*SWITCHING FROM COMPETITION TO SHARING OR
COOPERATION AT LARGE RESPONSE REQUIREMENTS:
COMPETITION REQUIRES MORE RESPONDING¹*

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Two pairs of high-school students matched-to-sample for money. On each trial, a subject could either respond on one lever to take the matching-to-sample problem himself (taking response) or respond on a second lever to give the problem to his coactor (giving response). The first subject to complete the response requirement determined the distribution of the problem. Competition maximizes the amount of responding over trials, *i.e.*, both subjects make taking responses on each trial. Sharing and cooperation minimize responding: only one subject makes a taking response (sharing) or a giving response (cooperation) on each trial, and the subjects alternate responding such that there is an equitable distribution of responses and reinforcers over trials. Large increases in the fixed-ratio response requirement to distribute problems produced: (1) a switch from competition to sharing or cooperation, (2) the expected concomitant change from inequitable to equitable distributions of reinforcers, and (3) a reduction in the amount of responding for three of the four subjects. Previous animal research has shown that large response requirements may have aversive properties. Switching from competition to sharing or cooperation at large response requirements allows a reduction in responding and, at the same time, a moderate number of reinforcers for each subject.

Key words: competition, sharing, cooperation, fixed ratio, adjusting ratio, force requirement, audit response, match-to-sample, humans

Hake, Vukelich, and Olvera (1975) described the major equitable and inequitable methods by which subjects could distribute reinforcers in a two-person social situation. That experiment scheduled one reinforcer per trial, and each member of a pair of subjects could either respond on one lever to take the reinforcer for himself (taking response), or respond on a second lever to give the reinforcer to his coactor (giving response). The first subject to complete the response requirement determined the distribution of the reinforcer. Competition, one method of responding, was defined as both subjects making taking responses for the same reinforcer. Competition maximizes the amount of responding by both subjects over trials, because both subjects respond during a trial. Competition also typically maximizes the number of responses per reinforcer, because neither subject typically "wins" every reinforcer he at-

tempts to take. As a result, the average number of responses per reinforcer usually exceeds the response requirement. Only when a subject receives a reinforcer every time he attempts to take it does the average number of responses per reinforcer equal the response requirement. Sharing and cooperation, the major noncompetitive methods of responding, require only one subject to respond during a trial. In sharing, only one subject makes a taking response for each reinforcer and the two subjects typically alternate taking reinforcers. Hence, in sharing, subjects respond less than in competition and the average number of responses per reinforcer should equal the response requirement. In cooperation, which involves giving rather than taking responses, only one subject makes a giving response on each trial, and the subjects alternate giving reinforcers. Consequently, when two subjects cooperate and each receives the same number of reinforcers, the subjects respond less than in competition and the average number of responses per reinforcer should equal the response requirement. Competitive and noncompetitive methods of responding also differ in the distribution of reinforcers: competition typically results in an

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inequitable distribution of reinforcers, whereas the alternated taking (sharing) or giving (cooperation) of the two noncompetitive methods ordinarily results in more equitable distributions of reinforcers. Hence, switching from competition to sharing or cooperation is one way that responding can be reduced and still result in a moderate number of reinforcers for each subject.

In the above experiment, as in most experiments that have allowed both competitive and noncompetitive methods of responding, the greater amount of responding in competition probably had little effect, because the response requirement to distribute a reinforcer was small. What if the response requirement were increased? Would a larger response requirement produce a switch from competition to a noncompetitive method that required less responding?

Several experiments have shown that animals will initiate a timeout from large fixed-ratio (FR) and progressive-ratio schedules of positive reinforcement (Appel, 1963; Azrin, 1961; Dardano, 1973; Thompson, 1964, 1965). Explanation of the functional relation between the size of the response requirement and timeout responses should probably include both (1) the aversive properties of the larger response requirement, and (2) the reduced frequency of reinforcement that accompanies a larger response requirement. These experiments could have implications for the ways individuals distribute reinforcers in social situations. Competition might be expected at small fixed-ratios where the additional responding involved in competition is negligible. However, at the large ratios, where the response requirement may have aversive properties, competition might give way to sharing or cooperation, which would allow each subject to (1) respond less, (2) have timeouts from responding, and (3) still obtain a moderate number of reinforcers.

Previous experiments have shown that the choice between different methods of responding in a social situation can be altered by arranging differential response requirements (e.g., Hake and Vukelich, 1973). In the present experiment, no differential response requirement was arranged other than the naturally larger number of responses per reinforcer that occurs during competition when neither subject "wins" each reinforcer he attempts to take.

To ensure that neither subject could "win" every reinforcer during competition, an adjusting-ratio schedule was used to reduce the response requirement of the subject with the fewest reinforcers. This natural difference has probably had little effect in previous experiments, because response requirements have been small. In the present experiment, a change from competition to sharing or cooperation was expected when the response requirement was increased to the point that it might have aversive properties.

A reduction in the number of ratios attempted by each subject is not a sufficient indicator of a switch from competition to sharing or cooperation. Increasing the response requirement alone could reduce ratios attempted, while competition remained the method of responding on a majority of the trials. For this reason, three measures were used to determine the effects of increasing the response requirement: (1) changes in the number of ratios attempted, (2) changes in the methods of responding (*i.e.*, competition, sharing, cooperation), and (3) changes in the degree of equity or correspondence of the pair-members' scores (one subject's score as a percentage of his coactor's higher score).

METHOD

Subjects

Four male high-school students, 14 to 16 yr of age, were tested daily during school periods when they normally attended study hall. Session earnings plus a bonus of 75 cents per day for attending five consecutive days were paid weekly. The daily bonus was used to maintain regular attendance, because session earnings could fluctuate. The bonus was paid to a subject whether his coactor attended or not.

Half of the days contained one session per day and the other half two sessions per day. Each block of three sessions consisted of a 16-, 18-, and 20-min session. Session length and number of sessions per day were both varied in irregular orders to prevent subjects from reaching equity by each of them taking all of the points on alternate days or alternate sessions.

Apparatus

The apparatus was similar to the one used by Hake, Vukelich, and Kaplan (1973); that

article can be consulted for exact dimensions. Each member of a pair had a matching-to-sample apparatus that consisted of a sample panel for producing sample stimuli (left side of Figure 1) and a matching panel for matching sample stimuli (right side of Figure 1). The subject's sample panel was next to his own matching panel, but the apparatuses of the two subjects were 2 m apart.

Each matching panel was affixed to a table in front of the subject. In the center of each matching panel, from top to bottom, was an opening through which the six-cent point value of each problem was projected (magnitude-of-reinforcement stimulus), a light that flashed after a correct matching response on that panel (feedback stimulus), three pairs of buttons with a letter corresponding to each button (matching-response buttons), and a button that was to be depressed before talking (conference button). Two counters, one labelled "me" (self-audit counter) and the second labelled "other person" (coactor-audit counter), were covered by one-way glass and located on the right side of the panel. Presses on the button (audit button) to the left of either of these counters, illuminated the area behind the one-way glass for 2 sec, thereby allowing access to the score on that counter. Two levers (distribution levers) were located on the left side of the matching panel. Pulls on these levers with a force of 6 lb (26.7 N) distributed the matching-to-sample problem on each trial. A subject could take a problem to work himself (taking response) by completing the response requirement on the top lever. Similarly,

a subject could give a problem to his coactor (giving response) by completing the response requirement on the bottom lever. The first subject to complete the response requirement determined the distribution of the problem on that trial. The distribution levers were not operative unless a button (activate-lever button) mounted on the back of each panel was depressed for the duration of responding. A subject had to use his right hand to pull the lever, because the button could be reached only with the left hand. This ensured that all responding was done with the right hand, thereby increasing the potential aversiveness of the response requirement.

Two lights (distribution lights), corresponding in color to the matching-to-sample panels, were located directly above the levers. Both lights were lit at the start of each trial, indicating that a problem was available for distribution. If a subject took a problem or if his coactor gave him the problem, the distribution light corresponding to the color of his apparatus remained on while the other colored light went off. Conversely, when a subject gave a problem to his coactor or his coactor took it, the coactor's light remained on while his own went off. Two lights (coactor-response feedback lights), located above the distribution lights, indicated to each subject whether his coactor was responding and on which lever.

The sample panel was fastened to the top of a stand at eye level of the seated subject. Illumination of a light (sample-operative stimulus) on top of the panel indicated that the

Fig. 1. Diagram of the sample panel (left) and matching panel (right) of one subject.

panel was operative. When the sample panel was operative, pressing a button (sample-producing button) produced one of two letters for 1 sec through each of three openings (sample stimuli). The letters were T or P, H or K, and V or R. The combinations were randomized on two, 33-pole steppers that alternated every 2 min.

The experimental room contained a closed-circuit television camera, a microphone, and a voice-operated relay, all in full view of the subjects; these permitted continuous visual and audio monitoring. The electromechanical scheduling and recording equipment, the video-monitor, and the speaker were in an adjacent room.

Procedure

General procedure for distributing and completing problems on each trial. Depending on session length, a session consisted of 30, 34, or 37 trials with one matching-to-sample problem available on each trial. Each problem was worth six cents if completed correctly.

The sequence of events during a trial was as follows. The magnitude-of-reinforcement stimulus was illuminated and remained on for 31 sec, the duration of the trial. One second after illumination of the magnitude-of-reinforcement stimulus, the distribution lights were lit, indicating that the distribution levers were now operative, provided that the activate-lever button was depressed. If a ratio was completed on one of the distribution levers within the next 30 sec, the sample-operative stimulus on the appropriate sample panel was illuminated and the subject at that panel could work the problem. If the first subject to complete the ratio completed it on his take lever, the sample-operative stimulus on his sample panel was illuminated and he could work the problem. If the first subject to complete the ratio completed it on his give lever, the sample-operative on his coactor's sample panel was illuminated and the coactor could work the problem. Working the problem consisted of producing the sample-stimulus for 1 sec by pressing the sample-producing button, and then matching the sample-stimulus by pressing the appropriate matching-response buttons. If the subject completed the problem correctly, his feedback stimulus flashed, six points (cents) were counted on his self-audit counter, and six points were counted on his

coactor's coactor-audit counter. At the end of the 30-sec period beginning with the onset of the distribution lights, all lights on the matching and sample panels were darkened, and problems could not be worked. Two seconds later, the magnitude-of-reinforcement stimulus came on again, indicating the beginning of another trial.

Five button presses illuminated an audit counter. Subjects were allowed to talk during sessions as long as they kept the conference button depressed. Talking without depressing the button interrupted the session for 2 min, during which the subjects could not work problems.

Training on matching-to-sample. To ensure that subjects could match-to-sample, each subject was first tested individually until he correctly completed five consecutive problems. Each subject was read instructions that indicated the function of each part of the matching and sample panels and the sequence of events on a trial. Each subject was required to wear a leather glove on his right hand to eliminate the possibility of skin irritation caused by pulling the levers.

Baseline. Pair members were tested together during baseline and all subsequent experimental conditions. Baseline sessions, with an FR 10 response requirement on the distribution levers, were continued for six sessions to determine if competition was a stable method of responding at low ratio values. Subjects were instructed that only one subject had to pull either of his levers to distribute a problem on each trial, but if they both pulled their levers on the same trial, the one who finished first would distribute the problem. Subjects could either give or take problems by completing an FR 10 on the appropriate lever within the time limit. Baseline was re-instated following exposure to the large-ratio condition to determine if the subjects would return to competition. For Pair 2, the second baseline consisted of only three sessions because Subject 3 suffered a basketball injury to his hand.

Large-ratio condition. To determine the effects of a large response requirement on the method of distribution, the response requirement was increased six-fold to FR 60. Pair 2 was also tested at ratios of 75 and 120. To determine if the members of Pair 2 were able to complete ratios over 75, they were given one session each at FR 90 and FR 110 before

exposure to FR 120. Pair 1 was exposed to FR 80 for two sessions. Ordinarily, there was a minimum of six sessions at each ratio value, and ratio values were changed only after three consecutive sessions with no consistent and sizable changes in degree of correspondence of scores or method of distribution. However, only two sessions were provided at FR 80 for Pair 1, because of the observed difficulty of Subject 1 to complete the ratio requirement. Subjects were not told the ratio values.

Adjusting-ratio procedure. Ratio adjustments were made to minimize the possibility that one subject could consistently obtain more points than his coactor. A subject's ratio requirement was reduced by 10% of the prescribed ratio whenever he earned less than 80% of the points obtained by his coactor in the previous session. However, once the ratio of one subject was reduced, the other subject's ratio was not reduced if he then obtained less than 80% of the points obtained by his coactor. Instead, the subject's ratio that was previously reduced was increased by 10% in order to maintain at least one subject's ratio at the prescribed value. Ratio requirements were not changed from the previous session when the subject with the lowest score earned at least 80% as many points as his coactor. Table 1 shows each subject's ratio requirement for each session of the experiment.

Nonsocial condition. Nonsocial sessions, with the FR matched to the highest ratio in the social condition, were provided at the end of the experiment to determine the extent to which reductions in ratio responding during the large-ratio conditions could have been attributed to the effect of increasing ratio size alone without any change from competitive to noncompetitive responding. The rationale was that the number of ratios attempted under the nonsocial condition would indicate the maximum number the subject could attempt at that ratio, because there was no coactor and, hence, no alternative social method of reducing the amount of responding. The nonsocial sessions occurred after the return to baseline. The ratio value was increased gradually until the ratio value and length of the last three nonsocial sessions could be matched to the mean ratio value and length of the last three social sessions (Table 1). There were three nonsocial sessions at this ratio value. Subject 3 did not start the non-

social sessions until one month after the last social session because of the hand injury described previously.

RESULTS

Ratios Attempted

When the ratio requirement was increased, ratio responding decreased for all subjects. Figure 2 gives the percentage of trials on which each subject completed a minimum of half of the ratio, hereafter designated as ratios attempted. Data are shown for the first and last three sessions at each ratio value, but all major comparisons between conditions are based upon the last three sessions. Ratios attempted appeared to be a better measure than ratios completed, because the latter did not include ratios that were half or more completed when (1) the coactor completed the ratio first, or (2) the time limit expired before either subject completed the requirement. Examination of the last three sessions at each ratio value reveals that the number of ratios attempted by Subjects 3 and 4 (Pair 2) remained fairly constant at 90% or more until FR 120, where the number dropped to 40 to 50%. The ratio responding of both members of the pair returned to nearly 100% upon return to the baseline schedule of FR 10. For Pair 1, only Subject 2 showed a sizable decrease in ratio responding: the percentage of ratios attempted dropped from 95% at baseline to 30 to 40% for the last three sessions at FR 60 and FR 80. Upon return to baseline, ratios attempted increased to about 80%. Subject 1 attempted fewer ratios at FR 80 than at the previous values, but the decrease was slight compared to the other subjects.

A comparison of the number of ratios attempted during the high-ratio social sessions and the nonsocial sessions matched for ratio size indicated the extent to which the reductions during the high-ratio social sessions could have been attributed to the effect of ratio size alone, without any change from competitive to noncompetitive responding. These comparisons were made for the last three sessions at the ratio requirement where the number of ratios attempted first decreased, *i.e.*, FR 60 for Pair 1 and FR 120 for Pair 2. The ratio requirement alone did have a reductive effect for Subjects 2, 3, and 4: none of these subjects attempted all of the ratios in

Table 1
The Adjusted Ratio Value for Each Session

Condition	Pair 1		Condition	Pair 2		Session Number
	Subject 1	Subject 2		Subject 3	Subject 4	
Baseline FR 10 ^a	10	10	Baseline FR 10	10	10	1
	10	8		10	9	2
	9 ^b	9		10	8	3
	10	10		10	9	4
	8	10		10	9	5
	7	10		10	10	6
FR 60	60	60	FR 60	60	60	7
	48	60		60	54	8
	54	60		60	48	9
	48	60		60	54	10
	48	60		60	48	11
	42	60		60	54	12
	42	60		60	48	13
	42	60		60	48	14
FR 80	48	60	FR 75	75	75	15
	80	80		75	67	16
	80	80		75	59	17
Baseline FR 10	10	10		75	67	18
	10	10		75	59	19
	10	10		75	67	20
	10	10	Transition Values	90	90	21
Nonsocial	10	10		110	110	22
	44	60	FR 120	120	120	23
	44	60		120	108	24
	44	60		120	96	25
				120	96	26
				120	96	27
				120	96	28
				120	96	29
			Baseline FR 10	10	10	30
				10	10	31
				9	10	32
			Nonsocial Transition Values	10	50	33
				60	64	34
				75	96	35
				75	96	36
				90	96	37
				90		38
			Nonsocial	120		39
				120		40
				120		41

^aFor the first eight sessions, ratios could be adjusted by 20%. For all other sessions, 10% was the maximum adjustment.
^bThe highest ratio was reduced by mistake.

the nonsocial sessions. However, only in the case of Subject 4 were the number of ratios attempted about the same for the social and nonsocial sessions, indicating that the reductions during the high-ratio social sessions could have been attributable to the ratio requirement alone. Subjects 2 and 3 attempted fewer ratios during the last three social sessions than during matched nonsocial sessions, suggesting that another method of reducing responding was operative during the social conditions. The FR 60 condition had little

Fig. 2. The mean percentage of trials on which at least 50% of the ratio requirement was completed (ratios attempted) for the first and the last three sessions at each ratio value. The nonsocial sessions are indicated by the shaded bars. The solid vertical lines indicate the range.

effect on the responding of Subject 1: he completed nearly 100% of the ratios during both the social and nonsocial conditions.

Predominant Methods of Problem Distribution

A reduction in the number of ratios attempted is not a sufficient indicator of the change from competition to sharing or cooperation. Increasing the response requirement alone could reduce ratios attempted (e.g., Subject 4) and competition could remain the method of responding on a majority of the trials. This was not the case, as shown in Figure 3 which illustrates the predominant method of distributing problems under each condition. Responding did switch from competitive to noncompetitive at the highest ratio value for both pairs.

Figure 3 shows the per cent of the total number of trials that each major response category was recorded for each subject. The data for the even-numbered member of the pair are indicated by the clear bars and the

odd-numbered member by the shaded bars. Data are shown for the first and last three sessions under each condition. An ineffective response was recorded when a subject completed at least 50% but not all of the ratio requirement on one of his manipulanda. An ineffective taking response on a trial where the coactor took the problem (top row), by making all of the required responses on his take lever, indicated competition. Because there could be only one ineffective taking response per competitive trial and because it could be made by either subject, the per cent of competitive trials is obtained by adding the ineffective take responses of both members of a pair. The top row of graphs in Figure 3 shows that competition was the predominant method at FR 10 for both pairs. For the last three sessions, the per cent of trials with competition was about 90% for Pair 1 (Subject 1 plus Subject 2) and almost 100% for Pair 2 (Subject 3 plus Subject 4). Competition was virtually eliminated for both pairs during the last three sessions at the highest ratio value

Fig. 3. Predominant methods of distributing problems for the first and last three sessions at each ratio value. The graphs show, from top to bottom, the mean percentage of trials on which a subject made ineffective taking responses (completed at least 50% of the ratio requirement on his take lever on trials when the problem was taken by the coactor), shared (completed less than 50% of the ratio requirement on his take lever on trials where the problem was taken by the coactor), took the problem, or gave the problem. The solid vertical lines indicate the range. The data for the even-numbered member of a pair are shown by the shaded bars and the odd-numbered by the unshaded bars.

(FR 60 and FR 80 for Pair 1 and FR 120 for Pair 2), the points where the number of ratios attempted also decreased (Figure 2).

Although competition was eliminated at the highest ratio, subjects continued to distribute problems by responding on their take levers. The third row of graphs in Figure 3, labelled take responses, shows the per cent of trials on which each subject took the problem. Taking can also result in the noncompetitive method of problem distribution called sharing, which requires that one subject does not respond on his take manipulandum on a trial or completes less than half of the response requirement on his take manipulandum (shares) while his coactor takes the problem (take response). The second row of graphs shows the per cent of trials that each

subject shared while his coactor took the problem. For Pair 2, the decrease in competition at FR 120 was accompanied by a change to sharing as the predominant method of problem distribution. For the last three sessions at FR 120, Subject 3 shared on about 40% of the trials and Subject 4 shared on about 50%, making a total of over 90% of the trials with sharing.

For Pair 1, the decrease in competition during the last three sessions at FR 60 and at FR 80 was accompanied by a solution in which Subject 1 distributed most of the problems by giving part of them to his coactor (bottom row) and taking part for himself (third row). This method was a combination of cooperation (give responses by Subject 1) and sharing (takes by Subject 1 and shares by

Subject 2). Subject 1 showed little reduction in ratios attempted (Figure 2), because he gave or took nearly all of the problems. On the other hand, his partner, Subject 2, showed the largest reductions in ratios attempted.

Although the major changes from competitive to noncompetitive responding have been described, following the switch to noncompetitive responding, each member of Pair 1 also made ineffective giving and taking responses for which there were no exact categories in Figure 3. These ineffective responses would not have changed the distribution of the problem had they been effective. For example, both subjects made ineffective giving responses on trials where their coactor took the problem (8% and 5% of the trials during the final sessions at FR 60 and 80 for Subjects 1 and 2, respectively). These ineffective giving responses were categorized as sharing in Figure 3, because the subjects did not attempt to take the problem on a trial where their coactor took it. Subject 2 also made ineffective take responses (not shown in Figure 3) on trials where Subject 1 gave him the problem (an average of 19% of the trials during the final sessions at FR 60 and 80). These two types of ineffective responses account for the higher number of ratios attempted in Figure 2 at the higher ratios and at the return to baseline.

These ineffective responses by Subject 2 may have helped maintain the distribution of most of the problems by Subject 1 at the higher ratios. In response to a postexperimental questionnaire both Subjects 1 and 2 stated that they understood that only one subject had to respond to distribute a problem, and that one subject's give responses and the other subject's take responses were not additive. They could also describe the function of the coactor response-feedback lights. Because Subject 1 could monitor the responding of Subject 2 by observing the coactor-response feedback lights, Subject 2's ineffective responding may have made it appear that he was doing or at least trying to do his share of responding. In response to the postexperimental questionnaire, Subject 1 stated that he and his coactor had done approximately the same amount of work.

The return to the FR 10 schedule was accompanied by a return to competition for Pair 2 (top row) and a switch to a different

noncompetitive method of distribution, predominantly sharing, for Pair 1. The responding of Subject 2 increased at this lower response requirement, as he now took about 40% of the problems, while Subject 1 shared on these trials. Subject 1 took about 50% of the problems and gave 10% to Subject 2.

Correspondence of Scores

Figure 4 shows that the correspondence of counter scores (one subject's score as a percentage of his coactor's higher score) increased at the high-ratio requirement concurrent with the change from competitive to noncompetitive responding. Increased correspondence is required by the definitions of sharing and cooperation (Hake *et al.*, 1975); hence its occurrence further indicates a switch from competitive to noncompetitive responding.

Figure 4 indicates the correspondence of counter scores for each session and which member of the pair had the highest score (open and closed points). For Pair 2, correspondence increased to 100% during the third session at FR 120 and remained over 90% for the remaining sessions at that ratio. When FR 10 was re-instated, correspondence

Fig. 4. Correspondence of scores for each pair for each session of the experiment. Solid circles indicate that the odd-numbered subject had the high score for that session, and open circles indicate that the even-numbered subject had the higher score for that session. Half-filled circles indicate 100% correspondence. The broken lines are the mean correspondence for the first and last three sessions at each ratio value.

decreased concomitant with the return to competitive responding (Figure 3). Pair 1 also generally had low levels of correspondence during the baseline, except for one session, which was the result of an equal number of points obtained by each subject by competitive responding (Figure 3). After an initial decrease in correspondence at FR 60, correspondence increased to over 90% beginning with the sixth session and remained at high levels throughout this ratio and the increase to FR 80. There was one exception (Session 14) where Subject 1 took a large percentage of problems without as many of the cooperative (give) responses that had previously served to equalize their scores. Correspondence for this pair remained over 90% when the baseline was re-instated, because they continued with noncompetitive responding, albeit a different method in which Subject 2 responded more.

The increased correspondence at the higher ratios was not an artifact of the percentage measure used in Figure 4: increased correspondence at the higher ratios was also evident in the smaller absolute differences

between the pair members' counter scores. This can be seen in Table 2, which shows the points per minute for the mean high score, the mean low score, and the mean difference between scores under each ratio requirement.

Subject 3, who matched with a mean accuracy of 86% at FR 120, was the only subject whose accuracy was ever below 90% for any condition. The lower accuracy level for Subject 3 was the result of occasional failures to complete the matching problem before time expired.

The postexperimental questionnaire revealed that the subjects' verbal behavior coincided with their experimental behavior. They stated that they decided to eliminate competition and "make the points come out even" at the high ratio conditions, because "the task was too difficult".

DISCUSSION

A switch from competition to sharing or cooperation was expected when the ratio requirement was increased, because large-ratio

Table 2
The mean high score, mean low score, and mean difference between high and low scores in terms of the mean number of points per minute for the first and last three sessions at each ratio value. The numbers in parentheses are the ranges.

Condition	Sessions	Pair 1			Condition	Pair 2		
		Mean High Score	Mean Low Score	Mean Difference		Mean High Score	Mean Low Score	Mean Difference
FR 10	First	7.18	3.97	3.21	FR 10	7.64	2.85	4.79
	Three	(5.58-8.67)	(2.69-5.58)	(0.00-5.98)		(6.33-9.19)	(1.84-4.33)	(2.00-7.35)
	Last	6.57	4.39	2.18		7.30	3.40	3.90
FR 60	Three	(6.25-6.71)	(4.11-4.60)	(1.65-2.64)	FR 60	(6.00-9.61)	(1.33-4.80)	(1.20-8.28)
	First	9.08	2.04	7.04		7.87	2.21	5.66
	Three	(8.11-9.63)	(1.48-3.00)	(5.11-8.15)		(5.60-10.41)	(0.37-3.31)	(2.65-10.04)
FR 80*	Last	5.93	4.61	1.32	FR 75	7.99	2.97	5.02
	Three	(4.83-7.32)	(3.66-5.63)	(0.00-3.66)		(5.71-9.75)	(1.18-5.11)	(0.60-8.57)
	First	4.01	3.66	0.35		8.59	1.31	7.28
FR 10	Three	(3.92-4.09)	(3.59-3.72)	(0.33-0.37)	FR 120	(7.52-10.38)	(0.37-2.95)	(4.91-10.01)
	Last	5.64	5.41	0.23		9.33	1.60	7.73
	Three	(5.58-5.73)	(5.21-5.62)	(0.00-0.34)		(7.51-10.83)	(0.30-3.01)	(4.50-10.53)
FR 80*	First	5.53	5.53	0.00	FR 10	5.30	3.09	2.21
	Three	(5.39-5.64)	(5.39-5.64)	(0.00-0.00)		(4.46-6.02)	(1.50-4.46)	(0.00-4.25)
	First	7.78	3.18	4.60		4.58	4.48	0.10
FR 10	Three	(5.74-10.52)	(0.99-4.83)	(0.91-9.58)		(3.91-5.71)	(3.91-5.41)	(0.00-0.30)
	First	7.78	3.18	4.60		7.78	3.18	4.60
	Three	(5.74-10.52)	(0.99-4.83)	(0.91-9.58)		(5.74-10.52)	(0.99-4.83)	(0.91-9.58)

*Only two sessions at FR 80.

requirements have been shown to possess aversive properties and, because competition involves more responding than sharing or cooperation. This was the only way to reduce unreinforced responding in the form of ineffective competitive responses, and still maintain reinforcement at a moderate level. The experiment confirmed this notion. First, the number of ratios attempted decreased for three of the four subjects when the ratio requirement was increased, and the number of ratios attempted increased when the ratio requirement was again reduced. Second, both pairs ceased competing and switched to noncompetitive methods of problem distribution that required less responding for at least one member of each pair. Third, consistent with the definitions of sharing and cooperation, this switch was accompanied by an increase in the correspondence of scores. When the ratio requirement was reduced, Pair 2 returned to competition accompanied by a decrease in the level of correspondence, while Pair 1 switched to a different noncompetitive method of problem distribution in which Subject 2 responded more, but remained at high levels of correspondence. The failure of Pair 1 to return to competition after the ratio requirement was reduced may be indicative of the stability of learned equitable methods of distribution (Hake *et al.*, 1975).

A reduction in the number of ratios attempted is not a sufficient indicator of a change from competitive to noncompetitive responding. Increasing the response requirement alone could reduce ratios attempted, with competition remaining the method of responding on a majority of the trials. However, all three of the subjects who showed a reduction in ratios attempted (Subjects 2, 3, and 4) also switched from competitive to noncompetitive responding at this time. The Pair-1 subjects never made taking responses on the same trial (competition), because Subject 1 alternately took and gave most of the problems. For Pair 2, the subjects took problems on alternate trials (sharing) and, again, they did not make taking responses on the same trial. And, consistent with the definitions of sharing and cooperation, correspondence of scores increased. The analysis of the methods of responding was especially important for Subject 4, because a comparison of the number of ratios attempted in the high-ratio

social sessions and the nonsocial sessions matched for ratio size revealed that a reduction of the magnitude obtained during the high-ratio social sessions could have been produced entirely by the ratio size alone. Analysis of the methods of responding for Subject 4, however, revealed a switch from competitive responding to sharing. This switch to sharing allowed this subject's reduced ratio output to produce more reinforcers than continued competition, because the switch eliminated all ineffective or unreinforced competitive responses.

Subject 1 did not have a sizable reduction in ratios attempted under any condition. The finding that he was the only subject to respond on all of the ratios in the matched nonsocial condition suggests that his ratio requirement was not increased sufficiently to acquire aversive properties. However, competitive responding did cease at the high-ratio requirements as his pair (Pair 1) did switch to a noncompetitive method of responding. This suggests that a switch from competitive to noncompetitive responding may result when the response requirement acquires aversive properties for only one member of a pair.

Although the present experiment may have contained features that contributed to the effectiveness of the large ratio, *i.e.*, the adjusting-ratio procedure, the phenomenon does not appear to be limited to the laboratory. For example, the phenomenon may be operating in academic situations where a small response requirement such as, "Read and be prepared to discuss this article for our next class", generates competition in the form of individual work. When the response requirement is then increased to, "Read and be prepared to discuss these six articles by our next class", students have been observed to divide the response requirement. This might take the form of, "You outline three articles and I'll outline the other three". Casual observation also suggests that it is more likely for students of equal ability to cooperate than students of substantially different abilities. In the present study, the adjusting-ratio procedure was included to produce equality within pairs. However, this experiment did not evaluate the importance of the adjustment procedure and further experimentation will be necessary to clarify its role in the choice of noncompetitive methods of responding.

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