LL choices. Specifically, a consistency score is determined by counting the instances of 0s (i.e., selection of the SS) prior to the given *k* value and instances of 1s (i.e., selection of the LL) at and following the given *k* value. This number is then divided by the number of items possible (7 in the case of overall). The larger the number, the more consistent the response pattern. Based on all 7 trials the mean choice consistency was 99% for Phase 1, Phase 2, and Phase 3, which were similar to the consistency of 94% and 96% in Kirby et al. (1999). According to Kaplan et al. (2016), cases where consistency scores were less than 75 % were deleted, including three cases in Phase 1 and two cases in Phase 3, as this may be an indication of a lack of attending to the questionnaire.

Then, the participants were asked to complete a cooperative game to activate their group identity, i.e., the fruit guessing game. When accomplishing the task, they sat next to each other. As shown in Figure 2, the participants were asked to work together to memorize the names and locations of the fruits in the grid and to fill in the names of the fruits correctly in the corresponding grid. Specifically, the fruit guessing game presents the task through setting up a 4×4 table or a 5×5 table with different fruit distributions. Different fruit distributions were randomly presented on the screen every 3 seconds. Participants were asked to complete the blank tables together based on their memory within 3 seconds. Therefore, the task is of great difficulty and cannot be accomplished individually. Only successful collaboration and division of labor within a group can complete it. At the end of the game, the scores

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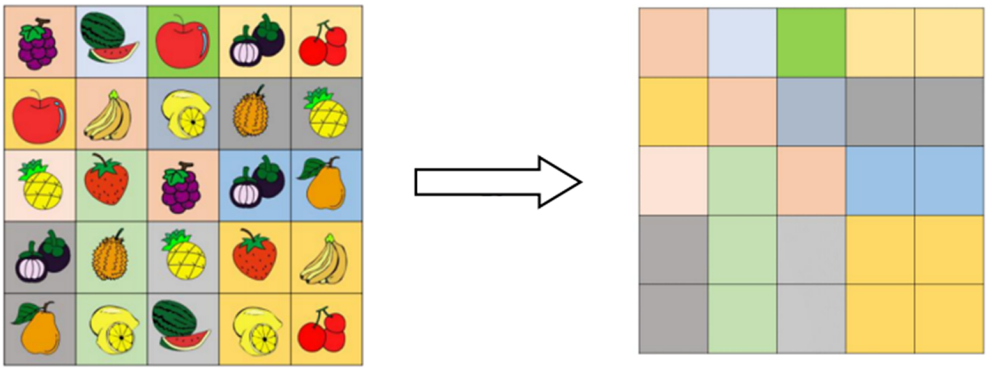

***Figure 2.*** *An example of the fruit guessing game.*

of the participants were calculated, and they were told "Congratulations on the completion of the fruit guessing game, your team did a good job". To check the effectiveness of the group manipulation, the participants were asked to fill out a group identity questionnaire (Mullin & Hogg, 1998), which consisted of five questions to evaluate the extent to which their liking the group members, the similarity among their attitudes and opinions, and the belonging to the group, 1= not at all, 7= extremely strong. The higher the score, the stronger the group identification. In the current research, $M = 6.48$, $SD = 0.76$, indicating that the group identity manipulation was effective.

Next, participants were asked to complete group collaborative intertemporal decision-making (Phase 2). If participants were asked to complete the same intertemporal choice task as in the independent phase (Phase 1), they might just copy their choices in the first phase. To prevent individuals in the collaboration phase from copying responses they had made in the precollaboration phase, another questionnaire developed by Wang and Dvorak (2010) was used, with different reward magnitudes and delayed days but the same distributions of associated *k*-values, as those in precollaboration phase (see Table 1). Upon completion of the precollaboration phase, all participants were gathered together and informed that they would be completing a similar task, but as a group. The group members were asked to make a consensus choice for each intertemporal choice after completely discussing it. Based on the group's consensus choice, each group member received the corresponding rewards individually, e.g., if they choose to receive ¥450 in 31 days, then each member will receive ¥450 in 31 days, and the ¥450 would not be divided among them[1].

Finally, the participants were asked to return to their originally separated seats to complete the postcollaboration intertemporal choices individually (Phase 3). The intertemporal choices in the postcollaboration phase were identical to that in the precollaboration phase (Phase 1).

### *2.2. Results*

#### 2.2.1. The Effect of group collaboration on group delay discounting

To analyze the effect of group collaboration on intertemporal decision-making at the group level, the delay discounting of group members in the pre- and postcollaboration phases was first averaged for each group as an indicator of group intertemporal decision-making. As shown in Figure 3, one-tailed paired-samples *t* test indicated that the delay discounting for intertemporal choices in the precollaboration phase was significantly greater than that in the group collaboration phase, $t\ (70) = 4.89$, $p < 0.001$, $d = 0.58$. The delay discounting for intertemporal decision-making in the precollaboration phase was also significantly greater than that in the postcollaboration phase, $t\ (70) = 6.71$, $p < 0.001$, $d = 0.80$.

[1]In fact, participants were paid according to their choices in intertemporal choice questionnaire. We randomly chose one item from the seven intertemporal choices, and paid 2% of reward amount which they chose in this item to participants. If a delayed choice option was chosen, the delivery of the reward also delayed by 2% of that amount.

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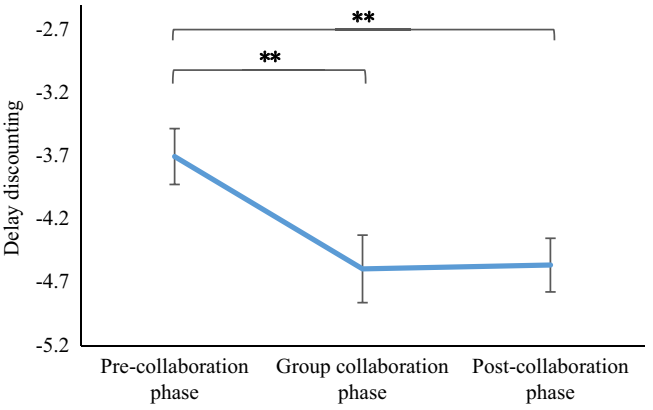


***Figure 3.*** *The delay discounting for three phases.*

*Note:* Error bars represent 2SE; ** $p<0.01$.

There was no significant difference between the delay discounting in the collaboration phase and the postcollaboration phase, $t$ (70) = 0.11, $p$ = 0.45.

#### 2.2.2. The effect of group collaboration on individual delay discounting

To examine the influence of group collaboration on individual intertemporal choices, using individuals as the analysis unit, a one-tailed paired-samples $t$-test found that the delay discounting for individuals in the precollaboration phase ($M$ = -3.72, $SD$ = 2.23) was significantly greater than that for individuals in the postcollaboration phase ($M$ = -4.61, $SD$ = 1.84), $t$ (141) = 6.65, $p < 0.001$, $d$ = 0.56.

### *2.3. Discussion of Experiment 1*

Experiment 1 found that after group collaboration, the delay discounting of the group was significantly lower than the mean of delay discounting of members before collaboration, indicating that group collaboration reduced the delay discounting of the group, which was consistent with Hypothesis 1. In addition, after group collaboration, the individual delay discounting is also significantly lower than that before collaboration, which is consistent with Hypothesis 2, indicating that people can learn from group collaboration. Therefore, after group collaboration, the delay discounting of individual's intertemporal decision-making is also reduced.

## 3. Experiment 2

There were three differences between Experiment 2 and Experiment 1. First, in Experiment 1, all participants were in the same condition. Experiment 2 had three conditions: group decision with collaboration, group decision without collaboration, and control condition (no group decision). In addition, to better examine how long the effect of group collaboration on intertemporal decision-making can last, Experiment 2 added a fourth phase, which tracked individuals' intertemporal decision-making one week after the group collaboration. Finally, although Experiment 1 used two-person groups, Experiment 2 used three-person groups.

### *3.1. Method*

#### 3.1.1. Participants

309 college students were recruited in a university in China, including 162 males and 147 females, with a mean age of 18.42 and a standard deviation of 0.66. There was a total of 103 groups with three people

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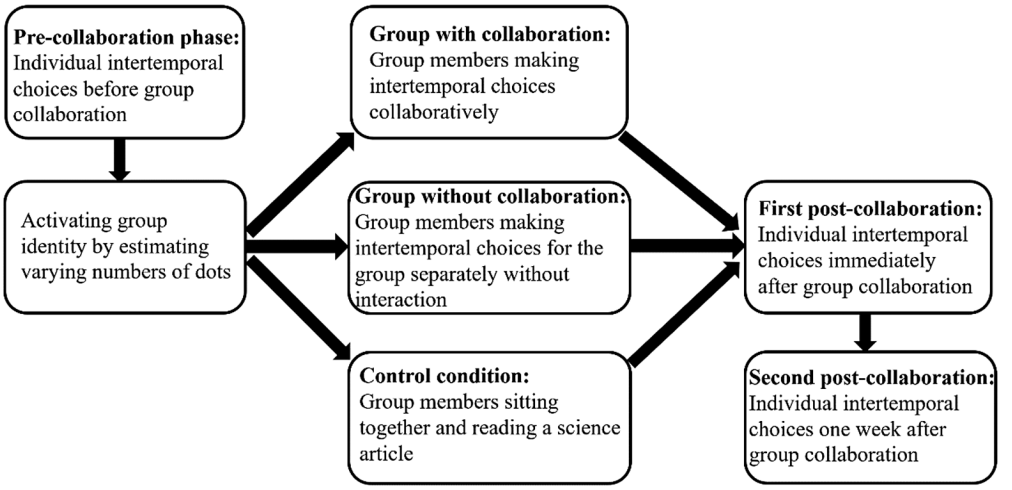


***Figure 4.*** *Experiment 2 procedure.*

as a group. They were randomly assigned to three conditions, including 36 groups with collaboration, 31 groups without collaboration, and 36 groups with control condition.

### 3.1.2. Experimental design

A mixed design of 3 (group decision with collaboration, group decision without collaboration, and control condition) × 4 (the precollaboration phase, the group collaboration phase, immediately after collaboration, 1 week after collaboration) was used, with the former variable as a between-subjects variable, and the latter variable as a within-subjects variable. The precollaboration phase (Phase 1) refers to the intertemporal decision-making of individuals before the formation of the group; the group collaboration phase (Phase 2) refers to the intertemporal decision made jointly by group members; the individual intertemporal decision-making immediately after collaboration (Phase 3) refers to the intertemporal decision-making completed independently by the group members immediately after the group decision; the individual intertemporal decision making 1 week after collaboration (Phase 4) refers to the intertemporal decision making made independently by group members one week after the group collaboration. The dependent variable is the delay discounting of intertemporal decision-making[2].

### 3.1.3. Procedure

Three participants entered the laboratory together and were seated in three separate seats. The experimental procedure is shown in Figure 4.

First, in the precollaboration phase, they completed the intertemporal choices individually which was the same as Experiment 1.

Second, to activate their group identity, participants were asked to evaluate varying numbers of dots (Tajfel et al., 1971). There were two groups of dots on the computer screen. Participants were asked to determine the number of which group of dots was closer to 20 (in fact, both groups have 20 dots with different distribution). After participants made their choice, they were given feedback as either overestimated (regarded as "overestimation group") or underestimated (regarded as "underestimation group") randomly. Then, based on the feedback, participants were asked to choose the corresponding color of team uniforms (white for the overestimation group and blue for the underestimation group)

[2]Because participants' choices are not always perfectly consistent with any single value of delay discounting k, we calculated the consistency as in Experiment 1. The mean choice consistency was 96% for Phase 1, 99% for Phase 2, 97% for Phase 3, and 96% for Phase 4. According to Kaplan et al. (2016), cases where consistency scores are less than 75 % were deleted, as this may be an indication of a lack of attending to the questionnaire.

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and sit around as a group. In order to test the effectiveness of the group identity manipulation, the participants were asked to answer the question, "Which group do you belong, the high-estimation group or the low-estimation group?" All participants answered correctly and wore team uniform correctly, indicating that the group identity manipulation was effective.

Third, groups were randomly assigned to three experimental conditions: group decision with collaboration, group decision without collaboration, and control condition (no group decision). Specifically, (1) in the group decision with collaboration condition, group members were required to make a consensual choice after group collaboration and discussion for each intertemporal choice. Based on the group's choice, each group member independently received the corresponding value of money, e.g., if they chose to receive ¥360 after 448 days, then each member would receive ¥360 after 448 days (Note: In fact, both the delay time and money would be multiplied by 2%, as in Experiment 1); (2) In the group decision without collaboration condition, group members were required to make a choice for the group without group collaboration using the average of the three members' intertemporal decision delay discounting as the outcome of group intertemporal decision making. There was no interaction among group members prior to the making of their independent choices. It is worth noting that although group members made intertemporal choices independently in the noncollaboration condition, they made choices for the group rather than for individuals, which was different from individual intertemporal choices in Phase 1. Each member received the corresponding value of money according to the group members' own choices; (3) In the control condition, group members sat together and read a popular science article about asteroids. To avoid the influence of the precollaboration on group intertemporal decision-making, seven different intertemporal choices were used (Wang & Dvorak, 2010) for group intertemporal decision-making, with different reward magnitudes and delayed days but the same $k$-values as those in precollaboration phase.

Next, in first postcollaboration phase (Phase 3), participants were asked to return to their initial separate seats and complete the individual intertemporal choices, which were the same as the precollaboration intertemporal choices independently.

Finally, in the second postcollaboration phase (Phase 4), one week later, the questionnaire was sent to the participants again via Sojump, an electronic platform for collecting data, and the intertemporal choices were the same as the precollaboration.

### *3.2. Results*

#### 3.2.1. The effect of group collaboration on group delay discounting

Since group decision-making was not performed in the control condition, the effect of group collaboration on delay discounting at the group level did not include the control condition. To test whether group decision process reduced delay discounting, one-tailed paired-samples $t$ tests were conducted between Phase 1 and Phase 2/3/4. As shown in Figure 5, for groups with collaboration, the delay discounting for Phase 2 was significantly smaller than that for Phase 1, $t(32) = 3.05$, $p = 0.002$, $d = 0.53$; Phase 3 was also smaller than Phase 1, $t(34) = 2.36$, $p = 0.01$, $d = 0.40$; Phase 4 was not significant from Phase 1, $t(30) = 0.43$, $p = 0.34$. For groups without collaboration, the delay discounting for Phase 2 was significantly smaller than that for Phase 1, $t(28) = 3.97$, $p < 0.001$, $d = 0.74$; Phase 3 was also smaller than Phase 1, $t(29) = 3.35$, $p = 0.001$, $d = 0.61$; Phase 4 was not smaller than Phase 1, $t(30) = 1.55$, $p = 0.07$.

To compare delay discounting between the group with collaboration and without collaboration, one-tailed independent-samples $t$ test was conducted. The delay discounting of groups with collaboration was not significant from that of groups without collaboration Phase 1 ($t_{(64)} = -0.45$, $p = 0.33$), Phase 2 ($t_{(61)} = -0.85$, $p = 0.20$), Phase 3 ($t_{(64)} = 0.58$, $p = 0.28$) and Phase 4 ($t_{(61)} = -0.32$, $p = 0.37$). In Phase 1, although the delay discounting of groups with collaboration was not the same as those without collaboration, the difference was small. In addition, the present research focused on the differences between Phase 1 and Phase 2/3/4, which were tested by paired-samples $t$ test. Therefore, the priori

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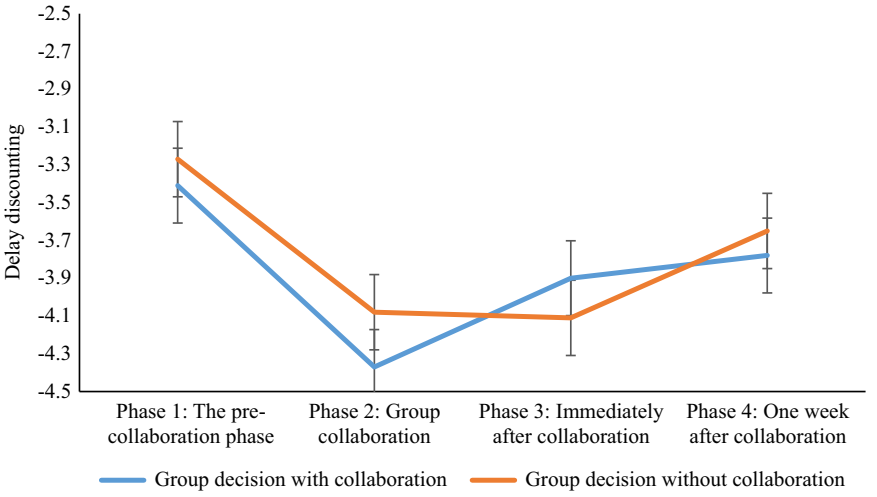


***Figure 5.*** *Changes in delay discounting for groups with and without group collaboration.*

*Note:* Error bars represent 2SE.

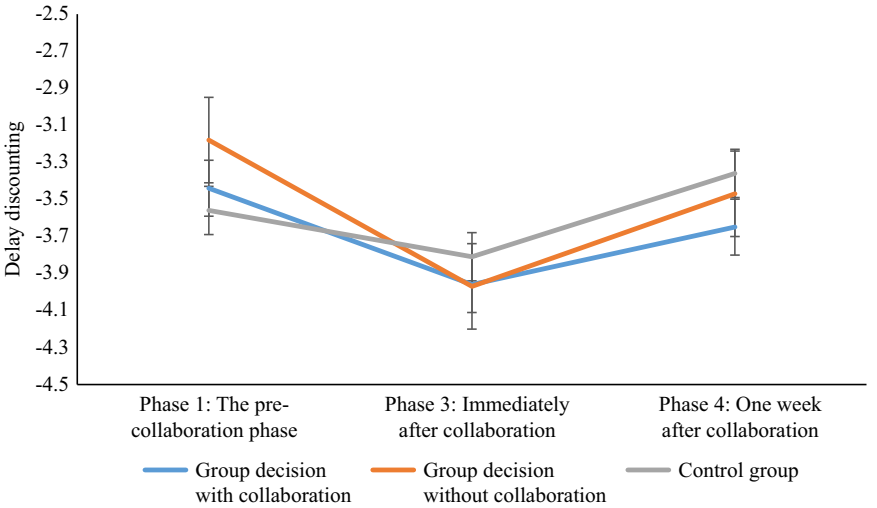


***Figure 6.*** *Changes in individuals' delay discounting under three conditions.*

*Note:* Error bars represent 2SE.

difference between groups with collaboration and those without collaboration may not have significant effect on the interpretation of results.

### 3.2.2. The effect of group collaboration on individual delay discounting

To test the effect of group collaboration on individual delay discounting, the delay discounting of individuals in Phase 1, Phase 3, and Phase 4 were used. To test whether the group decision process reduced individual delay discounting, using individuals as the analysis unit, one-tailed paired-samples *t* tests was conducted between Phase 1 and Phases 3 and 4 respectively. As shown in Figure 6, for the participants in groups with collaboration, the delay discounting for Phase 3 was significantly smaller than that for Phase 1, $t$ (93) = 2.84, $p$ = 0.003, $d$ = 0.29; Phase 4 was not significant from Phase 1, $t$ (76) = 0.20, $p$ = 0.42. For the participants in groups without collaboration, the delay discounting for

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Phase 3 was significantly smaller than that for Phase 1, $t$ (84) = 3.97, $p < 0.001$, $d = 0.43$; Phase 4 was not smaller than Phase 1, $t$ (76) = 1.36, $p = 0.09$. For the participants in control condition, the delay discounting for Phase 3 was not significantly smaller than that for Phase 1, $t$ (87) = 1.39, $p = 0.08$; Phase 4 was not smaller than Phase 1, $t$ (75) = -1.74, $p = 0.96$. In Phase 1, although the delay discounting of individuals in groups with collaboration was not the same as those without collaboration, the difference was small. The results of two-tailed independent-samples $t$ test indicated that there was no significant difference in the individual-level delay discounting between group with and without collaboration, $t$ (180) = −0.87, $p = 0.39$.

### *3.3. Discussion of Experiment 2*

We found that the delay discounting in the group's intertemporal decision-making (Phase 2) was significantly lower than the mean of the delay discounting in precollaboration phase (Phase 1), regardless of whether the group's decision-making had collaboration or not. This is consistent with the findings in the field of economics regarding intertemporal decision-making in groups (Denant-Boemont et al., 2017; Glätzle-Rützler & Sutter, 2021; Shapiro, 2010) and inconsistent with the study of Bixter et al. (2017).

Experiment 2 also compared the individual delay discounting among Phases 1, 3, and 4, and found that, for both the conditions of the group with collaboration and group without collaboration, the delay discounting in Phase 3 was significantly lower than that in Phase 1. However, under the control condition (i.e., no group decision), there was no significant difference between the delay discounting in Phases 1 and 3. It is noteworthy that the difference between the delay discounting of Phase 4 (i.e., 1 week after group collaboration) and Phase 1 is not significant, no matter whether the group collaborated or not. This suggested that people can learn from group collaboration, but this learning effect lasted for less than a week.

## 4. General discussion

In this study, we found that the delay discounting of group intertemporal decision-making was significantly lower compared to the average delay discounting of group members before collaboration. At the individual level, after the group collaboration phase, the delay discounting was significantly lower than that of precollaboration individuals and then went back to the initial level after one week.

After group collaboration, the delay discounting for groups decreased significantly, a result that is consistent with previous research in the field of economics on intertemporal decision-making for group collaboration (Denant-Boemont et al., 2017; Glätzle-Rützler & Sutter, 2021; Shapiro, 2010) but inconsistent with the findings of Bixter et al. (2017). In addition, for groups without collaboration, the group delay discounting also decreased significantly, which is consistent with previous studies on hypothetical group intertemporal choices (Charlton et al., 2011; Loya et al., 2018; Yi et al., 2020). For example, Charlton et al. (2011) asked participants to first make an intertemporal decision for themselves and then to make the decision for groups of 10 people (including the participants themselves), with the benefits of this decision being equally distributed among these 10 people. The delayed discounting for groups was lower than that for individuals. The current research found that not only groups with collaboration but also groups without collaboration could lead to smaller delay discounting than the averaged delay discounting of individual members, which indicated that perhaps collaborating with the knowledge that their decision applied to the group would reduce the group delay discounting.

This study found that at the individual level, after the group decision-making phase (whether the group collaborated or not), the delay discounting also decreased significantly, and returned to the precollaboration level one week after group collaboration. This result suggests that people can learn from group collaborative decision-making and that they become more farsighted after group collaboration. Bixter et al. (2017) and Bixter and Rogers (2019) found that individual intertemporal

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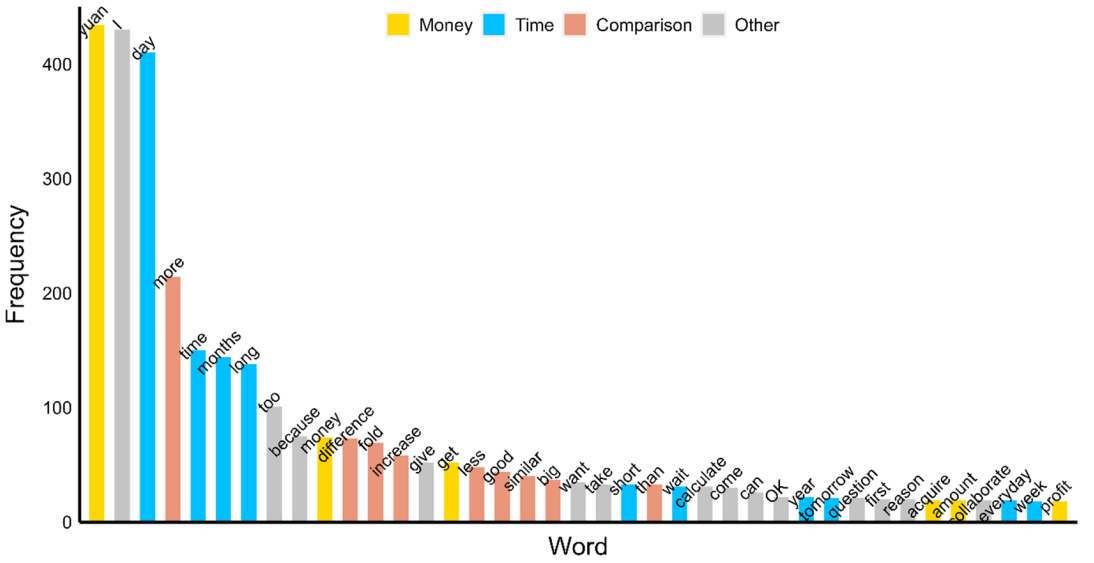


***Figure 7.*** *Frequency statistics of high-frequency vocabularies.*

*Note:* In Chinese, "Yuan" represents the basic unit of Chinese currency RMB.

decision-making after collaboration is influenced by group collaborative intertemporal decision-making and that postcollaboration phase converging toward their respective group, which also suggested people could learn from their group collaboration. In response to their findings of convergent effect, we conducted the same analysis using data from Experiment 1. According to Bixter et al. (2017), we computed the absolute differences between the group discount rates during the collaboration phase and group members' discount rates during the precollaboration/postcollaboration phases. That is, for each participant we calculated the absolute difference between his or her discount rate during the precollaboration phase and the respective group's discount rate during the collaboration phase. Within each group, participants' difference scores were then averaged together. We next calculated the absolute differences between the group members' discount rates during the postcollaboration phase and the group discount rate during the collaboration phase. The average absolute difference between the postcollaboration discount rates and the collaboration discount rates ($M = 0.79$, $SD = 0.82$) was smaller than the average absolute difference between the precollaboration discount rates and the collaboration discount rates ($M = 1.34$, $SD = 1.19$), $t\,(70) = 4.49$, $p < 0.001$, $d = 0.53$. This means that group members' discount rates during the postcollaboration phase converged toward their respective group, which is consistent with previous studies (Bixter et al., 2017; Bixter & Rogers, 2019).

Why does group collaboration reduce the rate of delayed discounting of intertemporal decisions? In order to further investigate how group cooperation affects group intertemporal decision-making, the word frequency of group discussions is analyzed by the text mining software ROST_CM6. The group discussion was transcribed into words, generating pure text totaling 23,679 characters. The top 40 high-frequency elements were selected by word segmentation and word frequency analysis, as shown in Figure 7. We can see that time-related words (e.g., days), money-related words (e.g., Yuan), and comparison-related words (e.g., more) are relatively high in frequency. It was found that the frequency of words related to "get money" counts 616, words related to time counts 986, and words related to comparison counts 659. It suggested that group members paid more attention to time, money and the comparison between time and money when they cooperated.

As the group discussion examples showed (Table 2), when group members disagreed on their choices, group members tried to convince their teammates from their own perspective. When one trying to persuade others, they consider the two dimensions of intertemporal choices, i.e., time and money,

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***Table 2.*** *Group discussion examples.*

| | |
|---|---|
| | **¥420 tomorrow, vs. ¥750 in 9 days with final choice of LL** |
| **Member 1**: | I choose 9 days later. |
| **Member 2**: | Me too. About a week, I can wait. |
| **Member 1**: | Yeah, the difference is considerable. What about you? |
| **Member 3**: | I think if I get it now, I can do other things in the rest of the time, so I don't have to wait. |
| **Member 1**: | What you can do with ¥700 is different from having ¥400, and you have to consider the time, 9 days. |
| **Member 2**: | She thinks nine days is quite long. |
| **Member 1**: | You can't wait even a day, can you? |
| **Member 3**: | I can't wait. I think I can do other things with this money now. |
| **Member 1**: | But you have to consider the risks. How can you ensure that you can get a profit with this money, instead of losing money? |
| **Member 3**: | Ok, 9 days later. |
| | **¥450 tomorrow, vs. ¥720 in 25 days with final choice of LL** |
| **Member 1**: | Tomorrow you get ¥450, 25 days later you get ¥720. The difference between the two is ¥270,we can get more ¥270 in 25 days. It's a good deal. |
| **Member 2**: | 25 days is OK. |
| **Member 3**: | I choose to get ¥450 tomorrow. |
| **Member 1**: | Do you feel more comfortable getting it right away? |
| **Member 3**: | I still think it's a high cost of time, I'm taking less at the moment but I might take that money and do something else I might make a fortune. |
| **Member 1**: | What your concern is the high cost of time. |
| **Member 3**: | You do the math it's ¥720 for 25 days and average it out for each day. |
| **Member 2**: | If you get money now, you could only get ¥450. However, if you wait for 25 days, you could get ¥720. Don't you think the difference is big? The difference is more than ¥200 . |
| **Member 3**: | All right. |
| | **¥480 tomorrow, vs. ¥690 in 70 days with final choice of SS** |
| **Member 1**: | 70 days, an increase of a little over ¥200. |
| **Member 2**: | I think I'd love to get it if I could get it now. |
| **Member 1**: | Me too. I think this money is already plenty. |
| **Member 2**: | Yes, ¥480 is quite a lot, I'm very satisfied. 70 days is not long. |
| **Member 2**: | But you also need to consider the initial income. Are you willing to accept that it has only increased by ¥200 in 70 days? |
| **Member 1**: | Yeah, too little. |
| **Member 2**: | Let's just get this money first. |
| **Member 3**: | All right. |

and then make comparisons between time and money. This is consistent with the tradeoff model of intertemporal decision-making (Scholten et al., 2014) and the single-dimension priority model (Jiang et al., 2016), which assumes that the decision-maker compares the difference in the "money" dimension (△money) with the difference in the "delay" dimension (△time) (i.e., the comparison of differences between dimensions) and then makes a decision based on the dimension with the greater difference

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(i.e., the priority dimension). People would be more farsighted if they perceived differences on the money dimension to be greater than differences on the time dimension. On the contrary, people would be less farsighted if they perceived differences on the time dimension to be greater relative to differences on the money dimension. Group collaboration enables group members to compare the money and time of two options (i.e., SSs and LLs) more frequently, which leads their intertemporal choices to be more rational. Glätzle-Rützler and Sutter (2021) also found that just one patient member of the group increases the patience of the whole group in intertemporal decision-making, which leads to more patient group intertemporal choices.

The present research contributes to the field of group intertemporal choices. First, previous findings on the effects of group collaboration on intertemporal decision-making are inconsistent. Some studies found that group collaboration reduces the delay discounting (Denant-Boemont et al., 2017; Glätzle-Rützler & Sutter, 2021; Shapiro, 2010), while others found that group collaboration does not reduce the delay discounting (Bixter et al., 2017; Bixter & Rogers, 2019). This current study examined the role of group collaboration on intertemporal choices both at group level and at individual level through rigor experiments and provided evidences from Chinese culture.

Second, the duration of the impact of group collaboration on intertemporal decision-making has not been examined in previous studies. This study is the first to explore the duration of group collaboration effects on intertemporal decision-making and found that the effect of group collaborative decision-making on individuals' intertemporal choices lasted for about one week. Therefore, the effect of reducing delay discounting will need to be reinforced regularly for lasting improvements via group collaboration.

Third, this study may have practical value. The results of this study provided an effective approach for nudging both groups and individuals to make farsighted decisions. Employers and policymakers may encourage farsighted choices by group collaboration. In addition, frequent group collaboration is needed to maintain the effect of group collaboration in reducing delay discounting.

The current study also has some limitations. Although by analyzing the content of group collaboration discussions, it proposed that persuasive arguments in group collaboration played an important role in reducing the delay discounting of group intertemporal decision-making, it did not directly manipulate the number of persuasive arguments to examine the direct effect on group intertemporal choices. A more direct approach to examine the process of group intertemporal decision-making is needed in future research. In addition, the duration of the group collaboration effect is needed to text in various retention intervals in future. Cultural difference might be a reason for the inconsistent results on group intertemporal choices. For example, participants in the study of Bixter et al. (2017) and Bixter and Rogers (2019) were from USA, while participants in the study of Glätzle-Rützler and Sutter (2021) came from Austria, Denant-Boemont et al. (2017) came from France. Cultural differences should be examined directly in the future work.

## 5. Conclusion

Two experiments in this study found that group collaboration decreases the delay discounting both at group and individual levels. However, the delay discounting of individuals rebounded to the initial level 1 week after group collaboration. Therefore, the current research demonstrates the effectiveness of group collaboration and provides a solution to nudge both groups and individuals to make farsighted choices.

**Supplementary material.** The supplementary material for this article can be found at https://doi.org/10.1017/jdm.2024.20.

**Data availability statement.** Data and code are available in the OSF repository at https://osf.io/3n4zb/?view_only=3971d32d606e4e14b123fac4cb9683f9.

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**Competing interest.** There is no competing interest for any of the authors.

**The statement concerning pre-registration.** The current research was not pre-registered due to our limited familiarity with the preregistration process at the time.

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