COMMITMENT AND SELF-CONTROL IN A PRISONER'S DILEMMA GAME

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Humans often make seemingly irrational choices in situations of conflict between a particular smaller-sooner reinforcer and a more abstract, temporally extended, but larger reinforcer. In two experiments, the extent to which the availability of commitment responses—self-imposed restrictions on future choices—might improve self-control in such situations was investigated. Participants played a prisoner's dilemma game against a computer that played a tit-for-tat strategy—cooperating after a participant cooperated, defecting after a participant defected. Defecting produced a small-immediate reinforcer (consisting of points convertible to gift cards) whereas cooperating increased the amount of subsequent reinforcers, yielding a greater overall reinforcer rate. Participants were normally free to cooperate or defect on each trial. Additionally, they could choose to make a commitment response that forced their choice for the ensuing five trials. For some participants, the commitment response forced cooperation; for others, it forced defection. Most participants, with either commitment response available, chose to commit repeatedly despite a minor point loss for doing so. After extended exposure to these contingencies, the commit-to-cooperate group cooperated significantly more than a control group (with no commitment available). The commit-to-defect group cooperated significantly less than the control group. When both commitment alternatives were simultaneously available—one for cooperation and one for defection—cooperation commitment was strongly preferred. In Experiment 2, the commitment alternative was removed at the end of the session; gains in cooperation, relative to the control group, were not sustained in the absence of the self-imposed behavioral scaffold.

Key words: commitment, cooperation, prisoner's dilemma, self-control, tit-for-tat, humans

With a simple choice between a particular smaller-sooner reinforcer (SSR) and a particular larger-later reinforcer (LLR), an organism may commit to an LLR by preventing the later availability of an (otherwise “tempting”) SSR. For example, a pigeon normally prefers four food pellets delayed by 14 s (LLR) to two food pellets delayed by 10 s (SSR). Ten seconds later, the pigeon's preference will reverse; the pigeon now strongly prefers two pellets available immediately (SSR) to twice as much food (four pellets) delayed by only 4 s (LLR). However if, at the earlier time, the pigeon can commit to the LLR, which it currently prefers, by removing later SSR availability, the pigeon will choose the commitment option and obtain the larger reinforcer (Rachlin & Green, 1972).

Conflicts between a single LLR and a single SSR are unusual in everyday human life. Much more common is conflict between a particular SSR and a more abstract and temporally distributed, but larger reinforcer—smoking a cigarette now (SSR) versus good health, for example. Let us call good health a larger-distributed reinforcer (LDR) rather than an LLR. As the comedian, Dick Cavett related: “Once, as [Cavett and Jonathan Miller of “Beyond the Fringe”] waited backstage together at the 92nd St. Y in New York City, [Cavett] pointed disapprovingly at [Miller's] lit cigarette. [Miller said,] ‘I know these will kill me, I'm just not convinced that this particular one will kill me.’” (*New York Times, Week in Review*, May 31, 2009, p.10.) The same could be said about one alcoholic drink, one shot of heroin, etc. —even one Twinkie.

The more complex kind of conflict may be studied in the laboratory by pitting a larger immediate reinforcer (LIR) that reduces the rate of reinforcement over the next 10 trials against an immediately smaller reinforcer that increases the reinforcement rate over the next 10 trials (LDR) (Herrnstein & Prelec, 1992). Kudadjie-Gyamfi and Rachlin (1996) arranged such a procedure and found humans more often chose the LDR when choices were

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patterned (three rapid choices followed by a 10-s interval) than when, in a separate condition, choices were separated by fixed intervals. Patterning in this experiment was labeled “soft” commitment; the participants tended to avoid switching once they had made the initial choice in the rapid three-choice sequence. Thus the first of the three choices constituted a kind of commitment to the same alternative two more times.

The conflict between LDR and LIR may be studied, as it was in the present experiments, with a prisoner’s dilemma (PD) game against a computer programmed to play according to a tit-for-tat strategy. Before explaining this, we must outline the basics of the PD game. Figure 1a is an example of a PD matrix of contingencies. Ordinarily there are two players: A and B. Each chooses between cooperation (C) and defection (D). In the example of Figure 1a, if both cooperate, each gets 25 points; if both defect, each gets 15 points; if one cooperates and one defects, the cooperator gets 10 points and the defector gets 30 points. The game is a dilemma because each player gets five more points by defecting than by cooperating, regardless of the other player’s choice. Yet if both defect, each gets 10 fewer points than if both had cooperated (i.e., 15 points each for mutual defection as opposed to 25 points each for mutual cooperation). In most repeated PD games, both players eventually defect, earning less than they would if both had cooperated (e.g., Rapoport & Chammah, 1965; Silverstein, Cross, Brown, & Rachlin, 1998).

One common strategy in repeated PD games is aptly called “tit-for-tat.” Player B, playing tit-for-tat, simply reflects Player A’s choice from the previous trial; if A cooperates on trial n , B cooperates on trial $n + 1$; if A defects on trial n , B defects on trial $n + 1$ (Axelrod, 1980). Figure 1b shows the tit-for-tat contingencies from A’s viewpoint. If B cooperates, A earns either 25 or 30 points; if B defects, A earns either 10 or 15 points. Clearly it is in A’s interest for B to cooperate. But, if B rigidly plays tit-for-tat, the only way for A to get B to cooperate is to cooperate herself. By playing tit-for-tat, B reinforces A’s cooperation (by cooperating on the next trial) and punishes A’s defection (by defecting on the next trial) (Rachlin, Brown, & Baker, 2000).

The dashed line in Figure 1b shows A’s average earnings over a series of repeated

Fig. 1. Upper panel (a): A Prisoner’s Dilemma point-distribution matrix. Player A’s choice determines the active column, either C by cooperating or D by defecting. Player B’s choice determines the active row. Within the resulting cell, points above the “/” are given to Player A and points below are given to Player B. Lower panel (b): The average number of points earned per trial by Player A as a function of cooperation rate by Player B (right to left). The dashed line indicates perfect reciprocation (tit-for-tat) by Player B. Player A averages the most points (25 points per trial) by cooperating on every trial but, after cooperating, may increase the reinforcer on the *current* trial (to 30 points) by defecting. However, alternating in this manner between cooperation and defection averages 20 points per trial while defecting on every trial averages only 15 points per trial.

trials, as a function of A’s own cooperation, with B playing tit-for-tat. In this situation, A maximizes earnings by cooperating on all trials (except the very last trial where defection has no future consequences—but generally play-

ers do not know when the game will end). In the present experiment, participants played the PD game of Figure 1 repeatedly against a computer that played tit-for-tat. The computer's rigid tit-for-tat contingency turned the game into a straightforward self-control situation. On any given trial, it was better for A to defect (as shown in Figure 1a) but, over a series of trials, it was better for A to cooperate (the dashed line in Figure 1b is highest at 100% cooperation). In a prior experiment, participants playing a PD game versus tit-for-tat, who were forced to plan each successive set of four choices in advance and to stick to their plan, cooperated significantly more (hence earned more) than those who chose separately trial by trial (Silverstein et al., 1998).

In the Kudadjie-Gyamfi and Rachlin (1996) and the Silverstein et al. (1998) experiments, commitment was imposed on participants by the experimenters. However, in everyday-life self-control situations, commitment may be voluntarily imposed. Behavioral self-control treatment programs may offer commitment as a kind of scaffold to be removed after behavior is brought into contact with long-term contingencies in the hope that those contingencies will gain control over behavior.

In the present experiments, participants played a PD game versus a computer opponent programmed to play a tit-for-tat strategy. Defection in the PD game was a choice of LIR; cooperation was a choice of LDR. In prior experiments with similar contingencies most participants gradually learned to cooperate (e.g., Rachlin et al., 2000). In Experiment 1 participants were assigned to one of four groups. In three of those groups, participants were given the option of committing to five successive trials of cooperation (Cooperate group and Choice group) or defection (Defect group and Choice group). For participants in the Control group, no commitment response was available.

We expected that Cooperate-group participants would choose to commit to cooperate and that this choice would increase their cooperation rate, hence their earnings, above that of Control-group participants. A crucial question was whether participants who had learned to cooperate through commitment would continue to cooperate without the "scaffold" of commitment. As for the Defect group, we expected that these participants

would initially choose to commit (while LIR was the preferred option), but would reduce commitment rate rapidly as they experienced the decrease in overall earnings. Finally, we expected that participants in the Choice group would learn to strongly prefer cooperation commitment over defection commitment, but that both kinds of commitment would decrease over the course of the experiment as participants learned to cooperate without commitment.

EXPERIMENT 1

METHOD

Participants

Seventy-five undergraduate students, recruited through the psychology subject pool at Stony Brook University, were randomly assigned to three groups: Control ($n = 25$; 18 female, 7 male), Cooperate ($n = 25$; 11 female, 14 male), and Defect ($n = 25$; 12 female, 13 male). Four participants failed to respond to one of the three (two in the Control group) available response keys and thus never experienced the contingencies associated with each key. Those participants' data have been excluded from all analyses. An additional 4 participants were recruited as replacements to yield an equal number (25) in each of the three groups. Another 37 undergraduate students (25 female, 12 male) were subsequently recruited for a fourth group: the Choice group. Twelve participants in this group never clicked on either of the commitment keys. These 12 participants' data were analyzed separately from the rest.

Apparatus and Instructions

Participants were seated at a cubicle measuring 2.5 m high, 2.1 m wide, and 2.2 m deep. They faced a personal computer with a 17-in. (43.2 cm) monitor atop a 1.2 m-wide square table. Experimental events were controlled by a custom program—designed using Microsoft Visual Basic® 6.0—that ran on the Microsoft Windows XP® operating system. A one-button mouse was used to interact with the objects on the computer screen. For the Control, Cooperate, and Defect groups, three 3.0-cm diameter circles, or response "keys," were horizontally aligned 3.3 cm apart near the center of the gray screen. For the Choice

Group, the center circle (commitment response key) was removed, and two identical circles (commitment keys) were added 0.3 cm below each of the remaining two circles (response keys). The two response keys on each side were vertically aligned.

A horizontally aligned row of five 2.2-cm-wide dark gray squares, 1.5 cm apart, were located 4.0 cm above the row of circles. From left to right, these five "point squares" were numbered 10, 15, 20, 25, and 30. A light gray rectangle, the "total-points box" measuring 2.5 cm high by 4.0 cm wide, was positioned 0.75 cm to the right of the row of squares. A 1.5 cm high by 3.0 cm wide "instructions button" was located at the bottom right corner of the screen.

When participants were first seated at the computer, a text box covered the screen except for the total-points box and the instructions button, which were labeled "40" and "Start," respectively. The text box contained the following (minimal) instructions, which were also read aloud to the participant by the experimenter.

You can earn (and lose) points by clicking lit circles. Please try to earn as many points as you can. If you finish with 1400 points (or more), you will win a gift card to take with you when you leave!

1400–1899 points = \$5 Card

1900–2299 points = \$10 Card

2300+ points = \$15 Card

Participants were further instructed that they could click on the "Start" button whenever they were ready and that the button would then change to an "Instructions" button; a click on the Instructions button would allow them to return to those instructions at any time. Each participant was tested alone; there was no pretense that they were playing against anyone else.

For the sake of clarity, we retain the "cooperate/defect" nomenclature even though there was no other participant with interests to cooperate with or defect from. However, participants playing against tit-for-tat may be thought of as cooperating with or defecting from their own long-term interests (Ainslie, 2001; Rachlin, 2000).

Procedure

The procedure for all groups consisted of two phases of 50 trials. For the first 50 trials, the baseline phase, the center commitment

key (or bottom commitment keys for the Choice group) remained unlit (gray, as the background color). For the Control group, the second phase was an identical 50-trial continuation phase. All other groups experienced a commitment phase for the final 50 trials, which began with the white illumination of the commitment key (or keys).

Control group. At the start of each trial, the left and right response keys were lit blue and red, with the position of each counterbalanced across participants. For half of the participants, blue was the cooperate key and red was the defect key; for the other half, the colors were reversed. An effective click on either of those two keys extinguished the key light (changing the circle to light grey) for 0.2 s, produced a "click" sound during that period, and immediately decreased the number in the total-points box by 1 point. This was followed by a reinforcement period signaled by yellow illumination of the point-square corresponding to the number of points earned. That square flashed on a 0.3 s on-off cycle for 2.1 s, a period accompanied by the sound of a harp-like strumming. Clicks on either key had no effect during the reinforcement period. The reinforcement period ended with the earned points being added to the number shown in the total-points box and a 0.75-s graying of both response keys prior to the start of the next trial.

Each click on the cooperate- or the defect-key earned a number of points determined by that (current) click and the prior one. Two successive clicks on the defect key earned 15 points, two successive clicks on the cooperate key earned 25 points, a defect-cooperate click sequence earned 10 points, and a cooperate-defect click sequence earned 30 points. Each click thus influenced earned points twice—once as the current click (Player A in Figure 1) and once as the prior click (Player B). The very first click of the session was treated as if it had followed a cooperate click. For the Control group, there was no signal between the first baseline phase (trials 1–50) and the subsequent, identical continuation phase (trials 51–100).

Commitment groups. For the Cooperate and Defect groups, the first 50-trial baseline phase operated exactly as for the Control group. Trials 51–100 constituted a commitment phase and began with the illumination of the white

center response key (commitment key) in addition to the red and blue cooperate and defect keys; all other contingencies were unchanged. No instructions accompanied the commitment key but a single click on this key subtracted 1 point from the total and extinguished both the center key and the defect key (for the Cooperate group) or the center key and the cooperate key (for the Defect group). The extinguished keys remained gray and inactive until five clicks were made on the remaining (cooperate or defect) active key. Commitment responses had no effect on the consequences for responses on the remaining, active key. A response on the center (commitment) key did not constitute a trial nor did it contribute toward the completion of the session (but the five subsequent cooperate or defect responses did contribute to the total trials). Thus, each phase consisted of 50 cooperate and/or defect responses regardless of the number of commitment responses.

Choice group. The procedure for the Choice group was identical to that for the Cooperate and Defect groups except for the following changes: After completion of 50 baseline trials, two commitment keys became simultaneously available. The commit-to-cooperate key, which functioned just like the commitment key for the Cooperate group, was located directly below the cooperate key. The commit-to-defect key, which functioned just like the commitment key for the Defect group was located directly below the defect key. A response on either commitment key extinguished all keys except the key directly above it for the duration of the next five key-presses which operated as described above.

RESULTS

Control and Commitment Groups

The 100-trial session was divided into 10 blocks of 10 trials each. Figure 2 shows the mean percentage of cooperate-choices relative to defect-choices in each of the 10-trial blocks for participants assigned to the Cooperate, Control, and Defect groups (Choice-group data are shown elsewhere). Participants in all three groups cooperated more in the final block than in the initial block. There were no significant differences in cooperation between the three groups during the first 10 (baseline) trials (one-way ANOVA, $F[2,72] = .64, p = .532$)

Fig. 2. The mean percent cooperation for the Cooperate (closed triangles), Control (circles), and Defect (open inverted triangles) groups as a function of 10-trial blocks. For the Defect and Cooperate groups, the commitment phase began in Block 6. Error bars indicate 95% confidence intervals for the Control group. For the sake of readability, error bars are not shown for the Cooperate or Defect groups, but were similar to those of the Control group. Ninety-five percent confidence intervals for all groups are listed in the Appendix.

with a combined average of 43% cooperation during those trials. By the end of the baseline phase (the fifth block of trials), cooperation had increased to an overall average of 57% with still no significant differences between the three groups (one-way ANOVA, $F[2,72] = .09, p = .914$). In the final 10 trials of the session, participants in the Cooperate group cooperated in an average of 81% of the trials, those in the Control group cooperated in an average of 66% of the trials, and those in the Defect group cooperated in an average of 50% of the trials. In those final 10 trials, all Cooperate-group participants cooperated in at least four trials (see Appendix A for individual participant data). Almost twice as many Cooperate-group participants ($n = 14$) as Control-group participants ($n = 8$) cooperated in at least 9 of the final 10 trials, and more than twice as many Control-group participants did so than Defect-group participants ($n = 3$). Both commitment groups' cooperation during the final 10 trials differed significantly from the Control group's cooperation (Cooperate group: $t(48) = 2.1, p = .038$; Defect group: $t(48) = 2.3, p = .027$).

The commitment response became available during the last five blocks for both the Cooperate and Defect groups. Figure 3 shows the average number of commitment responses

Fig. 3. Mean number of commitment responses for the Cooperate (closed bars) and Defect (striped bars) groups as a function of 10-trial blocks during the commitment phase. Error bars indicate 95% confidence intervals.

in each of those five 10-trial blocks; the maximum number of commitment responses in each block was 2. Across groups, participants averaged 1.48 commitment responses during the first block and 0.4 in the final block. A mixed-design ANOVA with trial-block as the within-subject factor indicated a significant effect of trial-block on commitment ($F[4, 192] = 27.18, p < .0001$), but no significant effect of group ($F[1, 48] = 0.82, p = .37$). However, during the final 20 trials (two blocks), Cooperate-group participants committed significantly more than Defect-group participants (an average of 1.24 commitments compared to 0.72; $t[48] = 2.1, p = .047$).

With an average of 1.48 commitment responses during the first block in which the commitment response was available, 70% of the trials in that block were forced trials (across both commitment groups). The percentage of forced trials was greatly reduced by the end of the session (31% during the final block), but this still indicates that a substantial portion of the group differences seen in Figure 2 occurred during these forced trials.

The forced trials have been removed in Figure 4, which shows the mean percentage of free-trial cooperate responses for each of the three groups during each trial block. Free-choice responses that occurred before any commitment responses had been made were not included in calculating percentage of

Fig. 4. Mean percent cooperation for the Cooperate (closed triangles), Control (circles), and Defect (open inverted triangles) groups during free-choice trials for each group as a function of 10-trial blocks. Free-choice trials prior to the first commitment response for each participant have been excluded. Cooperate-group participants experienced an average of 1.76, 5.88, 6.72, 6.96, and 7.24 (included) free-choice trials in Blocks 6, 7, 8, 9, and 10, respectively. Defect-group participants experienced an average of 2, 6, 7.52, 7.76, and 8.4 such trials over the final 5 blocks. Error bars indicate 95% confidence intervals for the Control group. Ninety-five percent confidence intervals for all groups are listed in the Appendix.

cooperation in Figure 4. As such, Figure 4 shows the percentage of cooperation that occurred when both options were available after the commitment contingencies had been contacted at least once. The significant differences in all-trials cooperation between control and commitment groups (i.e., Cooperate and Defect groups) during the final 10 trials (Figure 2) was not found when only free-choice trials were analyzed. The average difference in cooperation between the Cooperate (69.9%) and Control groups (66.4%; $t[47] = 0.7, p = .492$) and between the Defect (62.9%) and Control groups ($t[47] = 2.2, p = .057$) was only 3.5% for free-choice trials in the final block. The difference in cooperation between the Cooperate and Defect groups in the final 10 trials was reduced relative to the all-trials comparison (to an average difference of 7.1%), but was still significant ($t[46] = 2.6, p = .029$).

Choice Group

Figure 5 shows the average percentage of cooperate-choices made in each of the 10-trial

Fig. 5. Mean percent cooperation during all trials (closed triangles) and during free-choice trials after the first commitment response for each participant (open triangles) for the Choice group as a function of 10-trial blocks. Error bars indicate 95% confidence intervals based on all trials.

blocks for the Choice group. Closed triangles include all trials and the open triangles include only free choices after the first commitment response. The Choice-group participants increased cooperation, on average, in each successive block of the commitment phase, from 58.4% in the first block (Block 6) to 82.8% in the final block of trials (paired t -test comparison between those two blocks: $t[48] = 4.9$, $p < .0001$). Cooperation in the final block of trials was greater for the Choice group than for the Control group ($t[48] = 2.5$, $p = .015$) and the Defect group ($t[48] = 5.4$, $p < .0001$), but not significantly more than the Cooperate group ($t[48] = 0.4$, $p = .713$). Free-choice cooperation did not increase in every block, but did increase significantly from 51.1% in the first block of the commitment phase to 76.2% in the final block of trials ($t[33] = 2.6$, $p = .013$).

As with the Cooperate group, all Choice group participants cooperated in at least 4 of the last 10 trials and more than half ($n = 13$) cooperated in at least 9 of the last 10 trials. All but 3 cooperated in at least 7 of the last 10 trials. None of the Choice group participants demonstrated the consistent increase in cooperation from block-to-block during the commitment phase that was observed for the group average. However, 72% of these participants increased cooperation, and only 4% decreased cooperation, from the first block of the commitment phase to the last.

Figure 6 shows the average number of cooperate and defect commitment responses

Fig. 6. Mean number of commitment responses for cooperation (solid bars) and defection (striped bars) as a function of 10-trial blocks during the commitment phase of the Choice group. Error bars indicate 95% confidence intervals.

(out of a maximum of two) in each block of the commitment phase for participants in the Choice group. Participants committed one way or another an average of 3.92 times over the course of the 50-trial commitment phase. That is the same average as participants in the Cooperate group. During the first block of the commitment phase, choice was indifferent between the committing alternatives: an average of 0.64 commit-to-cooperate responses versus an average of 0.60 commit-to-defect responses. In later trials, however, the rate of responding on the commit-to-cooperate key remained relatively constant (with an average of 0.52 commit-to-cooperate responses in the final block of trials). Responding on the commit-to-defect key was reduced by half after the first block of trials, to an average of 0.28 responses in the second block of the commitment phase, and was virtually eliminated by the final block of trials (an average of 0.04 commitment responses).

Eight of the Choice-group participants responded only on one of the two commitment keys. Five participants never responded on the commit-to-cooperate key. Each of these made only a single response on the commit-to-defect key and then never committed again. The 3 participants who never committed to defection averaged 2.7 commitment (commit-to-cooperate) responses. Of the remaining 17

participants, those who responded at least once on each commitment key, 9 chose the commit-to-cooperate key more than the commit-to-defect key, 7 chose both equally (4 chose each only once), and only 1 chose the commit-to-defect key more than the commit-to-cooperate key. That 1 participant committed to defection twice and committed to cooperation once.

The Choice group participants, like those in the Cooperate group, increased average cooperation (Figure 5) and decreased average commitment (Figure 6) over the course of the commitment phase. As such, the percentage of cooperations that were forced decreased over time—at least, for the group average. Individual participants showed one of three basic patterns in what we will call the First Free block—the first 10 trials after completing the fifth forced trial of the session. Three participants cooperated without commitment: 10 out of the 10 trials were unforced cooperations. Nine participants cooperated (50% or more cooperation, 100% cooperation for 2 participants) with the help of the commitment key (at least 67% of cooperations were forced). And 12 participants cooperated in five or fewer trials with little or no commitment (an average of 3.5 unforced and 0.4 forced cooperations each).

All 3 participants who exclusively cooperated without commitment during the First Free block also cooperated in all 10 trials of the final trial-block. Participants who experienced forced cooperations during the First Free block cooperated in an average of 8.8 trials during the final trial-block (an average of 8.9 trials for the 7 of these that continued to experience forced cooperations during the final trial-block). Those that experienced no forced cooperations and did not exclusively cooperate during the First Free block cooperated in an average of 7.0 trials during the final trial-block, none of which were forced cooperations.

DISCUSSION

As in previous experiments (see review by Rachlin et al., 2000), the tit-for-tat contingency increased cooperation of all groups when commitment was not an option. Rachlin et al. suggested that increased cooperation under the tit-for-tat contingency may be explained by

noting that cooperation on trial n is reinforced when the computer cooperates on trial $n + 1$ and that defection on trial n is punished when the computer defects on trial $n + 1$. However, these contingencies that favor cooperation are obscured by three factors: (1) a delay of one trial (in the present experiment this delay was slightly longer than 3 s plus the latency to the subsequent choice response), (2) the immediate consequences of the current trial (which favor defection), and (3) the intervening choice of the following trial. Indeed, in prior tit-for-tat experiments, even when the contingency was explicitly explained, average cooperation did not rise above the levels shown by the Control group in Figure 2 (Silverstein et al., 1998). These impediments to learning suggest that the effective reinforcer for cooperating in the baseline condition was not the specific choice made by the opponent on the next trial, but rather the overall correlation between rate of cooperation and points earned as shown by the dashed line of Figure 1b. As Goodie and Fantino (1999) showed, overall correlations (base rates) can take many trials to influence human choice behavior. In the present experiment, Control group participants may have continued to increase their rate of cooperation if more trial blocks had been arranged; however, most individual participants reached a perhaps temporarily stable rate of cooperating (as can be seen in Appendix A). Some pigeons, after many thousands of PD trials versus tit-for-tat, learn to maximize their earnings by cooperating on nearly 100% of trials (Sanabria, Baker, & Rachlin, 2003). It seems likely that humans would reach corresponding levels were such extensive testing practical.

Figures 2 and 3 show that making commitment responses available had a very strong effect on cooperation (hence on points earned), sharply increasing earnings in the Cooperate group and sharply decreasing earnings in the Defect group. Commitment responses by participants in both of these groups occurred at a high rate as soon as commitment became available and decreased thereafter. As their commitment decreased, participants in the Defect group defected less. Even though commitment decreased for those in the Cooperate group, their total cooperations remained higher than those in the Control group. Commitment thus aided par-

ticipants in the Cooperate group and hindered those in the Defect group from amassing points. Nevertheless, as the experiment progressed, Defect-group participants began to commit less and cooperate more.

It is not surprising that commitment initially increased the Cooperate group's cooperation and the Defect group's defection. Note, however, that as commitment by participants in both groups decreased over the second phase, the Defect group's defection decreased, but the Cooperate group's cooperation remained high. One is tempted to conclude that the distributed consequences of forced-cooperation reinforced cooperating so that this choice would be made during free-choice trials. But, as Figure 4 indicates, the reason why the Cooperate group's total cooperations remained relatively constant throughout the commitment phase (as shown in Figure 2) is that cooperations during free-choice trials decreased sharply immediately after the first commitment and only gradually returned to control-group levels over the course of the commitment phase. Participants in the Cooperate group cooperated less than those in the Control group when the first commitment constraint ended (even though the constraint had been self-imposed). This is a behavioral contrast effect (Rachlin, 1973; Reynolds, 1963); the Cooperate group's defection rate (suppressed during cooperation commitment) increased during free choice above the rate at which it would have been emitted had it not been initially suppressed. A similar behavioral contrast effect occurred for the Defect group; the cooperation rate (suppressed during defection commitment) increased during free choice above the rate at which it would have been emitted had it not initially been suppressed.

It was somewhat surprising that the Defect-group participants committed as much as they did, but, as we said, abstract contingencies, such as that indicated by the dashed line in Figure 1, would be expected to affect behavior only after prolonged exposure. For a Defect-group participant, a commitment choice after a cooperate-choice would have been followed by the highest-point reinforcer and may thus have been reinforced. By the end of the commitment phase (the last 20 trials), however, as commitment by both groups decreased to low levels, the Defect-group participants

made fewer commitment responses than did those in the Cooperate group (see Figure 3). That is, the overall relative point reduction engendered by defect commitment eventually decreased the Defect group's commitment below that of the Cooperate group and, for the Choice group, decreased the rate of defect commitments relative to cooperation commitments.

As trials progressed, and commitment decreased, free-choice defections by the Cooperate-group participants and free-choice cooperations by the Defect-group participants decreased. For the Cooperate group, overall cooperation remained constant even though commitment responding decreased. Two opposing effects may have cancelled each other out: First, fewer commitment responses reduced the number of forced cooperations. Second, fewer commitment responses reduced the number of transitions from commitment to free choice (reducing behavioral contrast) and may have indirectly increased the fraction of cooperations from below that of the control group to just above baseline level (as Figure 4 shows). Thus the commit-to-cooperate option did not increase cooperation during free-choice trials significantly above that of the Control group; rather, the introduction of the commit-to-cooperate option initially *suppressed* cooperation in the free-choice trials (behavioral contrast). As that suppression faded, increasing free-choice cooperation compensated for the reduction in committed cooperation.

As with the Cooperate and Defect groups, many participants in the Choice group committed at a relatively high rate whenever a commitment alternative became available. However, substantially more participants never made a single response on either commitment key when two were present instead of one (32.4% with the Choice group procedure compared to 5.1% with the other procedures). We can only speculate as to the reason for that difference, but it seems likely that it was an artifact of the arrangement of the keys. That is, in the four-key arrangement, the commitment keys were located below the two point-earning keys instead of between them. This likely decreased the salience of the commitment keys—which, combined with the white coloring, perhaps less obtrusive than the red or blue of the point-earning keys—resulted in almost a

third of the participants never responding on either commitment key.

For Choice-group participants who pressed one of the commitment keys, levels of cooperation tended to fall somewhere between those participants who could only commit to cooperation (the Cooperate group) and those who could only commit to defection (the Defect group). However, participants who could choose between the two were much more likely to commit to cooperate than commit to defect as they gained experience with the contingencies. By the final block of trials, Choice-group participants cooperated, on average, more than participants from any other group (but not significantly more than the Cooperate group).

For all groups of this experiment, the availability of cooperate-commitment clearly increased self-control (i.e., choosing the LDR). Just as clearly, the availability of defect-commitment hindered self-control. Whether the Cooperate group's increased self-control will persist when commitment to cooperate is no longer available is an open question, which Experiment 2 was designed to answer.

EXPERIMENT 2

METHOD

Participants, Apparatus, and Instructions

Twenty-seven undergraduate students (13 female, 14 male), were recruited through the psychology subject pool at Stony Brook University. Two participants failed to click at least once on each of the three available keys, and their data were excluded from all analyses. The apparatus and instructions were the same as those for the Cooperate group of Experiment 1.

Procedure

The procedure was identical to that for the Cooperate group of Experiment 1, except that there were three phases instead of two. Participants began with a 30-trial baseline phase (no commitment available), followed by a 30-trial commitment phase (cooperate-commitment available), and then another baseline phase of 40 trials. The purpose of the reversal was to assess the effects of the commitment option on cooperation after this option was removed.

Fig. 7. Mean percent cooperation for the Reversal group of Experiment 2 (triangles) and the Control group of Experiment 1 (closed circles). For the Reversal group, closed triangles indicate all trials and open triangles indicate free-choice trials after the first commitment response for each participant. Participants experienced an average of 1.36, 4.72, 5.76, and 9.36 (included) free choice trials in Blocks 4, 5, 6, and 7 respectively. Error bars indicate 95% confidence intervals for the Control group. Ninety-five percent confidence intervals for all groups are listed in Appendix B.

RESULTS

Figure 7 shows the average percentage of cooperation in each of the 10-trial blocks. Results for the Control group of Experiment 1 (filled circles) are included for comparison. As with the Cooperate group of Experiment 1, participants in Experiment 2, the Reversal group, like those of all groups of Experiment 1, cooperated more, on average, in the final block of trials (73.6%) than in both the first and last block of trials of the initial baseline phase (48.4% and 49.2%).¹ Cooperation during the last four blocks of trials was not significantly different between participants in the Reversal group and those in the Control group of Experiment 1 (mixed-design ANOVA with trial-block as the within-subject factor; $F[1, 48] = 0.49, p = .487$). Thirteen of the 25 participants cooperated on at least 9 of the final 10 trials but the other 12 participants collectively cooperated on less than half of the final 10 trials (46.7%; see Appendix A).

¹ The white triangle in Block 7 is there because commitment responses toward the end of Block 6 resulted in some of the first choices of Block 7 being forced. Thus, the percent of free choices was not identical to the percent of forced choices in that block.

The open symbols in Figure 7 show percent cooperation in free-choice trials during the second phase when commitment was available. As in Experiment 1, free-choice responses prior to the first commitment response are not included. Percent free-choice cooperation during blocks 4–6, the commitment phase for the Reversal group, was slightly less than that of participants in the control group—much like the Cooperate group of Experiment 1 (Blocks 6–8 of Figure 4). However, this difference was not significant ($t[46] = .832$, $p = .410$) in the present experiment.

The commitment response became available 20 trials earlier for participants in the Reversal group than for those in the Cooperate or Defect groups of Experiment 1. As in Experiment 1, commitments decreased over the period of its availability. During the first three blocks of the commitment phase, Reversal-group participants did not commit significantly more than did the Cooperate-group participants of Experiment 1 (mixed ANOVA, $F[1, 48] = 1.46$, $p = .233$).

DISCUSSION

As with the Cooperate group of Experiment 1, commitment responses for the Reversal group occurred at a high rate when they were available, and cooperation increased sharply over baseline and control levels. Also, as with the Cooperate group, free-choice cooperation fell below the corresponding control performance when the opportunity for commitment was introduced (although this difference was not significant). For the Cooperate group, average free-choice cooperation returned to baseline levels by the fourth trial block of the commitment phase. In the present experiment, the commitment phase ended after three trial blocks, with average free-choice cooperation only exceeding average control cooperation immediately after the commitment phase. As in Experiment 1, commitment produced overall cooperation substantially above baseline levels (and participants earned more points) when commitment responses were available. In the present experiment, after commitment was made unavailable, the overall percentage of cooperation returned to levels similar to the Control group's final 40 trials. However, at least half of the Reversal-

group participants learned to cooperate without commitment.

Both experiments indicated that participants would commit, either to cooperate or to defect, when commitment was available. However, these experiments provide an ambiguous answer to the central question: Is commitment to cooperate an effective method for generating cooperation? As in Experiment 1, commitment to cooperate increased cooperation, hence earnings, but, on average, lost its effectiveness as soon as the opportunity to commit was removed. This was the case between commitment periods (during free trials in both experiments) as well as after commitment was removed (Experiment 2). Nevertheless, in Experiment 2, as in Experiment 1, as long as the opportunity to commit was available, participants used commitment to control their behavior and maintained a high level of overall cooperation even as they reduced commitment rates.

One limitation of the present study is that participants in the Choice group of Experiment 1 and the Reversal group of Experiment 2 were not randomly assigned, as were participants in the other three groups of Experiment 1. Participants in all five groups were recruited from the same psychology subject pool, but those in the Choice and Reversal groups were recruited after the other three groups, introducing an alternative explanation for any differences found for those two groups.

GENERAL DISCUSSION

On one hand, the results of these experiments are disappointing as regards application. Commitment may have brought behavior into contact with the long-term contingencies, but that contact did not serve to increase cooperation (self-control) significantly (above the control group) when the commitment was removed. Postcommitment cooperation observed in the third phase of Experiment 2 was slightly higher than the control group's cooperation after the same number of trials; perhaps an increased number of participants would have brought the difference to statistical significance but, even if significant, the differences after 100 trials were so small as to be essentially meaningless in real-world self-control situations.

On the other hand, participants in the Cooperate group of Experiment 1 committed to cooperating even though doing so involved a small cost. While the commitment-to-cooperate opportunity was in place, participants in both experiments maintained an above-baseline level of cooperative responding and earned larger-than-baseline overall rates of points. Participants in the Defect group of Experiment 1 also restricted their own choices, committing themselves to defection, earning smaller-than-baseline overall rates of points but, over the course of the commitment phase, decreasing commitment responding and increasing rate of points. With the opportunity to choose between the two commitment options, commitment to cooperate was strongly preferred over commitment to defect. All in all, these experiments imply that, with the temporally-extended contingencies of real-life, the availability of a tractable commitment device may improve self-control even though, eventually, it may rarely be used.

According to standard economic theory, in the present experiments it was irrational to make more than one or two commitment responses (to ascertain that they did not directly increase reinforcement rate). A rational person, playing against a tit-for-tat opponent, would cooperate without commitment because cooperation maximizes overall reinforcement rate (Figure 1b), and, in the present experiment, saves the points spent on commitment responses. But, in our opinion, true rationality considers one's future behavioral tendencies when making decisions in the present. The alcoholic behaves irrationally not by drinking at the party—a severe alcoholic has no choice in such a situation—but by going to the party in the first place. Similarly, many of our participants who were given the option of committing to cooperation but (after testing the consequences) did not spend the point that it cost to commit, were

behaving less rationally (and earned less) than those who made use of the commitment opportunity.

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APPENDIX A

Proportion of Responses for the Cooperate Key in Each 10-Trial-Block for Each Participant

10-Trial Block											
Rank	1	2	3	4	5	6	7	8	9	10	Session Average
Control Group											
1	0.4	0.7	0.7	0.7	0.9	0.9	1.0	1.0	0.9	1.0	0.82
2	0.4	0.3	0.7	0.9	0.7	1.0	1.0	1.0	1.0	0.8	0.78
3	0.6	0.6	0.7	0.5	0.8	0.6	1.0	0.9	1.0	0.8	0.75
4	0.6	0.6	0.2	0.1	1.0	1.0	1.0	1.0	0.7	1.0	0.72
5	0.4	0.3	0.4	1.0	0.8	0.8	0.9	1.0	1.0	0.4	0.70
6	0.4	0.7	0.8	0.3	0.9	0.7	0.7	0.8	0.8	0.9	0.70
7	0.4	0.3	0.4	0.5	0.6	0.7	1.0	1.0	1.0	1.0	0.69
8	0.3	0.2	1.0	0.5	0.4	0.9	0.7	1.0	0.8	1.0	0.68
9	0.4	0.4	0.2	0.5	0.5	0.8	0.9	0.9	1.0	1.0	0.66
10	0.4	0.7	0.6	0.6	0.7	0.7	0.4	0.7	0.7	0.8	0.63
11	0.5	0.3	0.2	0.5	0.9	0.8	0.8	0.6	0.8	0.9	0.63
12	0.4	0.5	0.3	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.58
13	0.2	0.6	0.7	0.3	0.6	0.7	0.6	0.7	0.7	0.6	0.57
14	0.9	1.0	1.0	0.6	0.3	0.2	0.3	0.3	0.4	0.5	0.55
15	0.3	0.5	0.5	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.47
16	0.5	0.3	0.2	0.8	0.5	1.0	0.7	0.3	0.2	0.1	0.46
17	0.5	0.5	0.2	0.2	0.2	0.1	0.2	0.7	1.0	1.0	0.46
18	0.5	0.5	0.2	0.5	0.4	0.5	0.5	0.6	0.2	0.6	0.45
19	0.3	0.3	0.4	0.3	0.5	0.3	0.4	0.5	0.5	0.5	0.40
20	0.0	0.4	0.5	0.3	0.5	0.4	0.5	0.4	0.5	0.5	0.40
21	0.5	0.3	0.5	0.2	0.5	0.5	0.2	0.3	0.5	0.4	0.39
22	0.3	0.2	0.3	0.3	0.3	0.5	0.5	0.5	0.5	0.5	0.39
23	0.4	0.7	0.2	0.3	0.3	0.6	0.4	0.3	0.4	0.2	0.38
24	0.5	0.3	0.4	0.1	0.4	0.4	0.3	0.5	0.5	0.4	0.38
25	0.3	0.3	0.2	0.6	0.3	0.1	0.6	0.1	0.4	0.5	0.34
Cooperate Group											
1	0.4	0.4	0.8	1.0	1.0	1.0	0.8	0.5	1.0	1.0	0.79
2	0.5	0.4	0.3	0.9	0.8	1.0	0.9	1.0	0.9	0.9	0.76
3	0.4	0.5	0.5	0.7	1.0	0.8	1.0	0.7	0.8	1.0	0.74
4	0.2	0.4	0.4	1.0	1.0	0.8	0.7	1.0	0.8	1.0	0.73
5	0.5	0.3	0.5	0.9	0.7	1.0	1.0	0.5	1.0	0.7	0.71
6	0.5	0.6	0.7	0.7	0.5	0.7	0.6	1.0	0.8	1.0	0.71
7	0.8	0.7	0.4	0.5	0.3	0.7	0.8	1.0	0.8	0.9	0.69
8	0.4	0.4	0.3	0.3	0.9	1.0	0.9	0.8	0.9	0.9	0.68
9	0.5	0.5	0.7	0.8	0.4	0.8	0.7	0.8	0.8	0.8	0.68
10	0.5	0.4	0.7	0.6	0.7	1.0	0.8	0.7	0.6	0.7	0.67
11	0.4	0.5	0.5	0.7	0.9	1.0	0.6	0.5	1.0	0.6	0.67
12	0.5	0.4	0.5	0.4	0.5	0.9	0.9	0.7	0.8	0.9	0.65
13	0.4	0.4	0.2	0.2	0.5	1.0	1.0	1.0	0.7	1.0	0.64
14	0.5	0.5	0.6	0.8	0.5	0.8	0.6	0.8	0.9	0.4	0.64
15	0.5	0.5	0.6	0.5	0.7	0.7	0.8	0.7	0.5	0.7	0.62
16	0.6	0.3	0.4	0.5	0.5	0.9	0.6	0.8	0.8	0.6	0.60
17	0.5	0.6	0.5	0.6	0.4	0.7	0.7	0.6	0.7	0.7	0.60
18	0.3	0.3	0.3	0.3	0.3	1.0	0.7	1.0	1.0	0.8	0.60
19	0.6	0.3	0.4	0.4	0.4	0.7	0.8	0.7	0.8	0.9	0.60
20	0.3	0.4	0.3	0.4	0.5	0.7	0.5	0.7	1.0	1.0	0.58
21	0.5	0.5	0.5	0.4	0.6	0.7	0.7	0.4	1.0	0.4	0.57
22	0.6	0.4	0.7	0.4	0.3	0.5	0.5	0.7	0.6	0.9	0.56
23	0.2	0.1	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	0.53
24	0.3	0.3	0.2	0.3	0.3	0.6	0.6	0.6	1.0	1.0	0.52
25	0.6	0.3	0.4	0.3	0.5	0.7	0.6	0.5	0.5	0.4	0.48

APPENDIX A
(Continued)

10-Trial Block											
Rank	1	2	3	4	5	6	7	8	9	10	Session Average
Defect Group											
1	0.5	0.5	0.9	1.0	1.0	0.5	0.4	0.7	0.8	1.0	0.73
2	0.3	0.5	0.6	1.0	1.0	0.1	0.4	1.0	1.0	1.0	0.69
3	0.4	0.3	0.9	1.0	1.0	0.2	0.8	1.0	0.6	0.6	0.68
4	0.2	0.6	0.6	0.8	0.8	0.5	0.4	0.9	1.0	0.9	0.67
5	0.5	0.5	0.9	0.6	0.8	0.2	0.8	0.3	0.7	0.5	0.58
6	0.8	1.0	1.0	1.0	1.0	0.3	0.1	0.1	0.0	0.2	0.55
7	0.3	0.5	0.3	0.9	0.8	0.3	0.5	0.4	0.5	0.5	0.50
8	0.3	0.1	0.2	0.9	1.0	0.0	0.1	0.9	1.0	0.5	0.50
9	0.4	0.6	0.7	0.4	0.4	0.4	0.6	0.3	0.5	0.5	0.48
10	0.5	0.4	0.5	0.5	0.5	0.3	0.5	0.5	0.2	0.5	0.44
11	0.5	0.5	0.5	0.3	0.5	0.2	0.4	0.5	0.5	0.5	0.44
12	0.5	0.3	0.4	0.6	0.6	0.3	0.5	0.1	0.5	0.5	0.43
13	0.3	0.5	0.4	0.5	0.5	0.3	0.3	0.5	0.5	0.5	0.43
14	0.4	0.2	0.4	0.5	0.5	0.3	0.4	0.5	0.5	0.5	0.42
15	0.8	0.8	0.5	0.6	0.5	0.1	0.2	0.2	0.1	0.3	0.41
16	0.5	0.4	0.6	0.3	0.3	0.1	0.2	0.5	0.4	0.8	0.41
17	0.3	0.3	0.4	0.4	0.5	0.2	0.4	0.5	0.5	0.5	0.40
18	0.6	0.6	0.3	0.4	0.4	0.2	0.3	0.4	0.2	0.5	0.39
19	0.4	0.3	0.3	0.6	0.4	0.1	0.3	0.5	0.5	0.5	0.39
20	0.2	0.2	0.4	0.5	0.5	0.3	0.5	0.3	0.2	0.6	0.37
21	0.4	0.7	0.4	0.4	0.7	0.1	0.1	0.1	0.2	0.0	0.31
22	0.3	0.1	0.3	0.4	0.5	0.2	0.3	0.3	0.3	0.3	0.30
23	0.2	0.3	0.2	0.3	0.4	0.2	0.3	0.3	0.4	0.3	0.29
24	0.4	0.4	0.3	0.3	0.2	0.0	0.1	0.2	0.0	0.4	0.23
25	0.5	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.11
Choice Group											
1	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.95
2	0.8	0.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.95
3	1.0	1.0	1.0	1.0	1.0	0.7	0.8	0.6	0.9	1.0	0.90
4	0.7	1.0	1.0	1.0	1.0	0.6	0.7	0.2	1.0	1.0	0.82
5	0.2	0.6	0.7	1.0	0.9	0.5	1.0	1.0	1.0	1.0	0.79
6	0.5	0.4	0.6	0.9	1.0	1.0	0.6	0.9	1.0	1.0	0.79
7	0.6	0.2	0.9	0.8	1.0	1.0	1.0	0.5	0.8	0.9	0.77
8	0.5	0.4	0.3	0.8	1.0	1.0	0.5	1.0	1.0	1.0	0.75
9	0.7	0.3	0.9	0.5	0.9	0.6	0.5	0.8	1.0	0.7	0.69
10	0.6	0.8	0.4	1.0	0.7	0.5	1.0	0.5	0.7	0.7	0.69
11	0.3	0.5	1.0	0.7	0.8	0.8	0.7	0.8	0.5	0.8	0.69
12	0.5	0.6	0.5	0.8	0.6	0.7	0.8	0.3	1.0	0.8	0.66
13	0.4	0.5	0.4	0.3	0.5	1.0	0.5	1.0	1.0	1.0	0.66
14	0.7	0.5	0.6	0.6	0.6	0.5	0.6	0.6	0.8	0.8	0.63
15	0.7	0.4	0.5	0.4	0.5	0.4	1.0	1.0	0.8	1.0	0.63
16	0.9	0.7	0.5	0.4	0.5	0.8	0.1	0.3	1.0	0.9	0.61
17	0.6	0.5	0.5	0.5	0.2	0.6	0.8	1.0	0.5	0.9	0.61
18	0.6	0.3	0.5	0.2	0.5	0.5	0.7	0.8	1.0	0.9	0.60
19	0.3	0.4	0.5	0.6	0.7	0.1	0.6	0.8	0.8	0.7	0.55
20	0.4	0.5	0.5	0.4	0.4	0.3	0.7	0.7	0.2	0.8	0.49
21	0.5	0.2	0.3	0.5	0.5	0.2	0.7	0.6	0.6	0.7	0.48
22	0.3	0.3	0.1	0.4	0.5	0.2	0.6	0.8	0.8	0.7	0.47
23	0.6	0.7	0.5	0.5	0.4	0.1	0.5	0.4	0.5	0.4	0.46
24	0.4	0.3	0.5	0.5	0.5	0.4	0.4	0.5	0.5	0.5	0.45
25	0.4	0.3	0.2	0.2	0.1	0.1	0.0	0.0	0.3	0.5	0.21

APPENDIX A

(Continued)

	10-Trial Block										Session Average
Rank	1	2	3	4	5	6	7	8	9	10	
Reversal Group											
1	0.5	0.8	0.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.91
2	0.5	0.9	0.6	0.9	1.0	1.0	1.0	1.0	1.0	1.0	0.89
3	0.9	0.4	0.8	1.0	0.9	0.8	1.0	1.0	1.0	1.0	0.88
4	0.3	0.8	0.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.85
5	0.7	0.6	0.3	0.9	0.7	0.7	1.0	1.0	1.0	1.0	0.79
6	0.5	0.4	0.5	1.0	0.8	0.9	0.7	1.0	1.0	1.0	0.78
7	0.4	0.2	1.0	0.7	0.8	0.9	0.9	0.8	0.9	1.0	0.76
8	0.4	0.4	0.0	1.0	0.7	1.0	1.0	1.0	1.0	1.0	0.75
9	0.4	0.3	0.6	1.0	0.7	1.0	1.0	1.0	1.0	0.4	0.74
10	0.4	0.2	1.0	1.0	0.9	1.0	0.7	0.5	0.7	1.0	0.74
11	0.3	0.4	0.6	0.7	0.7	1.0	1.0	0.6	0.9	0.8	0.70
12	0.4	0.8	0.7	1.0	0.9	0.8	0.5	0.6	0.9	0.3	0.69
13	0.5	0.5	0.5	1.0	0.9	0.6	0.6	0.3	1.0	1.0	0.69
14	0.5	0.5	0.5	0.6	0.6	0.8	0.6	1.0	0.8	0.7	0.66
15	0.8	0.3	0.2	1.0	0.6	0.6	0.5	0.7	0.8	0.8	0.63
16	0.5	0.4	0.3	0.8	0.4	0.3	0.9	0.9	0.8	0.9	0.62
17	0.5	0.5	0.3	1.0	1.0	1.0	0.4	0.2	0.3	0.7	0.59
18	0.6	0.4	0.5	1.0	0.9	0.8	0.7	0.3	0.2	0.2	0.56
19	0.6	0.5	0.2	0.9	0.7	0.5	0.6	0.5	0.2	0.9	0.56
20	0.4	0.3	0.7	0.6	0.5	0.5	0.4	0.4	0.6	1.0	0.54
21	0.6	0.6	0.4	0.6	0.7	0.7	0.3	0.4	0.5	0.5	0.53
22	0.3	0.4	0.5	0.7	0.5	0.6	0.7	0.5	0.6	0.4	0.52
23	0.5	0.6	0.4	1.0	0.6	0.6	0.3	0.4	0.3	0.3	0.50
24	0.4	0.3	0.4	1.0	0.5	0.6	0.3	0.2	0.4	0.4	0.45
25	0.2	0.1	0.1	0.7	0.8	0.7	0.3	0.2	0.1	0.1	0.33

Note. Participants in each group are ranked by average cooperation for the session

APPENDIX B

95% Confidence Intervals for the Percentage of Cooperation for Each Group Mean

Trial Block	Control	Cooperate	Defect	Choice	Reversal
1	6.37%	5.31%	6.20%	7.73%	6.16%
2	7.84%	4.89%	8.31%	9.42%	7.99%
3	9.99%	7.43%	9.73%	10.58%	9.92%
4	9.11%	10.25%	9.93%	10.62%	6.06%
5	8.76%	10.17%	10.67%	10.71%	6.99%
6	10.39%	6.04%	5.39%	12.22%	7.94%
7	10.42%	6.21%	8.01%	10.40%	10.52%
8	10.86%	7.52%	11.03%	11.35%	12.13%
9	10.10%	6.25%	11.71%	9.69%	12.08%
10	10.61%	7.91%	9.77%	7.02%	12.13%