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Are intertemporal preferences contagious? Evidence from collaborative decision making

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Abstract Prior research has provided substantial insight into individuals' intertemporal preferences (i.e., preferences about delayed rewards). In the present study, we instead investigated the preferences of small groups of individuals asked to express collective intertemporal decisions. The paradigm consisted of three phases. During the precollaboration and postcollaboration phases, participants completed an intertemporal decision task individually. During the collaboration phase, participants completed a similar task in small groups, reaching mutually-agreed-upon decisions. The results suggest that group preferences were systematically related to the mean of the group members' precollaboration preferences. In addition, collaborative decision making altered the group members' intertemporal preferences. Specifically, individuals' postcollaboration preferences converged toward the preferences of their respective groups. Furthermore, we found that individuals' postcollaboration preferences were independently related to both their precollaboration preferences and the preferences of the other group members, suggesting that individuals' postcollaboration preferences represented a revision of their precollaboration preferences based on the preferences observed in other group members. In Experiment 2, we demonstrated that similar patterns of results were found whether participants were making matching judgments or binary choices.

Keywords Collaboration · Social influence · Intertemporal preferences · Decision making

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Intertemporal preferences

Choices often have to be made between alternatives that have outcomes at different times in the future. For example, an individual may choose going to college instead of getting a job after high school, believing that achieving a college degree, though costly in the short term, will have greater benefits over the long-term. Such trade-offs between time and reward are referred to as intertemporal choices. The literature on intertemporal choice has paid particular attention to the finding that decision makers discount the value of delayed rewards (e.g., Myerson, Green, Hanson, Holt, & Estle, 2003; Rachlin, Raineri, & Cross, 1991). That is, the subjective value of a reward decreases as its delivery is increasingly delayed (for reviews, see Frederick, Loewenstein, & O'Donoghue, 2002; Luhmann, 2009).

Research on intertemporal choice in both psychology and economics has primarily focused on decisions made by individuals. This line of research has provided substantial information about individuals' intertemporal preferences and how they relate to other real-world behaviors. For example, prior research has demonstrated that individual differences in laboratory intertemporal choice tasks are associated with many consequential behaviors, including alcoholism (Petry, 2001; Vuchinich & Simpson, 1998), drug use and abuse (Kirby, Petry, & Bickel, 1999), pathological gambling (Alessi & Petry, 2003; MacKillop, Anderson, Castelda, Mattson, & Donovick, 2006), credit card borrowing (Meier & Sprenger, 2010), income (Green, Myerson, Lichtman, Rosen, & Fry, 1996), academic performance (Kirby, Winston, & Santiesteban, 2005), and dietary and exercise habits (Bradford, 2010).

The emphasis on intertemporal decisions made by individuals is potentially problematic, however, because many real-world decisions are made by groups of two or more decision

makers. For instance, a couple might jointly determine what portion of their discretionary income to designate for consumption and what portion they want to save. Similarly, individuals often discuss the costs and benefits associated with various short- and long-term investment options in consultation with a financial advisor. Because past research has focused on the intertemporal preferences of individuals, little is known about how such collaborative decision making might influence intertemporal decisions. The present study was designed to provide insight into this important question. The paradigm consisted of three phases. During the precollaboration and postcollaboration phases participants completed an intertemporal decision task individually. During the Collaboration phase participants completed a similar task in small groups, reaching mutually agreed-upon decisions. These groups consisted of three members in Experiment 1 and dyads in Experiment 2. The three phases of the present paradigm allowed us to explore two primary research questions: (1) how do the intertemporal preferences of individual group members shape the preferences exhibited by their collaborative group, and (2) how does the experience of collaborative decision making subsequently influence group members' individual intertemporal preferences?

Collaborative decision making

Though collaborative decision making has not been extensively studied in the context of intertemporal decisions, there is a large literature on group decision making in other domains. As a result, we first review research on collaborative decision making more broadly. Much of this research stemmed from the study of group polarization, which refers to the tendency of group members' attitudes (e.g., attitudes regarding capital punishment) to shift toward one extreme following group interaction and discussion (e.g., Moscovici & Zavalloni, 1969; Myers & Lamm, 1976). Early research on group polarization mainly focused on what has been referred to as the risky choice shift, which is the finding that a group will make riskier choices than the group members would make as individuals (Gardner & Steinberg, 2005; Johnson, Stemler, & Hunter, 1977; Wallach, Kogan, & Bem, 1964; but see Zajonc, Wolosin, Wolosin, & Sherman, 1968). Two broad classes of theories have been proposed to explain group polarization. The first is a social comparison process, which suggests that choice shifts and attitude polarization occur because individuals adjust their behavior in order to be perceived more positively by other group members (Blascovich, Ginsburg, & Veach, 1975; Goethals & Zanna, 1979). The second class of theory involves persuasive argumentation, which states that choice shifts and attitude polarization occur in response to the amount and quality of the arguments provided by the members of the group (Burnstein, Vinokur, & Trope, 1973; Vinokur & Burnstein, 1974). Isenberg's (1986) survey of the literature and meta-analysis suggested that social comparison processes and persuasive argumentation are independent of one another, but in certain contexts can act to jointly produce group polarization.

The research on group polarization has primarily focused on how decisions made by groups are systematically different from the decisions of the group's individual members. Less attention has been devoted to exploring whether collaborative experiences influence the behavior of individuals (i.e., changes between pre- and postcollaborative behavior). As others have noted (Schultze, Mojzisch, & Schulz-Hardt, 2012), this is problematic because it can lead to faulty assumptions and inaccurate theories of group decision making. For instance, the superiority of groups to individuals in completing quantitative judgment tasks may not be due to groups utilizing a differential weighting scheme (e.g., Sniezek & Henry, 1989, 1990), but may instead be due to group members learning from one another during collaboration and increasing their capabilities as a result (Schultze et al., 2012). Moreover, a better understanding of how collaborative experiences carry over to influence individual decision making has real-world importance, because the duration of many collaborative experiences is often relatively brief when compared to the potential lifetime of decisions individuals will make after a collaborative experience ends. For instance, an individual may meet with a financial advisor to discuss various investment options (an example of a "judge-advisor system"; Schrah, Dalal, & Sniezek, 2006), but the duration of this meeting will be much shorter than that of the many investment decisions the individual will go on to make following the meeting.

The concerns of Schultze et al. (2012) are particularly compelling because older work on group conformity has shown that social contexts can exert strong influences on individual behavior (Cialdini & Goldstein, 2004). For example, Asch (1956) famously found that individuals' stimulus discrimination judgments conformed to other group members' judgments. However, the reason it is important to include postgroup individual sessions in these paradigms is to demonstrate whether conformity during the group session is solely due to social pressure or whether individual group members' opinions and decision preferences are in fact changing as a result of social influence. Prior research suggests that at least certain conformity effects can carry over to subsequently influence individuals' behavior. For instance, in the classic experiments exploring the influence of social norms on perceptual judgments, Sherif (1936) found that observing the judgments of others led to the convergence of group members' judgments. That is, individual group members' perceptual judgments were more related to each other postcollaboratively than they were initially (i.e., precollaboratively).

However, there are reasons to believe that economic preferences, and intertemporal preferences in particular, may not be susceptible to the collaborative influences reported in this older literature. First, past work on conformity has frequently focused on decisions that entailed a large degree of response

uncertainty (e.g., the perceptual judgments in the autokinetic tasks of Sherif, 1936). Intertemporal preferences, in contrast, are conceptualized as an extremely stable property of an individual, with an individual's intertemporal decisions being similar across different contexts and goods (e.g., money, food; Odum, 2011) and over timespans as long as a year (Kirby, 2009). Second, other work in the collaborative decision making literature, such as group polarization, has focused on behavior that is known to be labile and/or susceptible to social pressure (e.g., attitudes, opinions). Conversely, past work has demonstrated that intertemporal preferences are extremely resistant to even deliberate influence, requiring elaborate instructions about normative behavior (Senecal, Wang, Thompson, & Kable, 2012) or long training/treatment periods (e.g., Bickel, Yi, Landes, Hill, & Baxter, 2011; Black & Rosen, 2011; Landes, Christensen, & Bickel, 2012).

Recognition of these empirical gaps has led to a small number of recent studies examining how collaboration influences individual group members' economic decision making. Typically, such influence is detected by having a precollaboration and postcollaboration phase during which participants make decisions individually. These individual decision making phases allow researchers to observe whether and how the experience of collaboration shifts individuals' decisions between the precollaboration and postcollaboration phases. These studies have explored decision making across various domains, including allotment decisions in the dictator game (Cason & Mui, 1997; Luhan, Kocher, & Sutter, 2009), cooperation in a prisoner's dilemma (Hopthrow & Abrams, 2010), and risk preferences (Deck, Lee, Reyes, & Rosen, 2012). Despite these studies involving different types of decisions and contexts, individuals' decisions have generally been observed to be influenced by the collaborative decision-making experience. For example, Hopthrow and Abrams found that individuals making decisions in a prisoner's dilemma became more cooperative following collaboration. Furthermore, these changes appear to be durable, including measurable effects observed five weeks later on reasoning tasks such as the Wason selection task (Maciejovsky, Sutter, Budescu, & Bernau, 2013). However, because of the different natures of the above decisions, it is difficult to predict how these results might inform collaborative intertemporal decisions. At the very least, though, such work does suggest that collaborative contexts may have the ability to subsequently influence the intertemporal preferences of individual group members.

Social influences on intertemporal decision making

Though collaborative intertemporal decision making is a relatively unexplored research topic, some recent research has demonstrated that intertemporal preferences are sensitive to social context (e.g., Charlton et al., 2013). Specifically, individuals making choices for themselves behave differently than when they are asked to make such choices on behalf of others. For example, it has been found that individuals are more patient when making choices for someone else than when they are making choices for themselves (Albrecht, Volz, Sutter, Laibson, & von Cramon, 2011; but see Weatherly & Ruthig, 2013). Ziegler and Tunney (2012) went on to find that this self–other asymmetry increases as the social distance between the decision maker and the "other" increases. That is, intertemporal choices were less patient when the referent "other" was socially close (e.g., parent, sibling), and more patient when the "other" was socially distant (e.g., unrelated stranger). These results demonstrate that intertemporal preferences may depend, in part, on social factors such as who is receiving the delayed rewards (see also Albrecht, Volz, Sutter, & von Cramon, 2013). However, self–other intertemporal decisions and collaborative intertemporal decisions differ in that the former still reflect the preferences of an individual decision maker.

The present study focused on intertemporal decisions made in a collaborative context, and consisted of two research questions. The first research question was to understand how the intertemporal preferences of individual group members shape the preferences exhibited by their collaborative group. A second research question was to determine whether the experience of collaborative decision making subsequently influences individuals' intertemporal preferences. That is, to what extent does observing the preferences of others in a social context subsequently influence the preferences of individual group members?

Experiment 1

To accomplish the two research questions mentioned above, the participants in Experiment 1 completed three decision phases. In the first phase, participants completed an intertemporal decision task individually (the precollaboration phase). Participants were then placed into groups of three and asked to complete a similar task, with the group arriving at a single, consensual decision on each trial (the collaboration phase). Finally, participants once again completed the decision task individually (the postcollaboration phase). This final phase allowed us to measure how the experience of collaborative decision making subsequently influenced the intertemporal preferences of individual group members.

Method

Participants

The participants were 61 Stony Brook University undergraduate students who participated in exchange for partial course

credit. Participants completed the study in 19 three-person groups and one four-person group.[1]

Materials

The study consisted of three phases: precollaboration, collaboration, and postcollaboration. In all three phases, participants completed an intertemporal decision task. In the pre- and postcollaboration phases, this task was performed individually. In the collaboration phase, the task was performed as a group.

The intertemporal decision task used in the present study was similar to matching tasks that have been used to elicit intertemporal preferences in previous studies (e.g., Chapman, 1996; Malkoc & Zauberman, 2006; Thaler, 1981). On each trial of the task, two reward items were displayed on the computer screen. The reward items included a magnitude (in dollars) and a delay until the reward would be received (in months). Importantly, each trial omitted one of the two reward magnitudes. Participants' task was to supply this missing reward magnitude with a value that would render them indifferent between the two reward items. That is, if given a choice between the two completed reward items, participants should not have a preference for one or the other.

The decision task included two factors that produced four trial types. The first factor was whether an immediate reward was present or not on a trial. For half of the trials, the less delayed reward item would be received today, whereas for the other half of the trials the less delayed reward item would be received in the future. The second factor was whether the missing reward magnitude that participants had to supply on a trial was for the less or the more delayed reward item. Because we were not interested in the influence of trial type, all results reported below are collapsed across trial types.

Trials in the precollaboration and postcollaboration phases were constructed using four reward magnitudes ($30, $75, $150, and $275) and three delays (3, 6, and 12 months). For the trials that included an immediate reward, the delays for the two reward items were a reward to be received today and a reward to be received at one of the three delays listed above. For the trials that did not include an immediate reward, the delays for the two reward items involved two of the three delays listed above (i.e., 3 vs. 6 months, 3 vs. 12 months, and 6 vs. 12 months). With the four trial types described above, this yielded 48 trials that were presented during the precollaboration and postcollaboration phases.

Trials in the collaboration phase were constructed using three reward magnitudes ($40, $125, and $250) and three delays (3, 6, and 12 months). With the four trial types described above, this yielded 36 trials that were presented during the collaboration phase. Within each phase of the study, trials were presented in a randomized order. Different reward magnitudes were used during the collaboration phase to prevent individuals in the postcollaboration phase from simply reiterating the exact responses their group had made during the collaboration phase.

[1] Excluding the one four-person group's data did not alter any of the reported results.

Statistical analyses

Participants' responses on each trial were converted to annual discount rates by using Eq. 1 (Zauberman, Kim, Malkoc, & Bettman, 2009):

$$r = \left[\ln\left(\frac{X_{t+\mathrm{h}}}{X_t}\right)\right]\left[\frac{\mathrm{h}}{12}\right]^{-1} \quad (1)$$

where X_t is the magnitude of the sooner-reward item, X_{t+h} is the magnitude of the later-reward item, t is the delay associated with the sooner-reward item, and h is the additional delay associated with the later-reward item. In the present task, participants provided X_{t+h} on trials that involved deferring a reward, whereas they provided X_t on trials that involved expediting a reward. Higher discount rates imply greater devaluing of delayed rewards (i.e., greater impatience). Overall discount rates were calculated for each individual participant and group by computing the discount rates implied by each response, and then averaging the resulting set of discount rates.

Procedure

Once all group members had arrived to the lab, participants received instructions regarding the intertemporal decision task in both verbal and written formats. Participants were not alerted to the fact that they would be collaborating with other participants. After receiving the instructions, participants were escorted to individual computer workstations where they completed the precollaboration phase of the study. On each trial, the two reward items were displayed on the left and right sides of the computer screen for 5 s. A small dialog box then appeared at the bottom of the computer screen into which participants entered their responses. The two reward items remained on the screen after the dialog box appeared and participants had unlimited time to enter in their responses. Once participants had entered a response and selected the "OK" button, the computer screen was cleared and remained blank for a 2-s intertrial interval (ITI). 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. Participants were also provided with the following instructions:

> As a group, you will only provide one answer on each trial. So you will have to come to a consensus for the reward amount that would lead to equal liking of the two

items on the screen. Now, you may disagree about the amount that makes the two items on the screen liked equally, but in these situations we would like you to discuss it as a group so that your answer is an amount that the group is satisfied with.
Also, even though you are making judgments as a group, imagine that 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.

After receiving these instructions, the group of participants was escorted to a single computer workstation where the collaboration phase of the study was performed. Upon completion, participants were instructed that they would again be completing a similar decision task, but once again individually. Participants were then escorted back to the same individual computer workstations and completed the postcollaboration phase of the study. The entire study took less than 1 h to complete.

Results

As a preliminary analysis, we first explored whether intertemporal preferences varied across the three phases of the experiment. Because of the previous research on group polarization (Isenberg, 1986), it was important to first investigate whether groups were systematically more or less patient than individuals. The average discount rate across group members during the precollaboration phase was 2.423 (SD = 0.55). Across groups during the collaboration phase, the average discount rate was 2.418 (SD = 0.75). Finally, the average discount rate across group members during the postcollaboration phase was 2.475 (SD = 0.73). Discount rates did not differ significantly across the three phases [all ts(19) < 1, ps > .05]. This means that groups were just as patient as individuals (on average), and individuals were just as patient (on average) before the collaborative experience as they were after (but see section "Group convergence" below for observed group convergence results).

We next investigated whether we could predict the discount rates of the groups themselves. We did so by first averaging group members' discount rates during the precollaboration phase. These averages were strongly correlated with the group discount rates derived from the collaboration phase (r = .77, p < .001). This means that group members exhibiting high [or low] discount rates during the precollaboration phase tended to produce groups that exhibited a high [or low] discount rate during the collaboration phase. Moreover, this strong correlation suggests that an averaging effect occurred during the collaboration phase, in which groups attempted to average together the intertemporal preferences of the individual group members and to produce responses that approximated the mean of the group members' precollaboration preferences. This averaging effect begins to answer the first research question mentioned above (section "Social influences on intertemporal decision making"), in which we sought to understand how the intertemporal preferences of individual group members shape the preferences exhibited by their collaborative group.

Group convergence

The second research question of the present study was to determine whether a collaborative decision-making experience would alter individuals' intertemporal preferences. Given that group decisions did not differ from those of the constituent individuals (i.e., arguing against polarization), we next explored whether individuals' postcollaboration decisions would come to resemble the decisions made by their groups during the collaboration phase (i.e., a convergence effect). Figure 1 includes two illustrative groups exhibiting convergence.

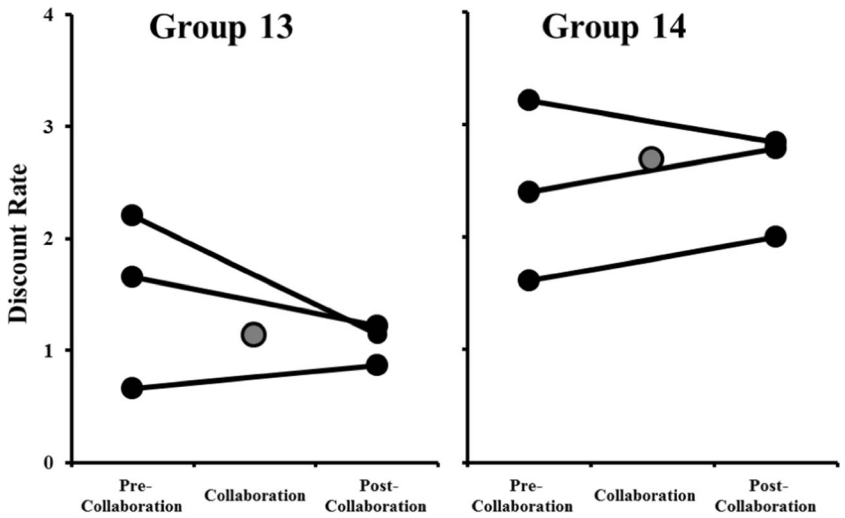

Fig. 1 Two illustrative groups' discount rates during the precollaboration phase, the collaboration phase, and the postcollaboration phase in Experiment 1.

To evaluate this convergence effect statistically, 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. If collaborative decision making led to convergence in group members' subsequent intertemporal preferences, the average of these difference scores should be smaller for the postcollaboration phase than for the precollaboration phase.

The average absolute difference between the postcollaboration discount rates and the collaboration discount rates ($M = .48$, $SD = .32$) was smaller than the average absolute difference between the precollaboration discount rates and the collaboration discount rates ($M = .75$, $SD = .32$) [$t(19) = 3.84$, $p < .01$]. This means that group members' discount rates shifted between the pre- and postcollaboration phases. Specifically, group members' discount rates during the postcollaboration phase converged toward their respective group's discount rate expressed during the collaboration phase (Fig. 2).[2]

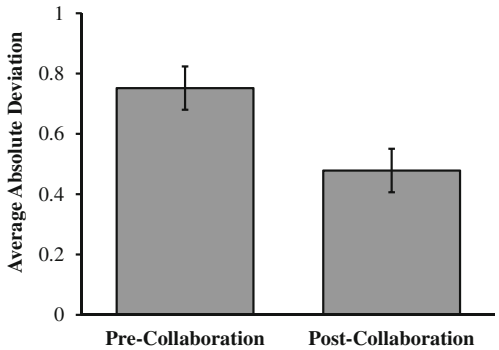

Fig. 2 Convergence results from Experiment 1: The average absolute deviations between discount rates in the precollaboration/postcollaboration phases and groups' discount rates during the collaboration phase. Discount rates during the postcollaboration phase converged toward groups' discount rates during the collaboration phase

Predicting individuals' postcollaboration discount rates

The following analysis focuses on predicting the decisions made by individuals during the postcollaboration phase. This contrasts with the analyses in section "Group convergence", in which behavior during the pre- and postcollaboration phases was primarily averaged across group members. By the time individual participants had reached the postcollaboration phase of the study, they had made individual intertemporal decisions during the precollaboration phase and as part of a group during the collaboration phase. To more thoroughly understand the origin of the effects reported above, we next explored how individuals' postcollaboration decisions were related to their precollaboration decisions and to the decisions made by their respective groups. If these two factors exerted independent influences, it would suggest that individuals' postcollaboration preferences represented a revision of their precollaboration preferences and that this revision was based on the preferences observed in the other group members.

A multiple regression analysis was performed to evaluate whether the individual discount rates during the precollaboration phase and the discount rates of other group members during the precollaboration phase predicted the individual discount rates during the postcollaboration phase.[3] The multiple regression analysis included individuals' precollaboration discount rates and the average of the other group members' precollaboration discount rates as predictor variables, and the postcollaboration discount rates as the criterion variable. The overall model accounted for a significant proportion of the variance in postcollaboration discount rates ($R^2 = .53$) [$F(2, 19) = 8.12$, $p < .01$]. Furthermore, both a participant's precollaboration discount rate and the precollaboration discount rates of the other group members accounted for unique proportions of the variance in the postcollaboration discount rates (see Table 1).

Discussion

The results from Experiment 1 begin to provide answers to the two research questions mentioned in the introduction (section "Social influences on intertemporal decision making"). First, the intertemporal preferences exhibited by a collaborative group fell between the extremes of the highest and lowest

[2] We note that a potential concern regarding the convergence effect reported above is that it could simply reflect a regression-to-the-mean process. That is, individuals may have converged because discount rates became less extreme over time (independent of any collaborative experience). Aspects of the present results suggest that this was not the case. For example, the results shown in Fig. 2 are differences between precollaboration/postcollaboration discount rates and group members' *respective* collaboration discount rates, whereas the regression-to-the-mean explanation suggests that the postcollaboration discount rates should converge to the mean of all groups' collaboration discount rates (i.e., a grand statistical mean). However, the precollaboration discount rates were no closer to the overall mean than were the postcollaboration discount rates. Specifically, the average absolute difference between the postcollaboration discount rates and the mean of all groups' discount rates during the collaboration phase ($M = .71$, $SD = .41$) was indistinguishable from the average absolute difference between the precollaboration discount rates and the mean of all groups' discount rates during the collaboration phase ($M = .73$, $SD = .31$) [$t(19) < 1$, $p > .80$]. Thus, we conclude that individuals' postcollaboration discount rates were not simply regressing toward a mean, but were instead converging toward their *respective* groups' discount rates following the social interaction that occurred during the collaboration phase.

[3] In this and all following regression analyses, standard errors were clustered by groups.

Table 1 Experiment 1: Postcollaboration discount rates predicted by each individual participant's precollaboration discount rate (Self) and the average of the other group members' precollaboration discount rates (Other)

Variable	*b*	*SE*	*β*	*t*	*p*
Intercept	.04	.61		0.07	.946
Self	.67	.17	.71	3.99	.001
Other	.33	.15	.24	2.24	.038

Overall R^2 = .532. Standard errors were clustered by groups.

discounters of the group (as measured by the group members' precollaboration discount rates). This averaging effect was also evidenced by a strong correlation between the mean of the group members' precollaboration discount rates and the discount rate exhibited by the group during the collaboration phase. Second, a convergence effect was observed in which the group members' individual intertemporal preferences during the postcollaboration phase were more similar to group preferences exhibited during the collaboration phase than they had initially been during the precollaboration phase.

A regression analysis (section "Predicting individuals' postcollaboration discount rates") demonstrated that individuals' precollaboration discount rates and the precollaboration discount rates of their respective group members exerted unique influences on the postcollaboration discount rates. This result suggests that individuals' postcollaboration preferences represented a revision of their precollaboration preferences, and that this revision was based on the preferences observed in the other group members during the collaboration phase. As a result, it appears that interacting with other individuals in a social context, even one as brief as the collaboration phase in the present study, can exert significant influences on an individual's intertemporal preferences.

Experiment 2: Matching and choice tasks

The general design of Experiment 2 was similar to that of Experiment 1, in that there were once again a precollaboration phase, a collaboration phase, and a postcollaboration phase. However, half of the participants in Experiment 2 completed an intertemporal matching task similar to the task used in Experiment 1, whereas the other half completed a binary intertemporal choice task. In binary choice tasks, participants simply have to make a choice between a smaller–sooner reward and a larger–later reward. Important distinctions between matching and choice tasks can lead to different effects being observed in collaborative intertemporal contexts. For instance, the matching task used in Experiment 1 allowed for continuous responses. This allowed participants to compromise during the collaboration phase by providing a response that was some function (e.g., the average) of each member's desired response. In a choice task, in contrast, averaging divergent binary choices is not feasible.

The addition of a binary choice task in a collaborative intertemporal experiment is critical for the following two reasons. First, as we alluded to in the previous paragraph, different psychological processes are involved during choice and judgment tasks (Einhorn & Hogarth, 1981; Hardisty, Thompson, Krantz, & Weber, 2013; Huber, Ariely, & Fischer, 2002), which becomes especially apparent in a collaborative context. Because groups can no longer simply combine the heterogeneous responses of their members, some group members may need to persuade other members to switch their responses if a disagreement exists. The social/psychological processes that influence collaborative intertemporal choices are unknown at this time. Second, choice tasks are a common paradigm for eliciting intertemporal preferences in both psychology and economics. As a result, any direct comparisons between the results of the present study and prior research on the intertemporal preferences of individuals would be aided by incorporating a choice task. The differences in processes between choice and matching tasks are not just relevant for research conducted in the lab, however. Various real-world situations involve intertemporal decisions that are more continuous in nature (e.g., deciding the specific amount of income to allot toward savings), whereas in other situations choices need to be made between preestablished items (e.g., defined-retirement-contribution plans). As a result, a complete picture of collaborative intertemporal preferences will require research conducted using both methodologies.

Experiment 2 also included a posttask questionnaire designed to capture individual differences in the extents that participants were influenced by the collaborative experience. One individual difference we were particularly interested in was decision confidence. The observed social influences on intertemporal preferences in Experiment 1 might stem from individuals having a degree of uncertainty about their preferences (Ariely, Loewenstein, & Prelec, 2003). Prior research in the conformity literature has found that uncertainty increases social influences on behavior (e.g., Tesser, Campbell, & Mickler, 1983; Walther et al., 2002; Wiener, 1958). This effect of uncertainty has been found in a variety of decisions, from stimulus discrimination tasks (Tesser et al., 1983) to recognition memory tasks (Walther et al., 2002). The results of Experiment 1 demonstrated that this type of effect can possibly be observed even in higher-order, cognitive behaviors, such as intertemporal decisions. In Experiment 2, participants provided self-reported confidence in their precollaboration decisions. As a result, we were able to directly gauge whether individual differences in confidence about one's behavior, among other things, predict the extent that an individual's intertemporal preferences are influenced by a collaborative experience.

Finally, in Experiment 2, participants completed the decision-making task during the collaboration phase in groups of two. This contrasted with Experiment 1, in which participants had completed the collaboration phase in groups of three. Having groups consist of two individuals allowed the opportunity to see how the results of Experiment 1 would extend to dyadic social interactions.

Method

Participants

Experiment 2 consisted of 120 undergraduate students participating in exchange for partial course credit. The sample consisted of 30 dyads completing the matching task and 30 dyads completing the binary choice task. Participants' average age was 19.74 years (*SD* = 1.95), and 59% of the sample was female.

Materials

Matching task The matching task was similar to the task used in Experiment 1, with the following exceptions. The trials in all three phases were constructed using four reward magnitudes ($20, $35, $50, and $75) and three delays (14, 30, and 60 days). With the four trial types also used in Experiment 1, this yielded 48 trials that were presented during each phase. For the nonimmediate trials, 30 days were added to each of the delays above. The reward magnitudes and delays were altered from the values used in Experiment 1 in order to more closely align with the values used in the choice task described below.

Choice task On each trial, a smaller–sooner reward and a larger–later reward were presented on the computer screen. See the Appendix for a complete listing of the reward values that were included in the task. The task consisted of 48 trials. Half of the trials required a choice between an immediate reward and a delayed reward, whereas the other half of trials required a choice between two delayed rewards. Prior research had demonstrated that intertemporal preferences differ when an immediate reward is present (e.g., Green, Myerson, & Macaux, 2005), so the inclusion of both types of trials was important to ensure that any observed effects were robust.

Whether the smaller–sooner reward or the larger–later reward was presented on the left side of the screen was randomized on each trial. The two reward items remained on the screen until participants had made their choices, which were accomplished by pressing the left or the right arrow on the computer keyboard. Once a choice was made, the computer screen was cleared and remained blank for a 2-s ITI. Within each phase of the experiment, trials were presented in a randomized order.

Posttask questionnaire Upon finishing the postcollaboration phase of the study, participants completed a questionnaire. The questionnaire items were designed to capture individual differences that were expected to inform who would be more or less affected by a collaborative experience. The following eight items were included in the questionnaire (words in square brackets reflect the instructions for the matching task/choice task):

1. In the first phase of the study, when you were [responding/making choices] individually for the first time, how confident were you when you were making your [responses/choices]? (1 = *Not confident*, 7 = *Confident*)
2. In the first phase of the study, when you were [responding/making choices] individually for the first time, how much did you believe there was a "correct" [response/choice] on each trial? (1 = *Didn't believe*, 7 = *Believed*)
3. When you and your partner were [responding/making choices] together, to what degree did you notice the [responses/choices] you and your partner wanted to make differed from each other? (1 = *Differed*, 7 = *Were the same*)
4. When you and your partner were [responding/making choices] together, how influenced were you by your partner? (1 = *Not influenced*, 7 = *Influenced*)
5. When you and your partner were [responding/making choices] together, were you ever nervous that your partner would judge you based on the [responses/choices] you wanted to make? (1 = *No*, 7 = *Yes*)
6. When you and your partner were [responding/making choices] together and you disagreed on a trial, who usually had the most influence on the [response/choice] that was ultimately made? (1 = *You*, 2 = *Equally influential*, 3 = *Your partner*)
7. In the final phase of the study, when you were [responding/making choices] individually for the second time, did you feel you were [responding/making your choices] similarly or differently from the first phase? (1 = *Similarly*, 7 = *Differently*)
8. In the final phase of the study, when you were [responding/making choices] individually for the second time, do you believe your [responses/choices] were influenced by the interaction with your partner? (1 = *Not influenced*, 7 = *Influenced*)

Procedure

The procedure during Experiment 2 was the same as that in Experiment 1, with the following exceptions. Participants were provided with the following instructions before the collaboration phase (words in brackets reflect instructions for the choice task):

As a pair, you will only make one response [choice] on each trial. So you will have to come to an agreement about the reward amount that would lead to equal liking of the two items on the screen [the reward that is most preferred]. Now, you may disagree on a trial about the amount that makes the two items on the screen liked equally [about which of the two rewards is most preferable], but in these situations we would like you to discuss it as a pair so that you can reach a response [choice] that both of you are satisfied with.

Also, even though you are making judgments [choices] as a pair, imagine that the rewards would be received individually. That is, if one of the reward items is $60 to be received in 30 days, that $60 would not be divided between you two, but would be received individually.

After completing the final trial of the postcollaboration decision-making task, a 2-s ITI occurred. The eight self-report questions were then presented on the screen one at a time. Participants used the numbers at the top of the keyboard to enter their responses. The entire experiment took less than 1 h to complete.

Statistical analyses

For the matching task, annual discount rates were calculated by using Eq. 1 with the following modification: Because the units of delay in Experiment 2 were days, the difference between the two delays was divided by 365 instead of 12.

For the choice task, we calculated the proportion of choices for the smaller–sooner reward. As a result, scores ranged from 0 to 1, with higher scores providing evidence of greater delay discounting.

Results

Given the results from Experiment 1, we were particularly interested in exploring whether the averaging effect and the convergence effect would be observed in different task environments. The *averaging effect* refers to the finding that group preferences during the collaboration phase were strongly predicted by the mean of the individual group members' preferences during the precollaboration phase. The *convergence effect* refers to the finding that the group members' individual preferences were more similar during the postcollaboration phase than they initially had been during the precollaboration phase.

Averaging effect

As is shown in Fig. 3, the preferences exhibited by dyads during the collaboration phase were significantly related to the means of the dyad members' individual preferences measured during the precollaboration phase. This averaging effect was demonstrated in both the matching task ($r = .94$, $p < .001$) and the choice task ($r = .77$, $p < .001$). These results suggest that dyadic intertemporal preferences were strongly related to the average preferences of the dyad members in both matching and choice environments, replicating and extending the findings of Experiment 1.

Convergence effect

As is shown in Fig. 4 (left), the average difference between dyad members' discount rates on the matching task was larger during the precollaboration phase ($M = 6.56$, $SD = 5.17$) than during the postcollaboration phase ($M = 3.03$, $SD = 4.04$) [$t(29) = 4.27$, $p < .001$]. Similarly, for the choice task (see

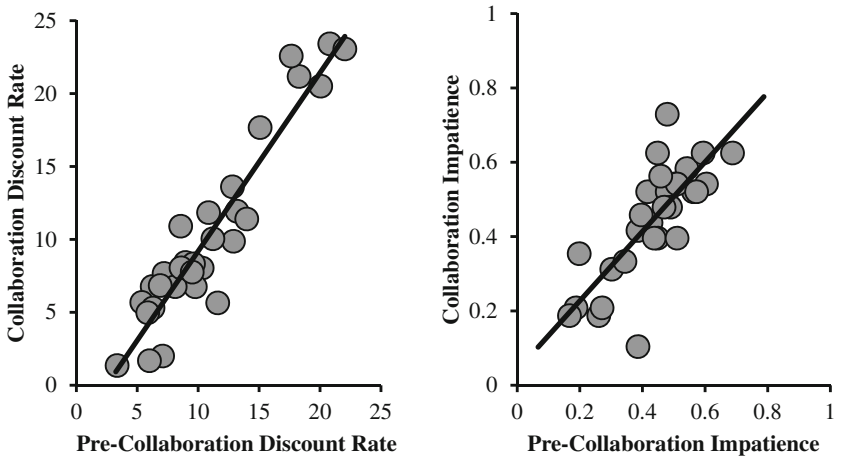

Fig. 3 Relationship between the means of dyad members' individual preferences during the precollaboration phase and the dyadic preferences during the collaboration phase in Experiment 2. The results from the matching task are on the left, and the results from the choice task are on the right

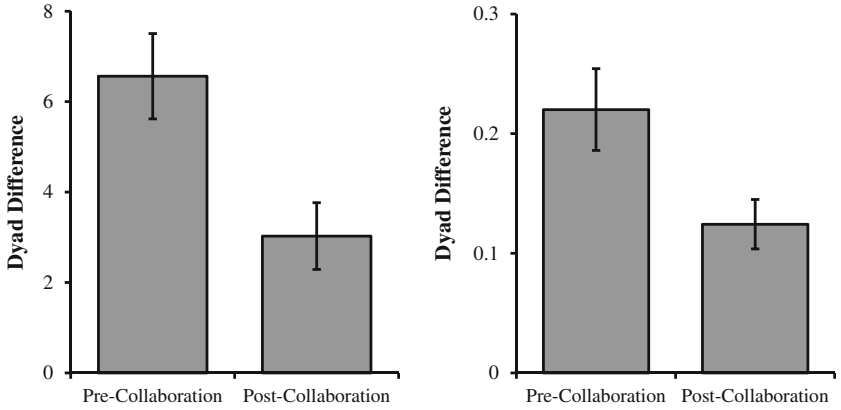

Fig. 4 Convergence results from Experiment 2: Average differences between dyad members' preferences during the precollaboration and postcollaboration phases. The results from the matching task are on the left, and the results from the choice task are on the right. Error bars represent standard errors of the means

Fig. 4, right), the average difference between dyad members' preference for the smaller–sooner reward was larger during the precollaboration phase (M = .22, SD = .19) than during the postcollaboration phase (M = .12, SD = .11) [$t(29) = 3.37$, $p < .01$]. These results demonstrate that the intertemporal preferences of dyad members were more similar following a collaborative experience than before that experience, replicating and extending the findings of Experiment 1.

Predicting individuals' postcollaboration preferences

The following analyses focused on the decisions made by individuals during the postcollaboration phase. Specifically, we explored how individuals' postcollaboration decisions were related to their precollaboration decisions and the decisions made by their collaborative partner. If these two factors exerted independent influences, as we had observed in Experiment 1, it would suggest that individuals' postcollaboration preferences represented a revision of their precollaboration preferences, and that this revision was based on the preferences observed in the other dyad members.

Matching task A multiple regression analysis was performed that included individuals' precollaboration discount rate and the precollaboration discount rate of their respective dyad partner as predictor variables, and the postcollaboration discount rate as the criterion variable. The overall model accounted for a significant proportion of the variance in postcollaboration discount rates (R^2 = .77) [$F(2, 29) = 70.73$, $p < .001$]. Furthermore, both participants' precollaboration discount rate and the precollaboration discount rate of their respective dyad partner accounted for unique proportions of the variance in postcollaboration discount rates (see Table 2).

Choice task An identical multiple regression analysis was performed that included individuals' and their respective dyad partners' preferences for the smaller–sooner reward during the precollaboration phase as predictor variables, and postcollaboration preferences for the smaller–sooner reward as the criterion variable. The overall model accounted for a significant proportion of the variance in postcollaboration preferences (R^2 = .64) [$F(2, 29) = 128.37$, $p < .001$]. Furthermore, both participants' precollaboration preferences and the precollaboration preferences of their respective dyad partner accounted for unique proportions of the variance in postcollaboration preferences (see Table 2).

The moderating role of confidence

In Experiment 2, participants self-reported their confidence in their precollaboration decisions (Item 1 in the posttask questionnaire). As a result, we were able to explore whether self-reported confidence moderated social influence on decision making.

Matching task To evaluate whether confidence moderated the social influence on changes in discount rates, we performed a multiple-regression analysis. The criterion variable was the observed changes in participants' discount rates (i.e., the

Table 2 Experiment 2: Postcollaboration preferences predicted by individuals' precollaboration preferences (Self) and their dyad partners' precollaboration preferences (Other)

Variable	*b*	*SE*	*β*	*t*	*p*
Matching Task (Overall R^2 = .765)					
Intercept	−1.68	1.15		−1.46	.154
Self	.76	.07	.76	10.12	<.001
Other	.34	.10	.34	3.40	.002
Choice Task (Overall R^2 = .639)					
Intercept	–.05	.04		−1.11	.276
Self	.77	.06	.78	13.54	<.001
Other	.31	.08	.31	3.76	.001

Standard errors were clustered by groups.

difference between precollaboration and postcollaboration discount rates). The predictor variables included the difference between individuals' precollaboration discount rate and the precollaboration discount rate of their respective dyad partner (which we refer to as the *discrepancy*), the self-reported confidence in individuals' precollaboration judgments, and the interaction between these two variables. The overall model accounted for a significant proportion of the variance in changes in discount rates (R^2 = .59) [$F(3, 29) = 44.18$, $p < .001$]. Furthermore, both discrepancy and the interaction between discrepancy and self-reported confidence accounted for unique proportions of the variance in changes in discount rates (see Table 3).

The significant interaction between discrepancy and confidence suggests that confidence moderated the social influence on changes in discount rates. Specifically, decreased confidence led to an increased influence of the other dyad member's preferences (as measured by the discrepancy variable) on an individual's change in preferences from the precollaboration to the postcollaboration phase. The negative coefficient of the discrepancy variable suggests that individuals with precollaboration discount rates higher [vs. lower] than those of the other member of the dyad adjusted their discount rates downward [vs. upward] in the postcollaboration phase.

Choice task To evaluate whether confidence moderated the social influence on choices, we performed a multiple-regression analysis with the observed change in participants' choices as the criterion variable. The predictor variables included the differences between individuals' precollaboration preferences and the precollaboration preferences of their respective dyad partner (discrepancy), the self-reported confidence in individuals' precollaboration choices, and the interaction between these two variables. The overall model accounted for a significant proportion of the variance in changes in preferences (R^2 = .46) [$F(3, 29) = 17.94$, $p < .001$]. Furthermore, the discrepancy variable accounted for a unique proportion of the variance in changes in preference for the smaller–sooner reward, with the interaction between discrepancy and self-reported confidence reaching marginal significance (see Table 3).

Table 3 Experiment 2: Changes in preferences predicted by the difference between individuals' precollaboration preferences and the precollaboration preferences of their respective dyad partner (Discrepancy), self-reported confidence in precollaboration decisions (Confidence), and the interaction between the discrepancy and confidence variables (Discrepancy*Confidence)

Variable	*b*	*SE*	*β*	*t*	*p*
Matching Task (overall R^2 = .586)					
Intercept	–.74	.41		−1.83	.078
Discrepancy	–.34	.04	–.72	−8.99	<.001
Confidence	–.06	.21	–.02	−0.27	.791
Discrepancy*Confidence	.13	.02	.47	5.79	<.001
Choice Task (overall R^2 = .458)					
Intercept	.00	.02		0.11	.913
Discrepancy	–.33	.07	–.69	−4.97	<.001
Confidence	–.01	.01	–.10	−0.78	.444
Discrepancy*Confidence	.16	.09	.42	1.77	.087

The confidence variable was mean-centered before constructing the interaction term. Standard errors were clustered by groups.

The marginally significant interaction between discrepancy and confidence suggests that confidence moderated the social influence on changes in preference for the smaller–sooner reward. Specifically, decreased confidence led to an increased influence of the other dyad member's preferences (as measured by the discrepancy variable) on an individual's change in preferences from the precollaboration to the postcollaboration phase. The negative coefficient of the discrepancy variable suggests that individuals with precollaboration preferences for the smaller–sooner reward that were higher [vs. lower] than those of the other member of the dyad adjusted their preferences downward [vs. upward] in the postcollaboration phase.

Posttask questionnaire items

Responses to the eight posttask questionnaire items are included in Table 4. We explored whether the responses differed between the two task conditions. For Item 1, participants in the matching condition reported less confidence in their responses (M = 4.95, SD = 1.56) than did participants in the choice condition (M = 5.75, SD = 1.34) [$t(118) = 3.02$, $p < .01$]. For Item 3, participants in the choice condition thought their own choices were more similar to their partner's (M = 5.45, SD = 1.42) than did participants in the matching condition (M = 4.48, SD = 1.96) [$t(118) = 3.09$, $p < .01$]. Finally, the responses to Item 7 indicated that participants in the matching condition believed that their decisions in the postcollaboration phase were more different from those in the precollaboration phase (M = 3.57, SD = 1.85) than did participants in the choice condition (M = 2.80, SD = 1.80) [$t(118) = 2.30$, $p < .05$].

Discussion

By including task conditions involving both intertemporal matching and choice measures, we were able in Experiment 2 to observe the generalizability of the results from Experiment 1. Specifically, the results from Experiment 2 demonstrated that dyadic intertemporal preferences were strongly predicted by the average intertemporal preferences of the individual dyad members in both matching and choice task environments. Furthermore, in both conditions, a convergence effect was observed in which the intertemporal preferences of individual dyad members were more similar postcollaboratively than they had initially been precollaboratively.

Table 4 Means (and standard deviations) for the eight posttask questionnaire items for the two task conditions included in Experiment 2

Questionnaire Item	Matching Task	Choice Task
1. Confidence**	4.95 (1.56)	5.75 (1.34)
2. Belief in correct decision	3.60 (1.74)	3.82 (2.05)
3. Observed partner differences**	4.48 (1.96)	5.45 (1.42)
4. Influenced by partner during collaboration	4.32 (1.72)	3.88 (1.79)
5. Nervousness	2.97 (2.01)	2.55 (1.77)
6. Most influence in the dyad	1.97 (0.52)	1.98 (0.54)
7. Decisions differed postcollaboratively*	3.57 (1.85)	2.80 (1.80)
8. Postcollaboration decisions influenced by partner	4.25 (1.72)	3.73 (2.01)

See section "Materials" for a description of the eight posttask questionnaire items. Asterisks denote significant differences between the two task conditions: * $p < .05$, ** $p < .01$.

The nature of these two tasks makes the consistency of our results somewhat surprising. For example, when making a binary choice, it is not clear how compromise can be made on individual trials. That is, if one partner wishes to select the smaller–sooner reward and the other partner wishes to select the larger–later reward, what response represents a fair compromise? Moreover, individual choice trials during the collaboration phase provide less information about a decision maker's underlying preferences, making it difficult for individuals to learn about and subsequently adapt to their partner's preferences. Whereas the matching task's continuous response space allows dyad members to observe the degree that their intertemporal preferences diverge from one another, the most that can be learned on an individual choice trial is that one dyad member prefers one of the two rewards and that the other dyad member prefers the other reward. However, regardless of these task differences, similar results were found in both the matching and choice task conditions of Experiment 2. This similarity in results suggests a generality to the observed collaborative effects in intertemporal decision making.

Even though the patterns of results were similar in the two task conditions, there were differences in participants' experiences between the two conditions. This was evidenced by differences in their responses to items on the posttask questionnaires. For instance, participants in the matching condition were less confident in their responses during the precollaboration phase and were more likely to perceive change in their responses between the precollaboration and postcollaboration phases. These differences most likely stemmed from the different types of responses required by the two tasks. For example, slight shifts in the choice task would be less apparent to participants than would slight shifts in responses in the matching task. Furthermore, the precision required to produce a specific numeric value on each trial in the matching task might have made participants less confident in their responses than participants who were only asked to choose between two presented rewards in the choice task.

General discussion

How individuals resolve intertemporal trade-offs has been the focus of a long history of work, in large part due to the fact that such preferences inform a variety of critical, real-world behaviors. However, the focus on individual decision makers ignores the fact that many real-world intertemporal decisions involve a group of two or more individuals making consensual decisions through a collaborative process. In the present study, we sought to shed light on how the intertemporal preferences of individual group members shape the decisions of a group, as well as how the act of collaborative decision making influences individuals' subsequent intertemporal preferences. The results demonstrated that group members' precollaborative intertemporal preferences were strongly related to the preferences exhibited by their group during the collaboration phase; individuals exhibiting high discount rates during the precollaboration phase tended to produce groups that exhibited a high discount rate during the collaboration phase. Furthermore, individuals' intertemporal preferences were altered as a result of the collaborative decision-making experience. Specifically, individuals' preferences converged toward the preferences exhibited by their fellow group members. Experiment 2 demonstrated that similar patterns of results could be observed whether participants were making matching judgments or binary choices.

Individuals' postcollaboration preferences were independently related to both their precollaboration preferences and the precollaboration preferences of their respective group members. These results suggest that individuals' ultimate preferences represented a revision of their initial preferences based on the preferences observed in other group members. This malleability appears to provide evidence against strong versions of the claim that intertemporal preferences are a stable property of individuals, which stands in contrast to the common conception of decision-related preferences and intertemporal preferences specifically. For example, it has

been argued (Odum, 2011) that intertemporal preferences meet the criteria for traithood. Moreover, the test–retest reliability of discount rates has been found to be high (Beck & Triplett, 2009; Black & Rosen, 2011), even over intervals of one week (Simpson & Vuchinich, 2000) and one year (Kirby, 2009). However, the present results suggest that individuals' intertemporal preferences can be systematically manipulated, and rather easily. Previous research had suggested that discount rates can be modulated; however, these prior reports had employed somewhat forceful manipulations. For example, one study (Black & Rosen, 2011) utilized a 36-week money management intervention and another (Senecal et al., 2012) utilized explicit instructions about how a normative decision maker ought to make intertemporal choices. In contrast, the shifts in intertemporal preferences observed in the present study were derived from the simple act of collaborative decision making and the observation of others' intertemporal preferences.

Why did collaborative decision making lead to subsequent shifts in individuals' intertemporal preferences? As we discussed earlier, persuasive argumentation and social comparison processes have been two standard explanations of social influence. We do not believe that the present results are likely due to persuasive argumentation (cf. Burnstein et al., 1973; Vinokur & Burnstein, 1974). Informal debriefing of our participants revealed that discussion during the collaboration phase did not include group members providing arguments in an effort to persuade others to alter their preferences. Furthermore, given the relatively impoverished nature of the stimuli used in the present study, it is not entirely clear what form a persuasive argument might take.

Instead, we suggest that our results may reflect a social comparison process (e.g., Buunk & Gibbons, 2007; Mussweiler, 2003). For example, participants may have believed that their fellow group members' behavior provided normative information about appropriate behavioral patterns (Meeussen, Delvaux, & Phalet, 2014), a mechanism that has been referred to as informational social influence (Deutsch & Gerard, 1955) and as social proof (Cialdini, 2001). If our participants became aware that their personal preferences were consistently more or less patient than other group members, they may have adjusted their preferences accordingly. This suggestion is consistent with the finding that the member in each group who exhibited the highest [or the lowest] discount rate in the precollaboration phase was more likely to decrease [or to increase] his or her discount rate in the postcollaboration phase (see Fig. 1).

The present results can also be seen as evidence that individuals have a degree of uncertainty about their preferences (e.g., Ariely et al., 2003), and that this uncertainty plays a critical role in shaping decisions in social contexts. Prior research has demonstrated that uncertainty magnifies social influences on decisions (e.g., increased conformity; Wiener, 1958). This effect of uncertainty has been found in a variety of decisions, from stimulus discrimination tasks (Tesser et al., 1983) to recognition memory tasks (Walther et al., 2002). The present study demonstrates that this type of effect can be observed even in higher-order decisions, such as economic choices. Specifically, our results suggest that confidence played a moderating role, with less confident individuals being more heavily influenced by the preferences observed in other members of the group. Quantifying preference confidence/uncertainty is a relatively recent development within psychology (e.g., Regenwetter & Davis-Stober, 2012) and future research will be needed to further explore its apparent critical role in the observed social contagion effects. Such work will provide important insights into how cognitive and social processes interact.

Finally, we note that a potential limitation of the present study is that it did not include a control, no-collaboration condition (i.e., in which individuals completed three phases of the intertemporal decision task without any collaboration). Previous research has demonstrated that delay-discounting behavior, including discount rates measured by laboratory tasks, is extremely stable (Kirby, 2009). For example, the test–retest reliability of intertemporal decision tasks has been found to be high, with *r*s above .90 even after a one-week delay, and discount rates not significantly changing from session to session at the individual level (Simpson & Vuchinich, 2000). As a result, we would expect little change in our intertemporal decision task within a single experimental session without a powerful intervention. In fact, this is part of the reason why we find our social-influence effects so encouraging. Nonetheless, we did take steps to ensure that our observed effects were due to social influence and not to alternative factors. For the convergence effect we observed, an initial concern was that the effect simply reflected regression to the mean. However, as we detailed in footnote 2, individuals' decision behavior was not regressing to a statistical mean, but instead was changing to be more aligned with their *respective groups'* behavior. Observing the preferences of other group members during the collaboration phase, we argue, is what was driving changes in decision behavior on the individual level. This is why the regression results demonstrated that other group members' precollaboration preferences were a significant unique predictor of postcollaboration preferences. As a result, there seems to be no corollary analysis to be done on decision behavior for individuals who are not collaborating with others. Yet, it will still be beneficial for future research to include a no-collaboration condition in the design, so that a baseline of change in delay-discounting behavior across a single experimental session can be established. This baseline can then be used as a comparison with individuals in a collaboration condition, to ensure that any observed changes in decision behavior can be attributed to social influence.

Appendix.

Table 5 The various rewards that were used in the choice task in Experiment 2

SS Reward	LL Reward	SS Delay	LL Delay	*k*
34	35	0	43	.00067
83	86	0	35	.00101
27	29	0	35	.00204
47	58	0	50	.00421
25	30	0	35	.00521
40	48	0	28	.00651
67	88	0	35	.00779
32	47	0	45	.00854
50	98	0	70	.00961
35	55	0	40	.01130
30	75	0	62	.01478
20	26	0	15	.01749
40	67	0	25	.02063
20	65	0	48	.02456
12	28	0	30	.02824
25	58	0	25	.03366
20	62	0	25	.04526
32	93	0	20	.05334
15	43	0	14	.07522
24	68	0	10	.10415
15	64	0	10	.14508
22	120	0	8	.21206
10	89	0	7	.31229
10	95	0	5	.45026

The nonimmediate trials were the same as the trials listed here, but with 30 days added to both the smaller–sooner (SS) delay and larger–later (LL) delay. The *k* column includes the value of the discount rate that would lead to indifference between the two reward items. The *k* value is derived from the standard exponential discounting model (Samuelson, 1937): $SV = A\exp(-kD)$, where *SV* is the subjective value of a delayed reward, *A* is the objective reward amount of the delayed reward, *D* is the delay interval associated with the delayed reward, and *k* is a free parameter that measures the degree that future rewards are discounted. Higher values of *k* imply greater impatience.

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