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PERFORMANCE UNDER COMPETITIVE AND SELF-COMPETITIVE FIXED-INTERVAL SCHEDULES OF REINFORCEMENT

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Participants completed blocks of trials under simple (i.e., work-alone), competitive, and self-competitive fixed-interval 20-s schedules of reinforcement. In general, response rates were highest during competition and lowest while working alone. In addition, whereas participants emitted responses at a constant rate while working alone, competitive responses often followed a break-and-run pattern; self-competitive responses, in contrast, were highly variable in both rate and pattern, often changing within a single session. Finally, no systematic relation was found between rates of responding and probability of reinforcement under competitive and self-competitive conditions. These observations suggest that self-competitive behavior may contain many of the characteristics of competitive behavior.

Behavior analysts have defined competition as a situation in which two or more individuals respond but not all receive reinforcers (e.g., Buskist, Barry, Morgan, & Rossi, 1984; Hake & Olvera, 1978; Lindsley, 1966; Skinner, 1953). But Buskist and Morgan (1988) suggested that competition does not necessarily need two or more individuals: "[Another] type of competition might be self-competition . . . in which an individual comes to respond to some standard such as time or the number of correct responses without direct respect to the presence of another individual" (p. 172). Although self-competition involves only one individual, Buskist and Morgan suggested that these episodes are functionally similar to competition, because self-competitive contingencies may minimize performance differences *across* competitors. For instance, a competitive swimmer may strive only to swim faster in each race than she swam in previous races. But if continued improvement eventually prevents another competitor from obtaining reinforcers, the episode remains functionally competitive. Therefore, although the concept of self-competition differs from the conventional view of com-

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petition, Buskist and Morgan suggested that it retains the functional relation necessary to be called competition (see also Parrott, 1983).

If self-competition does constitute a second type of competitive behavior, it seems plausible to assume that behavior under self-competitive contingencies may exhibit some, if not many, of the behavioral characteristics that emerge under competitive contingencies. In a series of studies, Buskist and his colleagues (Buskist et al., 1984; Buskist & Morgan, 1987) had participants respond for points under competitive fixed-interval (FI) schedules of reinforcement (i.e., only the first participant to complete the response requirement received points). Buskist and his colleagues identified two important characteristics of competitive behavior under FI schedules of reinforcement: (a) higher response rates, relative to those observed under simple FI schedules, and (b) a break-and-run pattern of responding.

Although self-competition has not been a topic of study in the experimental analysis of behavior, several non-behavior-analytic studies seem to provide support for the assertion that self-competitive behavior is somewhat similar to competitive behavior. Gordon, O'Connor, and Tizard (1955) had participants place nails into a board and observed that both competition and self-competition produced higher rates of responding than noncompetitive conditions. Similarly, Rudow and Hautaluoma (1975) found that participants who completed math problems under competitive and self-competitive conditions completed more problems than participants who responded under noncompetitive conditions. Swingle, Coady, and Moors (1966) had participants lever-press for points under various competitive and self-competitive conditions. They observed that competition and self-competition did not produce significantly different response rates; self-competition, however, produced considerably more response variability than competition.

Although self-competition has been the focal point of a small number of studies, certain problems have been evident in these studies. For one, researchers who have studied self-competition have examined the products of self-competitive behavior (e.g., number of nails placed into a board) but not the self-competitive behavior itself (e.g., Gordon et al., 1955). Moreover, when researchers have measured self-competitive behavior (e.g., rate of responding), conventional between-groups analyses have blurred individual aspects of responding (e.g., Swingle et al., 1966), which may shed light on various aspects of self-competitive behavior.

Ultimately, the examination of performance under self-competitive contingencies has yet to be conducted within a traditional behavior-analytic framework. Therefore, the purpose of the present experiment was to compare responding under noncompetitive, competitive, and self-competitive conditions. Buskist et al. (1984) suggested that FI schedules provide a useful baseline against which to examine the variables that affect competitive responding. Thus, participants in the present study responded under three different FI schedules: (a) a simple (i.e., noncompetitive, or "work-alone") FI 20-s schedule, in which the first response after the interreinforcement interval (IRI) produced points; (b) a competitive FI 20-s schedule, in which the first participant to respond after the IRI received points; and (c) a self-competitive schedule, in which increasingly shorter response latencies at the end of the IRI produced points.

Method

Participants

Twelve Auburn University students (4 women, 8 men), recruited from several undergraduate psychology classes, served as participants. In exchange for participation, each student received partial class credit contingent on regular attendance but not performance.

Apparatus

Participants sat alone at a desk that contained a computer screen and mouse, which participants used to respond on the experimental tasks. A second computer located in an adjacent room controlled the stimuli projected on the computer screen and collected experimental data.

Procedure

Participants completed four experimental sessions at approximately the same time on 4 consecutive days. Each session consisted of four 8-min blocks, each of which was separated by a short rest period. After completing the last block of the day, participants remained seated until the experimenter dismissed them.

General procedure. During each trial, a response box containing the words "Click here" appeared in the middle of the computer screen. For a mouse click to be operative, participants had to click on the response box. Once participants completed the response requirement, the computer added 50 points to a counter located on the screen, and the response box disappeared. In addition, a message, which varied depending on the condition (see below), appeared and a 5-s blackout period began. Responses made during this period were inoperative. At the completion of 5 s, the response box reappeared and the next trial started. If participants were in the middle of a trial when a block finished, the computer allowed them to complete the trial.

At the start of each condition, participants viewed portions of the following instructions on the computer screen. The instructions changed slightly during competitive and self-competitive sessions:

> By making responses on your mouse, you can earn points. Not every response, however, will produce points. You may have to respond several times. Each time you make a correct response, you will receive 50 points, which will be added to a counter in the upper right-hand corner of your screen. Your goal is to earn as many points as possible. Please click the box below to start the session.

After receiving these initial instructions, participants completed one or more practice trials under a simple FI 20-s schedule to familiarize themselves with the task. Participants completed practice trials prior to the first session but not before subsequent sessions. After completing the first practice trial, a message on the computer screen asked participants if they understood the task. In response, participants clicked either a "Yes" or "No" box that appeared on the computer screen. If participants responded affirmatively, they moved on to the first block of experimental trials; if they responded negatively, they

received additional practice trials until they indicated that they understood the task. No participant completed more than one practice trial.

Work-alone condition. Participants responded under a simple FI 20-s schedule of reinforcement by clicking on the response box. During this condition, only the participant's counter ("Your Score") appeared on the computer screen. After each trial, the following message appeared on the screen: "You completed the task. Please do not respond." Participants received points after every work-alone trial.

Competition. Prior to competitive sessions, participants received the following instructions on the computer screen:

> You will now be competing for points against another person. Each time you make a correct response before he does, you will receive 50 points. However, if the other person makes the correct response first, he will receive 50 points and you will not. Please click the box below to start the session.

During this condition, participants responded under a competitive FI 20-s schedule of reinforcement. Although they received general instructions that they would be competing against another participant, reinforcers were, in fact, delivered according to preprogrammed probabilities (Dougherty & Cherek, 1994). However, to help simulate a competitive context, a male confederate was present in the control room prior to the start of each session.

A second counter ("Other Competitor's Score") appeared in the upper right-hand corner of the computer screen during this condition. Participants received points across the four competitive blocks according to the following probabilities: .50, .25, .75, and .50 (Dougherty & Cherek, 1994). At the end of trials on which participants received points (i.e., a "win"), the message "You won. Please do not respond" appeared on the computer screen, and points accrued on the participant's counter. On those trials in which the participant did not receive points (i.e., a "loss"), the message "The other competitor won. Please do not respond" appeared on the screen, and the computer added points to the second counter.

Self-competition condition. Prior to self-competitive sessions, participants read the following instructions:

> You will now be competing against yourself. Each time you equal or improve on your prior best performance, you will receive 50 points. Please click the box below to start the session.

Self-competition utilized the same schedule of reinforcement as in the work-alone and competition conditions, but participants received points only if they equaled or improved on the fastest effective response for the current 8-min block. For example, if on the first trial the effective response occurred 1.5 s after the end of the IRI, the response on the next trial needed to occur no more than 1.5 s after the end of the IRI. If participants equaled or bested this standard on the second trial, a new criterion consequently was in place for the subsequent trial(s); if participants did not equal or surpass this standard on the second trial, the standard remained in effect until the participant equaled or improved on his or her performance. In essence, then, a self-imposed, decreasing limited-hold contingency was in effect during the self-competition condition. The delivery of points continued in a similar fashion for the remainder of the trials during each block. To preclude ceiling

effects during self-competitive sessions, the computer reset the criterion for reinforcement at the beginning of each 8-min block.

During self-competition, only the participant's counter appeared on the screen. After completing a winning trial, 50 additional points appeared on the participant's counter, as did the following message: "You equaled or improved on your best performance. Please do not respond." If a participant did not improve on his or her performance, the following message appeared: "You did not equal or improve on your best performance. Please do not respond." In addition, the number of points on the counter remained the same.

Table 1 shows the order in which each participant responded under the different experimental conditions. Conditions were counterbalanced across participants so that each participant responded under the competition and self-competition conditions once and the work-alone condition twice. Thus, participants completed four 4-block sessions for a total of sixteen 8-min blocks. At the end of the experiment, all participants received information regarding the purpose of the study.

Table 1
Order in Which Participants in Experiment 1 Experienced the Different Experimental Conditions

Participant	Order of experimental conditions			
BC, MA, PR	Work-alone	competition	work-alone	self-competition
PH, LA, BT	Competition	work-alone	self-competition	work-alone
ST, LD, BS	Work-alone	self-competition	work-alone	competition
TS, RT, UC	Self-competition	work-alone	competition	work-alone

Results

Figure 1 shows the response rates for participants under each condition. Because the average rates of responding did not differ considerably between the two work-alone conditions, only the response rates from the second session are included. Response rates varied considerably both within and across participants. Whereas some participants (e.g., TS, BT) responded at relatively high rates under all conditions, other participants (e.g., MA, PR) responded at relatively low rates throughout; and several participants (e.g., PH, LD) responded at relatively high rates under one or two conditions but at moderate or low rates otherwise.

Seven participants (BC, MA, LA, ST, LD, BS, RT) had response rates that were highest, on average, under the competition condition. Of those participants, 6 had response rates that were second-highest under self-competition; for MA, ST, and BS, though, the self-competitive rates were only slightly higher than the work-alone rates. Of the 7 participants whose competitive response rates were highest, only RT had response rates that were higher under work-alone than self-competition. In addition, for most of these participants, responding under the competition condition either decreased or remained relatively stable across sessions. Only LA showed a dramatic increase in competitive responding, which occurred during the fourth block of trials and followed a steady decrement in responding during the first three blocks.

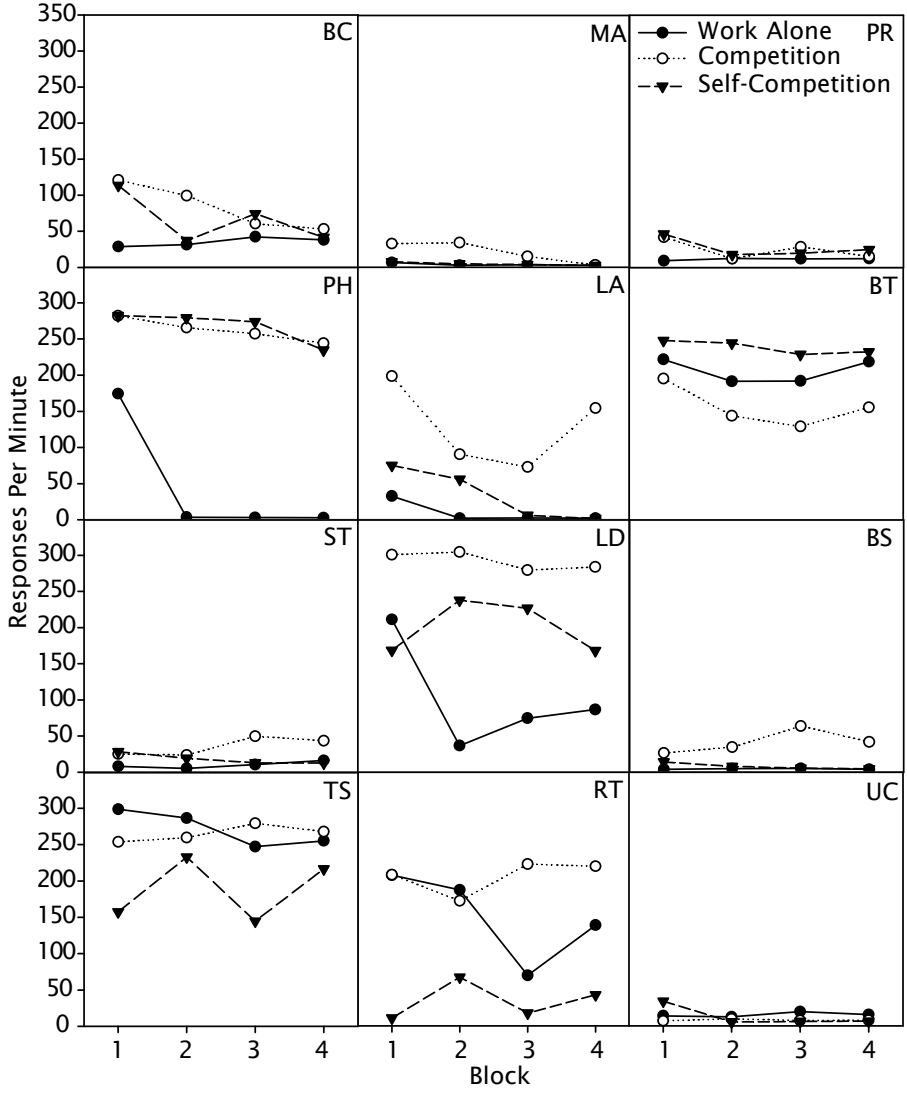

Figure 1. Shows individual response rates during each block under the different experimental conditions. Black circles represent work-alone response rates, open circles represent competition response rates, and black diamonds represent self-competition response rates.

Of the remaining 5 participants, 3 (PR, PH, and BT) had response rates that were on average highest under the self-competition condition and second-highest under competition, although this difference was negligible for PR and PH. BT, however, responded at considerably higher rates while working alone than while competing. Finally, 2 participants, TS and UC, had the highest average rates while working alone. For TS, work-alone rates fell below competition rates for the final two blocks of trials; for UC, the differences

between response rates across all three conditions were negligible during each block of trials.

Figures 2 through 6 show representative cumulative records for participants under the work-alone, self-competition, and competition conditions. Although rates of responding varied considerably across participants, five distinct patterns emerged, three of which were replicated by 3 participants each and one of which was replicated by 2 participants (see below).

Figure 2 shows representative cumulative records for LD, LA, and BS, each of whom showed different patterns under the competition, self-competition, and work-alone conditions. Under the work-alone condition, each responded at a relatively low rate; LD also showed some instances of a break-and-run pattern. Competition produced several break-and-runs by these participants and resulted in considerably higher response rates than the work-alone condition. Finally, self-competitive contingencies produced considerably more variability than either the work-alone or competition condition. Whereas each participant's pattern of responding early in the session was similar to the one observed while working alone, patterns later in the session approximated the higher-rate, break-and-run patterns observed during competition.

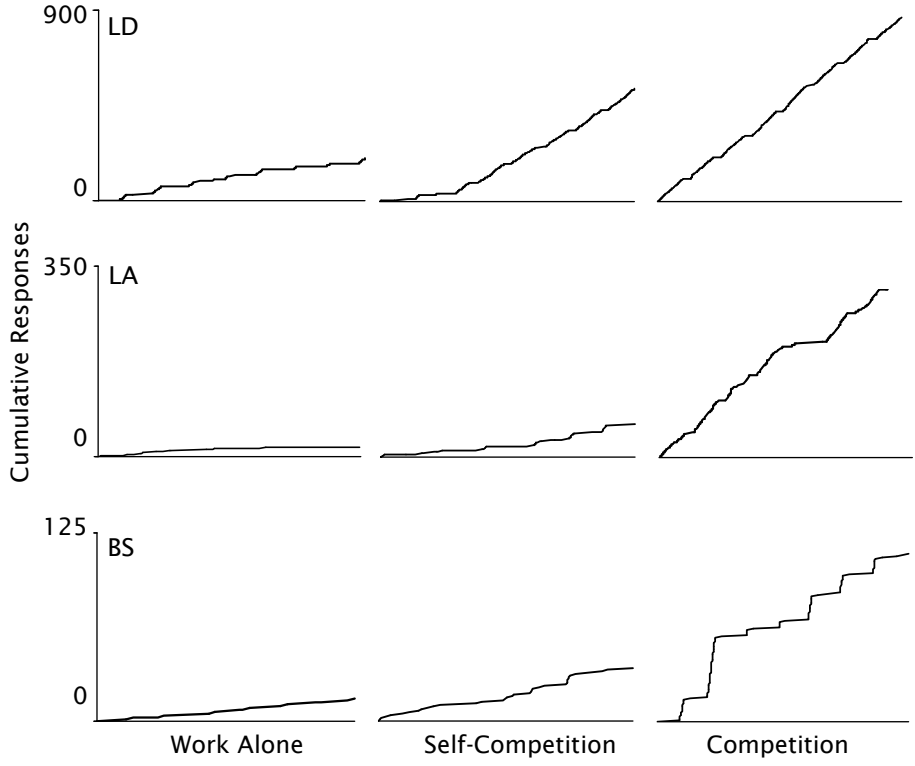

Figure 2. Shows representative cumulative records for 3 participants (LD, LA, and BS) who showed different patterns of responding under the competition, self-competition, and work-alone conditions.

Figure 3 shows representative cumulative records for BT, TS, and RT. For these participants, patterns of responding were relatively similar under all

three conditions, characterized by relatively high rates of responding and instances of a break-and-run pattern.

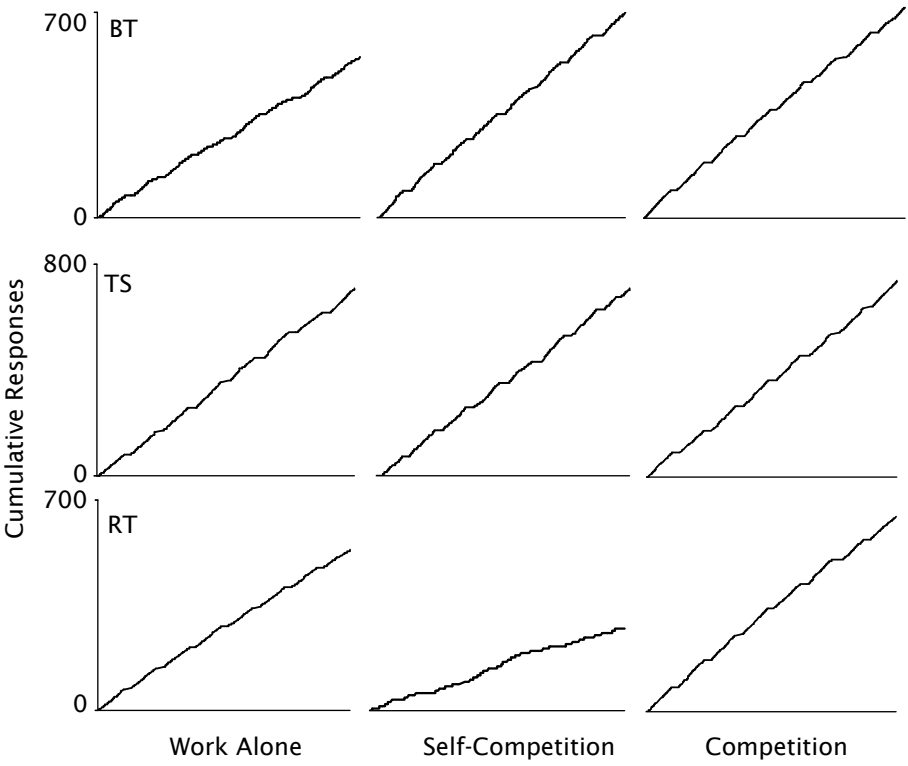

Figure 3. Shows representative cumulative records for 3 participants (BT, TS, and RT) whose patterns of responding were relatively similar under the competition, self-competition, and work-alone conditions.

Figure 4 shows representative cumulative records for ST, BC, and PH. These participants showed similar patterns of responding under the competition and self-competition conditions, both of which differed from the pattern of responding under the work-alone condition. For each, responding under the competition and self-competition conditions was similar, characterized by moderate to high rates of responding and either minor instances of a break-and-run pattern (PH) or a noticeable and recurring break-and-run pattern (ST, BC). Conversely, responding under the work-alone condition occurred at low rates and was relatively stable.

Figure 5 shows representative cumulative records for PR and MA. Whereas both participants produced low and stable patterns of responding under the work-alone and self-competition conditions, relatively higher rates and a break-and-run pattern (which was more noticeable with MA) characterized their responding under the competition condition.

Finally, Figure 6 shows representative cumulative records for UC, whose response patterns were distinct from those of any other participants. UC responded at relatively low rates under the work-alone and competition conditions, showing only minor instances of a break-and-run pattern during

competition. In contrast, UC responded at a higher rate and showed several break-and-runs under the self-competition condition.

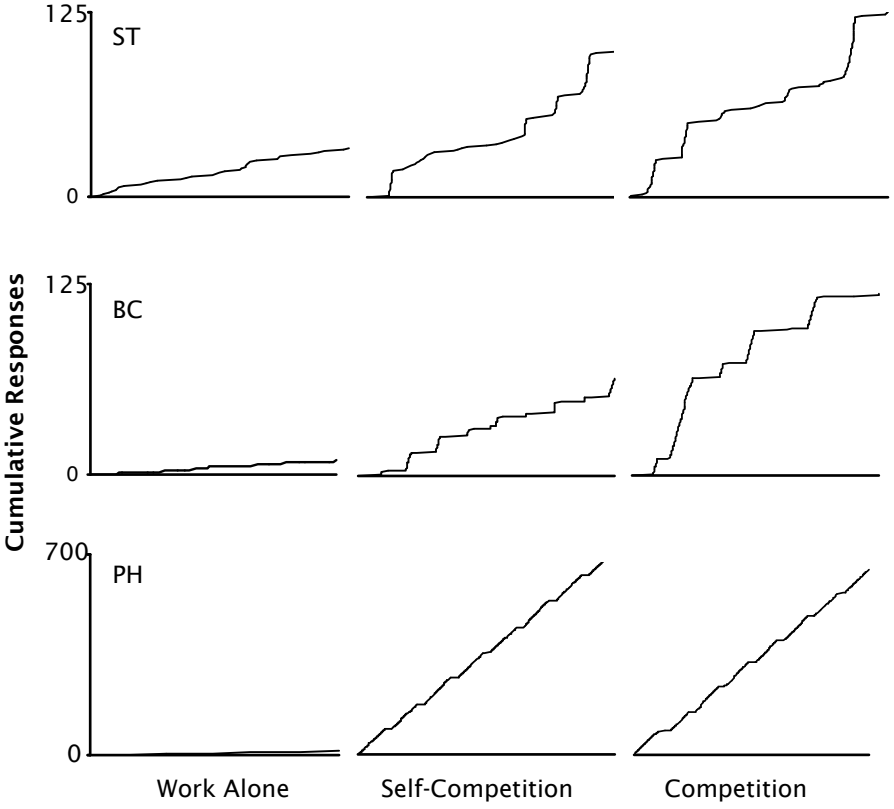

Figure 4. Shows representative cumulative records for 3 participants (ST, BC, and PH) whose patterns of responding were similar under the competition and self-competition conditions.

Table 2 shows the proportion of reinforcers obtained by each participant during the competitive and self-competitive blocks. Although the probability of reinforcement across competitive blocks was programmed to be .50, .75, .25, and .50, respectively, these were long-term probabilities and, thus, the actual proportion of reinforcers obtained by each participant under competitive conditions deviated slightly from the programmed probabilities. On average, the probability of reinforcement under competitive contingencies (.50) was greater than the probability of reinforcement under self-competitive contingencies (.25). But no systematic relations between the rates of reinforcement under each condition and the probability of reinforcement emerged (see Figure 7).

Discussion

The results from the present study can be summarized as follows: (a) In general, rates of responding were highest while competing and lowest while working alone, with self-competitive rates falling between the two;

(b) most participants emitted competitive responses at relatively high rates, and several responded in a break-and-run pattern; (c) participants showed either low constant or high constant response rates while working alone; (d) response rates and patterns under self-competitive conditions varied considerably both within and across participants; and (e) there was not a systematic relation between rates of responding and probability of reinforcement under competitive or self-competitive conditions.

Figure 5. Shows representative cumulative records for 2 participants (PR and MA) whose patterns of responding were similar under the work-alone and self-competition conditions.

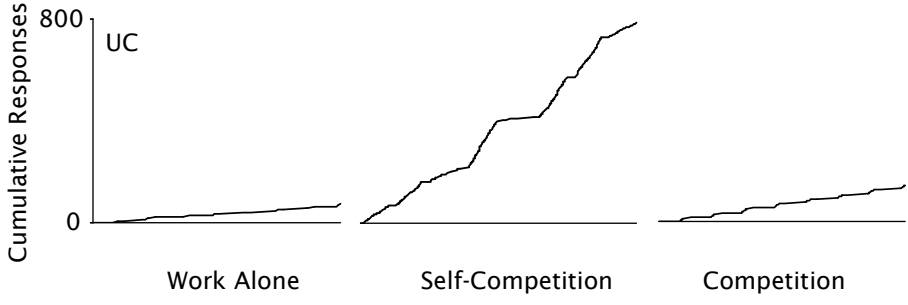

Figure 6. Shows representative cumulative records for UC, whose patterns of responding were similar under the work-alone and competition conditions.

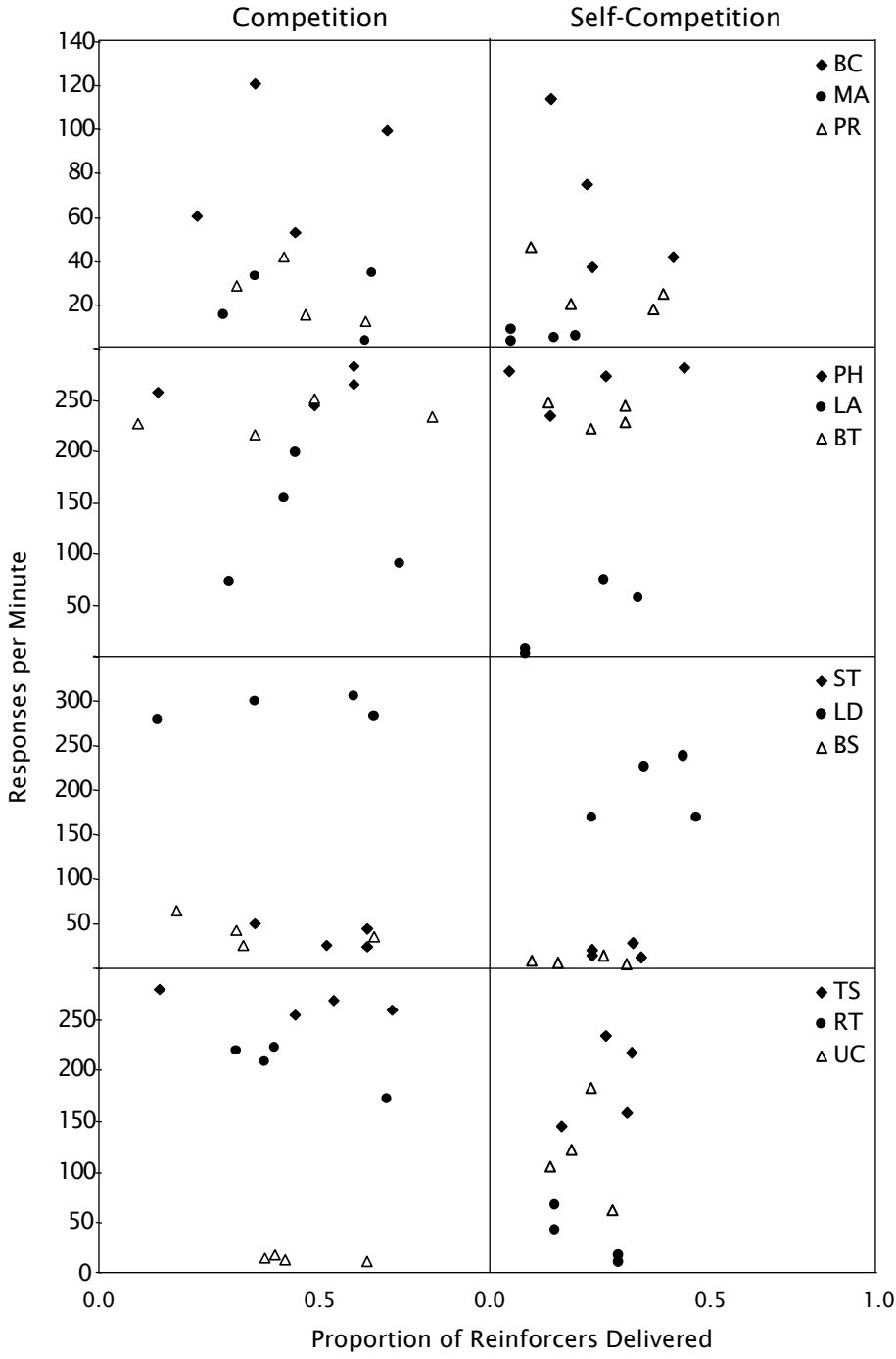

Figure 7. Shows the relation between individual response rates and proportion of reinforcers obtained during each block of competition and self-competition.

The present results are in accord with previous studies of competitive and self-competitive behavior. Buskist and his colleagues (Buskist & Morgan, 1987; Buskist et al., 1984) and Dougherty and Cherek (1994) observed that response rates under simple FI schedules of reinforcement tended to be lower than response rates under competitive FI schedules. Similarly, the majority of participants (9 of 12) in the present study emitted responses at the lowest rate under simple FI schedules (i.e., under work-alone conditions). In addition, a slight majority of participants (7 of 12) showed the highest average response rates under the competition condition. Moreover, of the 5 participants who did not respond at the highest rates under the competition condition, 4 had competitive response rates that nearly equaled their highest rates. Only BT had competitive rates that were considerably lower than the rates of responding under the self-competition and work-alone conditions.

Table 2
Proportion of Reinforcers Received During Competitive and Self-Competitive Blocks

	Block			Block	
	Competitive	Self-competitive		Competitive	Self-competitive
BC	.40	.16	PH	.65	.50
	.74	.26		.65	.05
	.25	.25		.15	.30
	.50	.47		.55	.16
MA	.40	.06	LA	.50	.29
	.70	.22		.76	.38
	.32	.17		.33	.09
	.68	.06		.47	.09
PR	.47	.11	BT	.55	.15
	.68	.42		.85	.35
	.35	.21		.10	.35
	.53	.45		.40	.26
ST	.58	.37	TS	.50	.35
	.68	.26		.75	.30
	.40	.26		.15	.19
	.68	.39		.60	.37
LD	.40	.53	RT	.42	.33
	.65	.50		.74	.17
	.15	.40		.45	.33
	.70	.26		.35	.17
BS	.37	.29	UC	.47	.32
	.70	.11		.68	.21
	.20	.18		.45	.26
	.35	.35		.42	.16

Also in accord with previous studies, there was considerable variability in self-competitive responding. Although self-competitive rates approximated, or even exceeded, competitive rates for some participants (e.g., BT), self-competition also occurred for others at rates that more closely approximated working alone (e.g., MA). Gordon et al. (1955) observed that participants in a self-competition condition responded at slightly higher rates than participants in either a competition condition or a work-alone condition, and Rudow and Hautaluoma (1975) observed that response rates during competition and self-competition were not significantly different from one another. However, Swingle et al. (1966) noted considerable variability in response rates under self-competitive contingencies. Several participants in their study showed high response rates under self-competition, whereas others responded at significantly lower rates.

Furthermore, Buskist and his colleagues (Buskist & Morgan, 1987; Buskist et al., 1984) observed that behavior under competitive FI schedules tended to follow a break-and-run pattern of responding, whereas working alone typically occurred at a constant rate. Similar patterns of behavior emerged in the present study. Seven of 12 participants showed discernable break-and-run patterns while competing. The remaining 5 participants responded at relatively high constant rates throughout the majority of the trials but did show some instances of break-and-run responding (e.g., LD). In addition, although some minor break-and-run patterns were evident for a few participants (e.g., BT) under the work-alone condition, low constant or high constant rates of responding were more the norm. The latter patterns tend to be representative of human FI performance (e.g., Baron, Kaufman, & Stauber, 1969; Buskist, Bennett, & Miller, 1981; Hyten & Madden, 1993; Lowe, 1979).

For several participants, patterns of responding under the work-alone condition seemed to be affected by a history of responding under previous competitive or self-competitive contingencies. For example, BC and BT responded in a break-and-run fashion after exposure to competition, and TS completed several work-alone trials in a break-and-run pattern after exhibiting similar patterns under self-competition. Thus, it seems possible that the order of conditions in the present study may have exerted a history effect on several participants, a finding observed by others (e.g., Buskist & Morgan, 1987; Weiner, 1964)

In contrast to responding under the work-alone and competition conditions, patterns under self-competitive contingencies showed considerable variability both within and across participants. For BC and ST, responding tended to follow a break-and-run pattern that was similar to the break-and-run pattern observed while they were competing. For MA, PR, and RT, self-competitive responding occurred at a relatively low constant rate, similar to the patterns observed while they worked alone. In contrast, PH, BT, and TS emitted responses at a high constant rate. Finally, LA, LD, BS, and UC exhibited patterns of responding that varied considerably even within blocks.

There are at least two ways to interpret the patterns of responding observed in the present study. Church (1962) and Buskist and Morgan (1987) suggested that competition places a limited-hold contingency on interval schedules of reinforcement. For example, under an FI 20-s schedule with a 1-s limited-hold contingency, the reinforcer is delivered only if a response occurs no more than 1 s after the end of the 20-s interval. Correspondingly, under competitive FI schedules, responding well after the end of the IRI decreases

the likelihood of obtaining reinforcement, because another competitor is likely to make the effective response first. Hearst (1958) observed that adding a limited-hold contingency to simple interval schedules dramatically increased pigeons' rates of keypecking. Similarly, Buskist and Morgan (1987) showed that a 1-s limited-hold contingency increased the rate of human responding under simple FI schedules and produced response patterns that were similar to those observed under competitive FI schedules. The high rates of competitive responding observed in the present study may have been produced in a similar fashion.

Moreover, a similar limited-hold contingency may have been at least partially responsible for the varied patterns of behavior that emerged under self-competitive contingencies. Whereas a second competitor determines the criteria for reinforcement while competing, the contingencies of reinforcement for self-competition are such that a participant's previous responses determine the criteria for reinforcement. In essence, as performance improves, consistently better performance must occur if the participant is to obtain reinforcement. Consequently, self-competitive FI performance might be conceptualized as entailing a simple FI schedule and a *decreasing* limited-hold contingency. Thus, consistently high rates of responding, similar to those observed under competitive contingencies (e.g., Buskist & Morgan, 1987), might be necessary for participants to meet the existing response criterion if a small limited-hold contingency is in effect from the start of the session (e.g., a participant responded shortly after the end of the IRI on the first trial). If the criterion for reinforcement includes a relatively long limited-hold contingency but decreases as the session continues, dramatic changes in response rates and patterns across even a small number of trials may emerge (cf. Hearst, 1958). Thus, as the limited-hold contingency becomes smaller and smaller, emitting an effective response becomes less likely. As a result, behavior may become more variable as the individual attempts to find a "successful" pattern of responding, and, ultimately, self-competitive responding may undergo extinction.

But drastic changes in responding like those mentioned above may not be necessary for "success" under self-competition. If participants initially establish criteria they can exceed without considerable improvements in performance (i.e., an effective response on the first trial occurred long after the end of the IRI), constant low rate responding like the variety often observed under simple FI schedules may emerge. Thus, depending on how participants respond under self-competitive contingencies, a variety of response rates and response patterns similar to those observed in the present study are apt to appear.

Although it seems plausible that conditions akin to that of a limited-hold contingency may have affected responding in the present study, the considerable variability in rate and pattern of responding both within and across participants suggests that other factors were operating. A more likely interpretation, therefore, comes from previous research on schedule sensitivity and rule-governed behavior. Considerable research has shown that humans are often insensitive to changes in reinforcement contingencies (see, e.g., Harzem, Lowe, & Bagshaw, 1978; Hayes, Brownstein, Zettle, Rosenfarb, & Korn, 1986; Kollins, Newland, & Critchfield, 1997; Matthews, Shimoff, Catania, & Sagvolden, 1977; Shimoff, Matthews, & Catania, 1986; Shull & Lawrence, 1998; Weiner, 1970), especially when different conditions do not necessarily require different patterns of responding to produce reinforcement. Because

participants in the present study may have been able to earn reinforcers by responding in much the same way under two or more conditions (e.g., at high rates under all conditions [see Figure 3], or similarly under competitive and self-competitive conditions [see Figure 4]), they may have been relatively insensitive to changes in the reinforcement contingencies.

In addition to schedule insensitivity, it is possible that rules in the form of instructions may have affected the way participants responded under the different conditions (e.g., Baron & Galizio, 1983; Baron et al., 1969; Galizio, 1979; Weiner, 1970). For example, instructing participants that they would be working alone, competing against another participant, or competing against themselves may have occasioned lower or higher rates of responding to begin with, even before participants contacted the reinforcement contingencies. In a prior study on competitive responding, Dougherty and Cherek (1994) gave participants the option of completing competitive or noncompetitive FI schedules. They found that participants who received instructions denoting competition responded at higher rates than participants who received "nonsocial" instructions (i.e., there was no mention of competition). Likewise, in the present study, participants' responding may have come under instructional control and thus been relatively insensitive to changes in reinforcement contingencies (e.g., Galizio, 1979; Weiner, 1970). This seems feasible, given that many participants continued to respond at high rates, especially under the competition and self-competition conditions, where many rarely received reinforcement for doing so (see Table 2).

Participants' response patterns may have also been affected by rules they constructed during the course of the study. Since Skinner's (1969) discussion on the difference between contingency-shaped and rule-governed behavior, many researchers have shown that human participants formulate rules that may affect the way they respond (see, e.g., Hayes, 1989). Rosenfarb, Newland, Brannon, and Howey (1992), for example, found that participants who typed self-rules about how to respond under a multiple schedule of reinforcement showed schedule control faster than participants in a no-rules condition. In addition, participants who typed rules began emitting responses in accordance with the schedule at approximately the same time that they first typed rules that accurately described the prevailing contingencies. However, it also took longer for their responding to change under a subsequent extinction condition. Similarly, Hackenberg and Joker (1994) gave participants instructions on how to maximize reinforcement and then had them choose between a fixed-time (FT) schedule and a progressive-time (PT) schedule (choosing the latter systematically decreased the accuracy of the instructions). Hackenberg and Joker observed that participants' responding was initially schedule-appropriate, most likely because the initial instructions were accurate. In addition, as the instructions became less accurate, responding became highly variable and verbal reports about effective responding accompanied changes from instruction-appropriate to schedule-appropriate patterns. These studies' results suggest that self-rules function in much the same way as external rules: Both may bring behavior under schedule control faster, but they may also reduce schedule sensitivity.

Although participants in the present study did not provide verbal reports regarding their response patterns, it is certainly possible that exposure to the reinforcement contingencies may have led them to construct their own rules regarding the most effective way to respond. For example, although

experimenter-provided instructions about competition or self-competition may have initially occasioned high rates of responding, the inability to obtain frequent reinforcement under competitive and self-competitive contingencies may have led some participants to develop their own rules that then acquired some control over their responding. The highly variable response patterns both within and across participants suggest that factors other than contact with the reinforcement contingencies were affecting the ways in which they responded. Because previous research has found that increases in response variability often accompany the development of self-instructions (e.g., Hackenberg & Joker, 1994), it seems possible that the increased variability observed in the present study, especially under the competition and self-competition conditions, was a sign that participants' responding was at least partially under the control of self-instructions.

In sum, the combination of reinforcement contingencies, experimenter-generated instructions, and participant-constructed rules likely interacted to affect the way in which participants responded under the different experimental conditions. This has been a common finding in human operant research (e.g., Hackenberg & Joker, 1994; Hayes et al., 1986; Rosenfarb et al., 1992). Attempting to tease apart the differential effects of each of these variables on competitive and self-competitive responding would be valuable for researchers wanting to know more about social behavior in general and competitive behavior, including self-competition, more specifically.

Finally, response rates under competitive and self-competitive contingencies were not systematically related to changes in the probability of reinforcement. Buskist and Morgan (1987) found that the addition of a limited-hold contingency, and not changes in reinforcement probability, led to increases in response rates under simple FI schedules that approximated competitive response rates. Similarly, Dougherty and Cherek (1994) noted that changes in the probability of reinforcement affected the choice to compete or work alone but did not systematically affect competitive response rates. The present results support these findings. Although the probability of reinforcement was, on average, smaller for self-competition than competition, individual response rates did not change reliably as a function of changes in the probability of reinforcement. Rather, changes in response rate were probably related either to changes in the limited-hold contingency that likely occurred under self-competitive conditions or, more likely, to a combination of experimenter- or self-imposed rules for responding that emerged under each condition.

To summarize, working alone and competing under FI schedules of reinforcement tended to produce significantly different patterns of behavior. Whereas working alone was characterized by relatively low rates and constant patterns of responding, competitive behavior was exemplified by higher rates of responding and break-and-run patterns. Self-competitive FI responding tended to occupy a position somewhere between working alone and competition, not only in terms of the rate of responding but also in terms of response patterns. Although for some participants self-competition produced low response rates and constant patterns of responding reminiscent of working alone, it also at times resembled competitive behavior, with its higher rates of responding and break-and-run patterns. Self-competitive FI responding often deviated from working alone and competition by showing considerably more variability in both rate and pattern of responding.

Although future research is needed to clarify the extent to which schedule sensitivity and instructional control affect competitive and self-competitive behavior, the present observations nevertheless suggest that competition and self-competition share several behavioral characteristics.

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