JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1976, 26, 321-333 NUMBER 3 (NOVEMBER)

PRODUCING A CHANGE FROM COMPETITION TO SHARING: EFFECTS OF LARGE AND ADJUSTING RESPONSE REQUIREMENTS[1]

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Pairs of high-school students matched-to-sample for money. On each trial, the first pair member to complete a fixed ratio of knob-pulling responses could work the matching problem on that trial. Competition occurred when both pair members responded for the problem. Sharing occurred when only one pair member responded on each trial, and the subjects alternated trials. Hence, sharing requires less responding and still allows a moderate number of reinforcers for each subject. Recent research has shown that increasing the response requirement to the point that it may have aversive properties will produce a change from competition to sharing. A related variable is an adjusting schedule that adjusts the subjects' response requirements so that their abilities to take reinforcers are equal. In this way, subjects might learn that competition requires more responding but produces no more reinforcers. However, recent research also suggests that competition decreases over sessions without experimental manipulations. Because of this possibility of a time-related variable, ratio size and an adjusting schedule were studied in a group design. Competition did decrease for all groups over sessions, but the large-ratio groups switched from competition to sharing sooner than the low-ratio groups. The adjusting schedule had a similar but smaller effect.

Key words: competition, sharing, cooperation, ratio requirement, adjusting schedule, audit, match-to-sample, knob pull, high-school students

Competition naturally requires more responding than the major noncompetitive methods of responding. For example, consider a recent experiment in which one reinforcer was scheduled per trial, and each member of a pair of subjects could either respond on one button to take the reinforcer for himself (taking response), or respond on a second button to give the reinforcer to his coactor (giving response) (Hake, Vukelich, and Olvera, 1975). The first subject to complete the response requirement determined the distribution of the reinforcer. 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 on a trial, and the two subjects typically alternate trials. In cooperation, which involves giving rather than taking responses, only one subject makes a giving response on a trial, and the subjects typically alternate trials. In competition, however, both subjects attempt to take the same reinforcer; hence, competition maximizes the amount of responding by both subjects over trials, because both subjects respond during each trial.

Competitive and noncompetitive methods of responding also differ in the distribution of reinforcers. Competition typically results in an inequitable distribution, whereas the alternated taking (sharing) or giving (cooperation) of the two noncompetitive methods ordinarily results in a more equitable distribution. Hence, switching from competition to sharing or cooperation is one way each subject can reduce responding and still produce a moderate number of reinforcers.

The greater amount of responding in competition suggested a way to change competitive to noncompetitive responding. Animals will initiate a timeout from large fixed-ratio (FR) and progressive-ratio schedules of positive reinforcement (Appel, 1963; Azrin, 1961; Dar-

[1]The experiment was conducted at Anna State Hospital, supported by the Illinois Department of Mental Health, and is based on the first author's doctoral dissertation at Southern Illinois University in August, 1974. Thanks are due Reed Williams and Richard Foxx for their helpful reading of the paper. Reprints may be obtained from Dennis R. Olvera, W. A. Howe Developmental Center, 7600 W. 183rd Street, Tinley Park, Illinois 60477, or Don F. Hake, Psychology Department, West Virginia University, Morgantown, West Virginia 26506.

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dano, 1973; Thompson, 1964, 1965). This functional relation between size of the response requirement and timeout responses could be due to both (1) the aversive properties of the larger response requirement, and (2) the reduced frequency of reinforcement that accompanies a larger response requirement. At any rate, these findings suggested that increasing the FR requirement might produce a change from competition to sharing or cooperation, because the change would allow each subject to (1) respond less, (2) have timeouts from responding, and (3) still obtain a moderate number of reinforcers. The greater amount of responding in competition has probably had little effect in previous experiments on competitive and noncompetitive responding, because the response requirements have been small.

Hake, Olvera, and Bell (1975) showed that large response requirements did produce a switch from competition to sharing or cooperation. That experiment was similar to Hake *et al.* (1975*a*) except that the button-press response by which reinforcers were distributed was replaced by a more effortful knob-pull response and the FR values were increased. Subjects who competed at FR 10 shared or cooperated when the response requirement was later increased to FR 60 or FR 120.

One goal of the present study was to evaluate the effects of ratio size in a group design. This is important because our previous research also suggests that competition decreases over sessions without experimental manipulation (Hake *et al.,* 1975*a*). Subjects who began by competing usually switched to cooperation or sharing without the introduction of any experimental variable. A time-related variable(s) was indicated by the finding that noncompetitive methods were more likely to develop when subjects were tested for several sessions spaced over days than when an equal number of sessions was massed into one day.

A variable related to ratio size that might also produce a change from competitive to noncompetitive responding is an adjusting schedule that adjusts the subjects' response requirements so that their abilities to take reinforcers are equal. Under such a schedule subjects can learn that competition requires more responding (*i.e.,* than sharing or cooperation) but results in no more reinforcers. The earlier study on ratio size (Hake *et al.,* 1975*b*) had an adjustment procedure that may have facilitated the switch from competition to sharing or cooperation. A second goal of the present study was to evaluate the effects of an adjusting schedule in a group design and to compare them to the effects of the ratio-size variable. The adjusting schedule in this study differed from the earlier study in that adjustments could be made on each trial, rather than only on a session-to-session basis.

This study also differed from Hake *et al.* (1975*a,b*) in that competition and sharing were the only alternatives. Eliminating the giving response (cooperation) eliminated any possibility of the giving response serving as a stimulus to do something other than compete.

Three measures were used to detect changes from competition to sharing: (1) changes in the number of fixed ratios attempted by each subject, (2) changes in the method of responding (*i.e.,* competition with both members responding on a trial, or sharing with only one pair member responding) 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). A reduction in the number of ratios attempted by each subject was not sufficient, because attemped ratios could decrease with increasing the response requirement while competition remained the major method of responding.

METHOD

Subjects

Fourteen pairs of 14- to 17-yr-old male high-school students participated. Consistent attendance was maintained in two ways. First, subjects were provided transportation. When school was in session, a member of the laboratory staff met the subjects at the beginning of their study hall, transported them to the laboratory, and returned them to school before the end of their study hall. The four pairs that were tested during summer vacation were picked up at their homes and returned there after the session. Second, subjects were paid a bonus of $3.75 per week in addition to their session earnings if they attended all of the sessions during that week. On days when one subject was absent, the other subject was given one-half of the money that would be available during sessions ($1.60), in addition to 75¢ toward his $3.75-per-week bonus. This pay-

ment of session earnings even when the other subject was absent minimized the possibility that the absent subject could use his atendance as a contingency to force his coactor to share during the sessions. Subjects were paid weekly but on different days.

Apparatus

Each subject's apparatus consisted of a sample panel for producing stimuli (left side of Figure 1) and a matching panel for matching responses (right side of Figure 1). A subject's sample and matching panels were next to each other, but the apparatuses of the two subjects were 2 m apart. The panels were similar to those used by Hake, Vukelich, and Kaplan (1973), which may be consulted for exact dimensions. Each matching panel was affixed to the table in front of the seated subject. In the center of each matching panel, from top to bottom, were an opening through which the number six was projected to indicate the six-cent point value of each problem (magnitude-of-reinforcement stimulus), a light that flashed after a correct matching response (feedback stimulus), three pairs of buttons with a letter corresponding to each button (matching-response buttons), and a button that had to be depressed by subjects while talking (conference button). Two counters labelled "me" (self-audit counter) and "other person" (coactor-audit counter), covered with one-way glass, were mounted on the right side of the matching panel. The subjects' scores were recorded on these counters. Five presses on the button (audit button) corresponding to a particular audit counter illuminated the area behind the one-way glass for 2 sec so that a subject could view the score on the counter. A Lindsley manipulandum (distribution lever) was mounted on the left side of the matching panel. A subject could produce the matching-to-sample problem on a trial by fulfilling a fixed-ratio requirement on the distribution lever. A response counted when the subject exerted six pounds (26.7 N) of pull on the lever with one hand while depressing a button (activate-lever button) mounted on the back of the matching-response panel with the other hand. A subject had to use his right hand to pull the lever, because the button could be reached only with the left hand. Forcing consistent use of one hand to pull the lever was intended to increase the aversive properties of the FR requirement. (Left-handed subjects had to depress an activate-lever button on the other side of the back of the panel, thereby ensuring consistent use of the left-hand to pull the lever.) Two lights (distribution lights), one green and one brown, color coded to match the color of each subject's matching panel, were mounted above the distribution lever. On each trial they indicated when a subject took the problem to work and which subject took it. A light (response feedback) mounted above the problem-distribution lights flashed when his coactor was responding.

The sample panel was fastened to a stand, which put it at eye level of the seated subject. When the light (sample-operative stimulus) located on the top of the panel was on, pressing the button (sample-producing button) at the

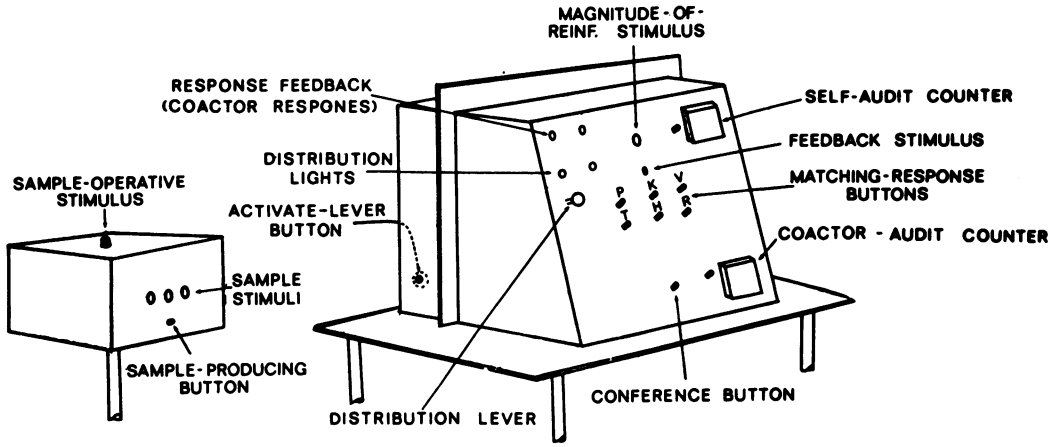

Fig. 1. Diagram of the sample panel (left) and matching-response panel (right) of one subject.

bottom of the panel produced a letter in each of the three openings on the panel face (sample stimuli). One of two letters randomly appeared in each opening: the letters were P or T, K or H, and V or R.

The experimental room, approximately 6 by 7 by 2 m, also contained an intercom unit and a closed-circuit television camera, all in full view of subjects; these permitted continuous visual and audio monitoring. The television screen, the microphone speaker, and the scheduling and recording equipment were all in an adjacent room.

Procedure

Basic procedure for distributing and completing problems. Each pair was tested for one or two, but usually two sessions per day for a total of 14 sessions. One of the pairs (Pair 8) was terminated after 11 sessions, because of an injury which one of the subjects (S-16) sustained at his home. The length of sessions was varied randomly within three-session blocks over 16-, 18-, or 20-min values, which consisted of 24, 27, and 30 trials, respectively. Because neither the number of sessions per day nor the length of sessions was constant, pair members were forced to even their scores on a within-session rather than a between-sessions basis if they were going to come out even at all.

Each trial began with presentation of the magnitude-of-reinforcement stimulus, which presented the six-cent point value of the upcoming problem and remained on for the next 31 sec. One second after the onset of the magnitude-of-reinforcement stimulus, both colored problem-distribution lights were illuminated, thereby indicating that responses on the distribution lever would then count toward the FR requirement if the subject depressed the activate-lever button while he responded. A subject could take the problem to work himself if he fulfilled the ratio requirement before his coactor and before the magnitude-of-reinforcement stimulus and problem distribution lights went off (30 sec required to complete the ratio).

When a subject took a problem, the problem-distribution light corresponding to the color of his coactor's apparatus went off. Simultaneously, the sample-operative stimulus on top of his own sample panel was lit. Pressing the sample-producing button then produced a sample (*e.g.*, T, K, and R) on his sample panel for 1 sec. If he then pressed only the three corresponding matching-response buttons (*e.g.*, T, K, and R in this case) the feedback light on his matching panel flashed, six points were counted on his "me" audit counter, and six points were counted on his coactor's "other person" audit counter. Any incorrect matching response prevented point delivery and feedback. Also, correct matching responses that occurred more than 30 sec after the onset of the problem-distribution lights were not followed by feedback or points. At the end of the 30-sec period, all of the panel lights were darkened for 9 sec. The presentation of the magnitude-of-reinforcement stimulus signalled the start of the next trial.

A subject was able to check his own score at any time by pressing the button labelled "me" five times. A subject was also able to check his coactor's score at any time by pressing the button labelled "other person" five times. A measure of the number of times pair members talked to each other and the total time they spent talking to each other during sessions was obtained by having subjects press the button labelled "conference" while they talked. If the subjects talked without pressing the conference button, they were not allowed to work problems for 2 min.

Instructions and training. At the start of the study, one subject at a time was seated in front of a response panel and told that the panel could be used to work problems which, if worked correctly, were worth six cents each. The subject was then read instructions that indicated the function of each part of the matching and sample panels and the sequence of events on each trial. The subject was instructed that only one subject had to pull his lever to distribute a problem on each trial, but if they both pulled their levers on the same trial, the one who finished first would be allowed to work the problem. That instruction, plus reminders to use the activate-lever button and to pull the lever out all the way out on each response, constituted the abbreviated instructions that were read before each subsequent session. Each subject was required to wear a leather glove on his right hand (left hand for left-handed subjects) to eliminate the possibility of skin irritation caused by pulling the lever. Before the first session, each subject was allowed to produce and to work a matching-to-sample problem individually. This was

done to ensure that the subjects could match-to-sample.

First session test for competition. The 14 pairs were tested for competition during the first half of the first session. The ratio requirement was FR 30 for all subjects and no adjustments were made. The 12 pairs who competed on more than 70% of the problems during the half session were immediately assigned to one of four groups without interrupting the session. The other two pairs were discontinued.

Experimental Groups

Low-Ratio. From the first session on, a subject assigned to this group could take a problem by fulfilling an FR 30 knob-pull requirement.

High-Ratio. The ratio value was ultimately set at the highest ratio value—FR 80 or 100—that both pair members could consistently complete in less than 20 sec. After the first half of the first session, the requirement was increased from FR 30 to FR 60 for the second half of the session. The ratio for the first half of the second session was FR 60, but it was increased to FR 80 for the second half if both members completed the FR 60 in less than 20 sec. All subjects in the High-Ratio group reached FR 100 during the third session.

Low-Adjusting-Ratio. Adjustments started at the beginning of the last half of the first session. For the first trial, the ratio value was FR 30 for both members of a pair, but adjustments could then occur for each member. However, on a given trial, the ratio was always kept at FR 30 for at least one of the pair members. No ratio was ever decreased below FR 15, nor was any ratio ever greater than FR 30. No adjustments were made if (1) the subjects shared and (2) the correspondence of scores (one subject's score as a percentage of his coactor's higher score) was 80% or greater. When the correspondence of scores dropped below 80%, or if the subjects competed, adjustments were made as follows. If the subject having the lower score did not take the problem on the last trial, his ratio for the next trial was reduced by 10% of the FR 30 (three responses). His ratio was decreased by three more responses for each trial he did not take the problem until a minimum of FR 15 was reached. If he took the next problem, his ratio stayed the same. When he took two successive problems, his ratio was increased three responses.

High-Adjusting-Ratio. The highest ratio values were reached in the same way as for subjects in the High-Ratio group. Two of the pairs in this group reached FR 100, but the third pair (Pair 12) reached only FR 80, because neither pair member could complete FR 80 in less than 20 sec. Adjustments followed the criteria specified for subjects in the Low-Adjusting-Ratio group, but the 10% adjustments were 10 responses (eight for Pair 12) and the minimum ratio was FR 50 (40 for Pair 12).

The ratios in effect for both subjects were recorded each trial on a print-out counter so that a mean ratio value could be calculated for each subject at the end of each session. The mean ratio value for all subjects in the Low-Adjusting-Ratio group was 26, with a range of 23 (Subject 11) to 29 (Subject 12). The first session was not included in these averages, because adjustments did not start until the second half of Session 1. The mean ratio value for the four subjects of the High-Adjusting-Ratio group who reached FR 100 was 84, with a range of 72 (Subject 21) to 93 (Subject 22). The two subjects who reached only FR 80 had mean ratio values of 69 (Subject 23) and 65 (Subject 24). The averages for High-Adjusting-Ratio group do not include Sessions 1 to 3, because the ratio did not reach its final value until the last half of Session 3.

Nonsocial sessions. With the exception of Subject 16, each subject in the High-Ratio and High-Adjusting-Ratio groups was tested alone for two sessions after the 14 social sessions. These nonsocial sessions, with the FR matched to the mean FR of the preceding four social sessions, evaluated the extent to which reductions in responding during the high-ratio conditions could be attributed to ratio size alone, without any change from competition to sharing. The rationale was that the number of ratios attempted during the nonsocial sessions would indicate the maximum number the subject could attempt, because there was no coactor and, hence, sharing could not be a method of reducing responding. If, for example, a subject attempted no more ratios in the nonsocial sessions than in the social sessions, the reduction during the social sessions could be attributed to ratio size alone, without any switch from competition to sharing. On the other hand, if a subject attempted many more ratios during the nonsocial sessions than in the social sessions, the reduction during the so-

cial sessions could not be attributed to ratio size alone. Rather, the reduction during the social sessions would indicate a switch from competition to sharing.

RESULTS

Competitive Responding

Because subjects could distribute problems by take responses only, pair members could only compete, share, or neither of them respond at all. During social sessions, fewer than 5% of the available problems were not distributed; hence, subjects either competed or shared on over 95% of the trials. Competition occurred on trials where one subject completed at least 50% of the ratio requirement for a problem that his coactor took. The 50% criterion was used to define an attempted ratio, and hence a competitive response, instead of 100%, because 100% could not include ratios that were half or more completed when the coactor completed the ratio first. For all groups, the 50% criterion was calculated relative to the ratio at the start of the session.

Figure 2 shows the per cent of trials with competition for each group over sessions. The per cent of trials with sharing can also be calculated almost exactly from Figure 2. Because subjects either competed or shared on over 95% of the trials, the area above each point indicates the per cent sharing. Hence, Figure 2 shows that competition decreased and sharing increased across sessions for all four groups. There were, however, differences among the groups in terms of the speed and extent to which this happened. The arrows along the x-axis indicate the first of four consecutive sessions during which competitive trials dropped below 50%. The High-Adjusting-Ratio and High-Ratio groups met the stability criterion during Sessions 3 and 4, respectively, and were consistently below 10% competition by Sessions 6 and 8, respectively. In contrast, the Low-Adjusting-Ratio group did not meet the 50% stability criterion until Session 7 and was not consistently at the 10% level until Session 12. The Low-Ratio group went below 50% competition for the last three sessions but never approximated the 10% level. Thus, the major conclusion is that high ratios were effective in producing a change from competition to sharing. Figure 2 also shows that the Low- and High-Adjusting groups met criterion one

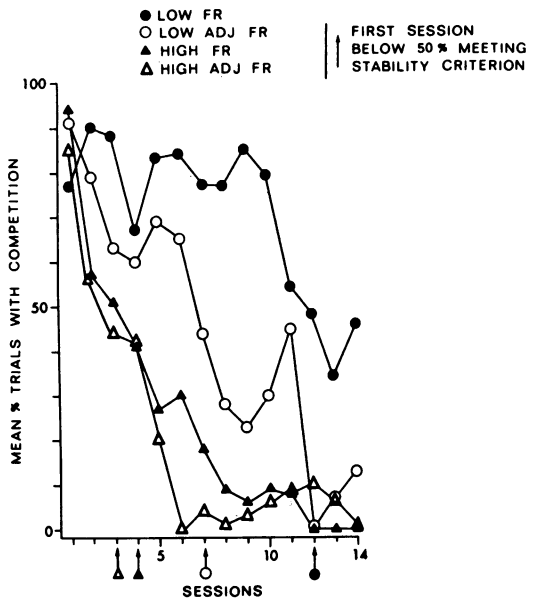

Fig. 2. Mean per cent of trials with competition for each of the four groups over sessions. The arrows below the x-axis indicate the first of four consecutive sessions with less than 50% competition (stability criterion). One pair in the High-Ratio group (Pair 8) completed only 11 sessions and the data points for the High-Ratio group for Sessions 12, 13, and 14 are the average of the remaining two pairs.

and four sessions, respectively, before their nonadjusting counterparts. Although the large ratio was more effective in producing sharing than the adjusting procedure, the adjusting procedure was more effective than the nonadjusting procedure.

The difference among groups can also be seen in the individual data of Figure 3. First, consider the per cent of trials with competition for each pair (X's). The unconnected X at Session 1, the first-session test for competition, indicates at least 75% competition for all pairs, and usually 80 to 100%. However, competition decreased sooner with pairs tested under the higher ratios. The High-Adjusting-Ratio pairs met the 50% criterion (arrows on x-axis) by Session 3 (Pair 12), Session 5 (Pair 11), and Session 6 (Pair 10). Similarly, two High-Ratio pairs met the 50% criterion just as quickly (Pairs 7 and 9 during Sessions 4 and 3, respectively) while the third pair (Pair 8) did not attain criterion until Session 8. In contrast, the Low-Adjusting-Ratio and Low-Ratio pairs did not attain criterion as quickly. The three pairs in the Low-Adjusting group did not meet criterion until Session 3 (Pair 4), Session 7 (Pair

6), and Session 11 (Pair 5). Moreover, Pairs 4 and 6 competed substantially after meeting criterion (*e.g.*, Session 11 for Pair 4 and Session 11 for Pair 6). The low-ratio procedure was the least effective: only Pair 2 met the stability criterion (Session 11). Pair 1 showed some decrease in competition over sessions, but Pair 3 competed on about 80% of the trials across all 14 sessions.

Figure 3 also shows the per cent ineffective competitive responses for each subject. These are the trials in which a subject completed over 50% of the ratio for a problem taken by his coactor. The effect of the adjustment procedures can be seen by comparing these ineffective competitive responses for pair members in the adjusting and nonadjusting groups. The small differences each session between pair

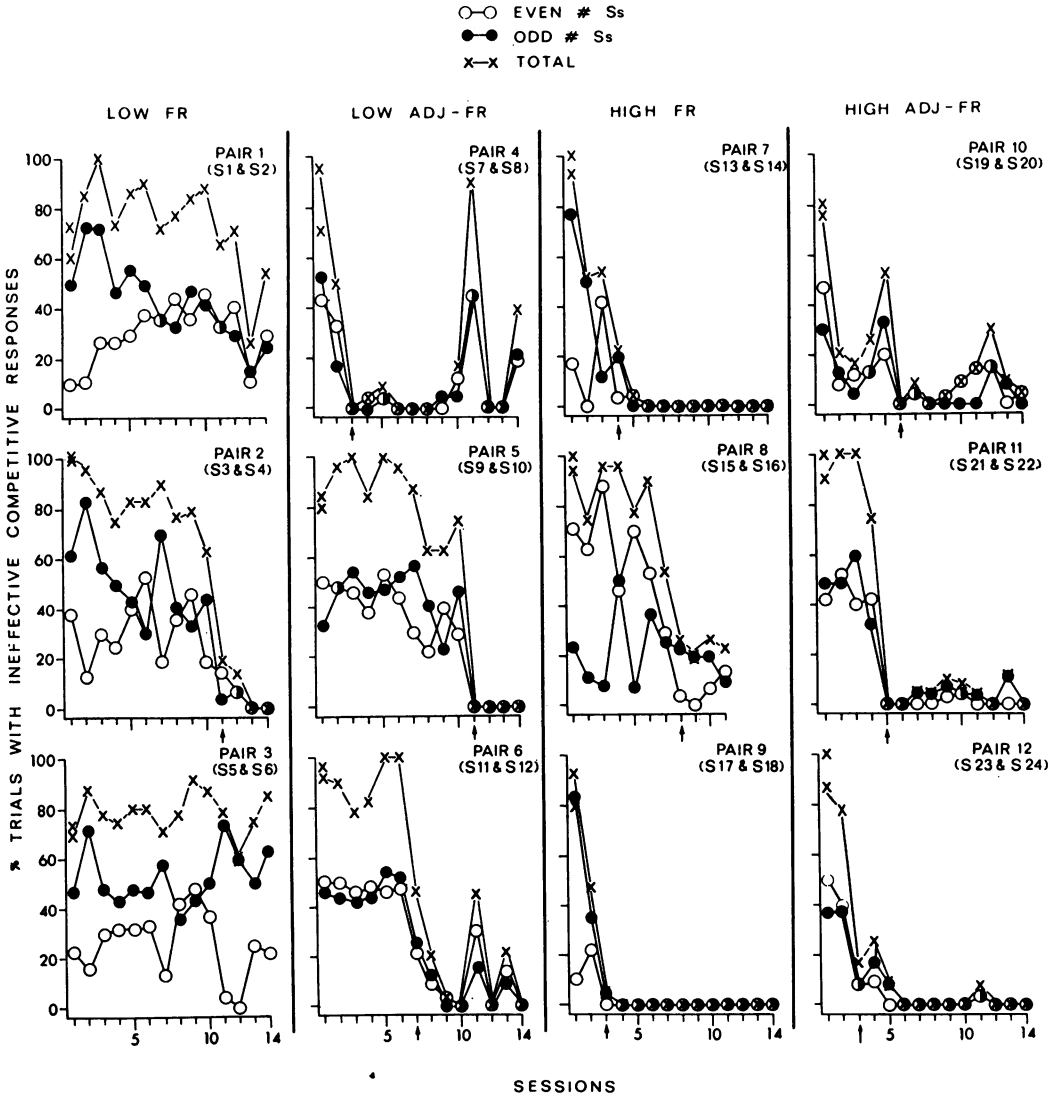

Fig. 3. Per cent of trials with ineffective competitive responses for each pair and each subject over sessions. An ineffective competitive response was recorded when a subject completed at least 50% of the ratio requirement on a trial while the other subject completed his ratio and took problem. Open circles indicate the per cent of trials with ineffective competitive responses by the even-numbered pair member and closed circles indicate the per cent of trials with ineffective competitive responses by the odd-numbered pair member. The X's indicate the total trials with ineffective competitive responses for each pair. The arrows along the x-axis of each graph indicate the first of four consecutive sessions with a total of less than 50% ineffective competitive response (stability criterion for sharing).

members in the adjusting groups indicate that when the adjusting-group subjects competed, each pair member won and lost about as much as his coactor. The larger differences each session between pair members in nonadjusting groups reveal that pairs in these groups usually had one subject who won more often than his coactor during competitive responding.

Ratios Attempted

Since competition requires more responding than sharing, a change from competition to sharing should be accompanied by decreased responding. Figure 4 shows the per cent of ratios attempted by each subject. Because an attempted ratio was defined as at least 50% of the ratio requirement, it included ineffective competitive responses, as well as completed ratios in which the subject took the problem. Both members of the pairs initially attempted 80 to 100% of the ratios, as would be expected during competition. Subsequently, the percentage of ratios attempted by pair members of the High-Ratio and High-Adjusting-Ratio pairs consistently dropped to near 50% during about the same sessions that these pairs began

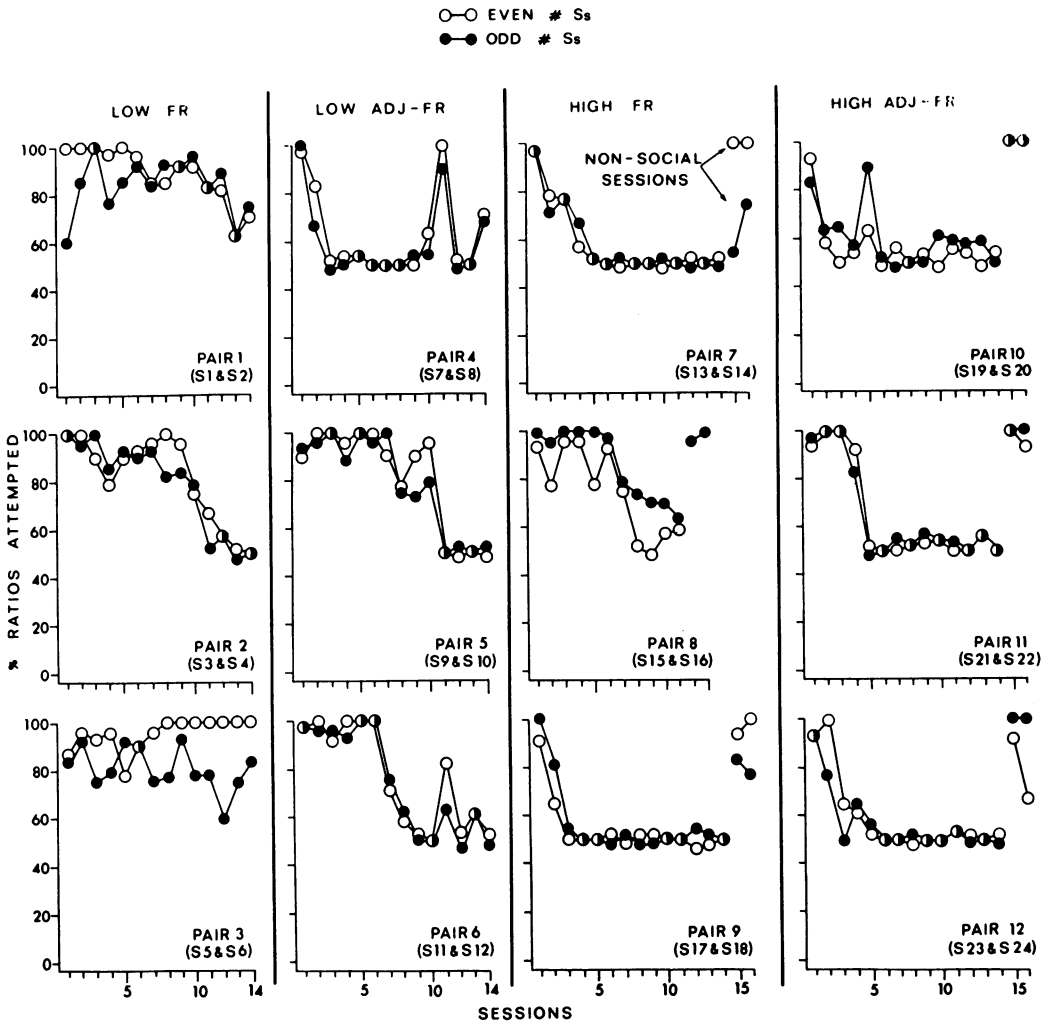

Fig. 4. The percentage of ratios attempted (at least 50% of the ratio completed) by each subject over sessions. Open circles are for the even-numbered subjects and the closed circles are for the odd-numbered subjects. Half-filled circles indicate that both members of a pair attempted the same percentage of ratios during a session. The percentage of ratios attempted by the high-ratio subjects during nonsocial sessions are indicated at Sessions 15 and 16 (Sessions 12 and 13 for Subject 15).

to share consistently (Figure 3). This is the expected result when pair members switch from competition to sharing. In contrast, both pair members of the Low-Ratio and Low-Adjusting-Ratio groups did not ordinarily come close to the 50% level as quickly or as consistently.

Now compare the per cent of ratios attempted for the high-ratio subjects during the last four social sessions and during the nonsocial sessions matched for ratio size. The two unconnected points (Sessions 15 and 16, 12 and 13 for Subject 15) on each graph for the two high-ratio groups show the percentage of ratios attempted by each pair member during nonsocial sessions. Most subjects attempted nearly all of the ratios in the nonsocial sessions, and even those who did not still attempted more than in the social sessions. This indicated that the reductions in the ratios attempted during the social sessions could not be attributed to the ratio requirement alone. Rather, this finding, taken in conjunction with the previous figure showing a change from competition to sharing as a function of ratio size, points to ratio size plus the availability of another social method of reducing responding, *i.e.*, sharing. Ratio size did not simply reduce responding; rather, it reduced responding by producing a switch to sharing.

Correspondence of Scores

Since sharing is defined by increased correspondence as well as by the alternate taking of reinforcers (Hake *et al.*, 1975*a*), correspondence should have increased sooner for the high-ratio than for the low-ratio groups. Figure 5 shows the level of correspondence for each pair and each group (bottom row of graphs with triangles) over sessions. As expected, the mean level of correspondence for the Low-Ratio group exceeded 80% only once (Session 9), while the mean level of correspondence for the High-Ratio group was below 80% only four sessions—all during the first five sessions. The data for individual pairs in these groups reflect these differences. After Session 5, the range for High-Ratio pairs was 62 to 100%, with almost all of the values above 80%. In contrast, the range for Low-Ratio pairs over these same sessions was 0 to 100%, with most of the values below 80%.

The adjusting-groups were not included in the above comparison, because the adjustment procedures were directed at producing high levels of correspondence. That the adjustments were effective can be seen by comparing correspondence for adjusting and nonadjusting groups. Except for Session 3 for the High-Adjusting group, the mean levels (bottom graphs) of correspondence for the adjusting groups were always over 80%.

The increased correspondence in the high-ratio and adjusting groups was not an artifact of any change in the absolute number of points per session. Table 1 shows the mean number of points for each pair member and the mean difference between pair members' scores for the first three and last three sessions. The mean differences between scores changed little over sessions for pairs in the adjusting groups. However, over sessions, the mean difference for High-Ratio group dropped from 79.3 to 8.0 points. The total number of points earned during sessions can be calculated by adding the pair member's scores. The mean points per session stayed about the same across sessions for all of the pairs except one. Pair 12 averaged only 118 points per session for the first three sessions, because the pair members did not match-to-sample accurately. They averaged only 73% correct for the first three sessions, while all other pairs averaged at least 90%. Thereafter, accuracy for all of the pairs was always above 90% and usually above 94%. By the last three sessions, all pairs earned about 150 points per session.

Time to Distribute Problems

Subjects had a full 30 sec to complete the ratio requirement and work the problem. They usually worked problems in 3 to 4 sec, leaving 26 to 27 sec to distribute problems. A comparison between sessions when subjects competed on more than 50% of the trials and sessions in which they shared on more than 50% of the trials revealed that subjects distributed problems faster when they competed. This comparison was not possible for all subjects, because not all switched to sharing (Pair 3), and some switched to sharing as soon as they reached their maximum response requirement (Pairs 7, 9, and 12). However, of the remaining eight pairs, only two had about the same times under competition and sharing, and the remaining six took considerably longer to distribute problems when they shared. The clearest support is from the pairs in the groups with constant ratios and, hence, identical ratios for

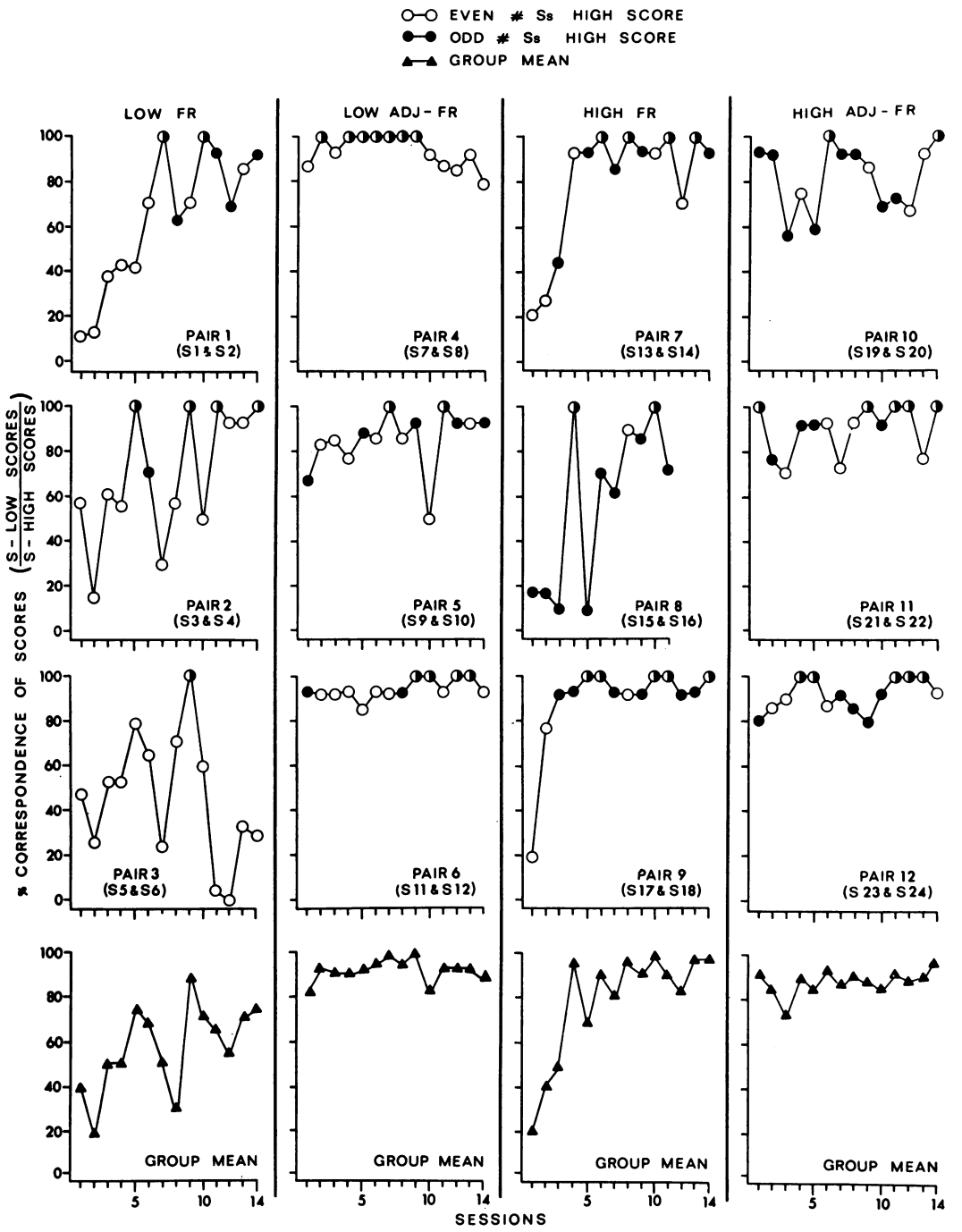

Fig. 5. Correspondence of scores for each pair (circles) and mean correspondence of scores for each group (triangles) over sessions. Open circles indicate that the even-numbered pair member had the higher score for a session, while filled circles indicate that the odd-numbered pair member had the higher score. Half-filled circles indicate that pair members obtained the same number of points for a session.

each session under competition and sharing. In the Low-Ratio group, Pairs 1 and 2 averaged 5.9 and 4.2 sec, respectively to distribute problems when competing, but they took 7.7 and 8.4 sec, respectively, when they shared. Similarly, Pair 8, the one pair under the nonadjust-

Table 1

Mean number of points for each pair member and the mean difference between pair members' scores for the first three and last three sessions.

Group; Pair	First Three Sessions			Last Three Sessions		
	Odd Numbered S	Even Numbered S	Mean Diff.	Odd Numbered S	Even Numbered S	Mean Diff.
LOW-RATIO						
1 (S1 + S2)	24	132	108	80	72	16
2 (S3 + S4)	44	104	60	78	82	4
3 (S5 + S6)	44	106	62	24	136	112
Group Mean			77			44
LOW-ADJ. RATIO						
4 (S7 + S8)	76	82	6	66	78	12
5 (S9 + S10)	80	76	20	76	76	8
6 (S11 + S12)	76	78	6	76	78	2
Group Mean			11			7
HIGH-RATIO						
7 (S13 + S14)	52	98	82	76	82	10
8[a] (S15 + S16)	132	20	112	80	70	10
9 (S17 + S18)	52	92	44	76	72	4
Group Mean			79			8
HIGH-ADJ. RATIO						
10 (S19 + S20)	86	68	18	68	80	12
11 (S21 + S22)	74	76	14	70	76	6
12 (S23 + S24)	60	58	10	76	78	2
Group Mean			14	78	71	7

[a]Data for last three sessions for Pair 8 were for Sessions 9, 10, and 11.

ing-high-ratio condition that had some competitive sessions after the ratio reached 100, took 19.1 sec when competing and 23.1 sec when sharing. There are two reasons why this finding would be expected. First, under competition, the problem was usually distributed by the fastest member of the pair, whereas under sharing, each pair member distributed about half of the problems. Second, competition imposed the additional requirement of responding faster than the coactor. Church (1961) also reported that subjects in a competitive situation responded faster than control subjects; he attributed this finding to differential reinforcement of the response characteristic that was selected as the basis for the competition.

Conferences and Audits

All subjects used the conference button, but there was considerable variability among subjects. On average, a subject depressed the conference button for 1 to 2 sec about 20 times each session. Occasionally, subjects talked about their scores and possible methods of problem distribution, but usually they discussed events unrelated to the study. The 2-min timeout penalty for talking without pressing the conference button was used only once.

Subjects generally made audit responses throughout the study, the overall average being about nine self-audits and nine coactor-audits per session. There was, however, a consistent trend for both types of audits to decrease over sessions in the high-ratio groups where competition gave way to sharing earliest and most consistently.

DISCUSSION

Size of the response requirement. The size of the response requirement produced the largest effects: the High-Adjusting-Ratio group reached the criterion for switching from competition to sharing in three sessions, or four sessions before the Low-Adjusting-Ratio group, while the High-Ratio group reached criterion in four sessions, or eight sessions before the Low-Ratio group. The switch from competition to sharing was expected to occur sooner at the large-ratio requirements, because larger ratio requirements have been shown to

have aversive properties (Appel, 1963; Azrin, 1961; Dardano, 1973; Thompson, 1964; 1965) and, because competition involves more responding than sharing (Hake *et al.*, 1975*b*). Switching from competition to sharing was the only way to reduce responding in the form of unreinforced competitive responding and still maintain reinforcement at a moderate level. The switch was indicated by three behavioral changes consistent with the definition of sharing. First, the number of ratios attempted decreased for both pair members. Second, pair members alternated taking reinforcers (sharing) instead of both responding to take the reinforcer on each trial (competition). Third, the correspondence of pair members' scores increased. Furthermore, a comparison of the number of ratios attempted in the social sessions and the nonsocial sessions matched for ratio size revealed that subjects in the high-ratio groups could have attempted many more ratios than they did in the social sessions. Hence, the switch from competition to sharing at the large ratios was not due to ratio size alone; rather, it was due to ratio size plus the availability of another social method of responding (sharing) that required less responding.

Two other aspects of competition may have also had aversive properties. First, competition imposed the additional speed requirement that was the basis for competition. Second, since only one of the competing individuals' responding was reinforced on each trial, competitive responding frequently went unreinforced. Although both of these variables operated in all of the groups during competition, both the speed contingency and the possibility of nonreinforced responding may be more aversive when the response requirement is large. At any rate, neither of those variables operated during sharing.

The effects of large ratios on competitive responding may not be limited to the laboratory. For example, in everyday life, high-school students might work individually and compete when a homework assignment is small and easy, such as collecting newspaper items on a current event. However, when the response requirement is large and/or difficult, such as several complicated geometry problems, collaborative efforts might be observed. The first indication of this might take the form of one of two students suggesting, "You work the odd numbered problems, and I'll work the even numbered ones", or "Let's do them together".

Adjusting schedule. The adjusting schedule also speeded the switch from competition to sharing. This was clearest for the Low-Adjusting-Ratio group, which met the stability criterion for sharing five sessions before the Low-Ratio group. The fact that the high-ratio variable produced such a fast change to sharing (three to four sessions on average) eliminated any possibility of the adjusting schedule having much of an effect with the large-ratio groups. The High-Adjusting-Ratio group met the stability criterion only one session before the High-Ratio group.

During competition, the adjustment procedure kept the pair members' scores about even (Figure 5) and each pair member won about as many trials as he lost (Figure 3), so that the greater amount of responding in competition produced no more reinforcement than the lesser amount involved in sharing. On the other hand, during competition for the nonadjusting subjects, one pair member usually won consistently over sessions (Figure 3); therefore, competition did have a greater payoff than sharing for that pair member (Figure 5). The reinforcement advantage a subject did or did not gain through competition could be monitored by the subject accurately and continuously through the self- and coactor-audit counters.

Acquisition of sharing without either major variable. Previous research suggests that sharing will eventually develop even when no conditions are changed, and that once sharing occurs it will be more stable than competition (Hake *et al.*, 1975*a*). Whatever variables are responsible, they would be expected to operate even when other experimental conditions are introduced or removed, thereby reducing the possibility of a reversal in a single-subject design. This happened for one pair in the previous study on ratio size (Hake *et al.*, 1975*b*) and was one reason the present study used a group design. Several variables could be responsible: (1) as long as there is some response requirement, competition will require more responding than sharing (Hake *et al.*, 1975*b*), and impose an additional contingency (speed of responding in this experiment) that is the basis for competition (Church, 1961); (2) a social relationship could develop; (3) experiments have shown that some subjects prefer a more equi-

table reinforcer distribution, even when it means a reduction in reinforcers for them and/or when they are obtaining a greater number of reinforcers than their coactor (Marwell and Schmitt, 1975; Shimoff and Matthews, 1975). The tendency for sharing to develop, albeit at a slower rate, in the Low-Ratio group, where neither ratio size nor adjusting variables were in effect, suggests that some variables capable of producing a change from competition to sharing were also operating in the present experiment.

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Received 2 April 1976.
(Final Acceptance 16 June 1976.)