HUMAN OPERANT PERFORMANCE: SENSITIVITY AND PSEUDOSENSITIVITY TO CONTINGENCIES

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Undergraduates' button presses occasionally produced points exchangeable for money. Left and right buttons were initially correlated with multiple random-ratio (RR) and random-interval (RI) components, respectively. During interruptions of the multiple schedule, students filled out sentence-completion guess sheets describing the schedules, and points were contingent upon the accuracy of guesses. To test for sensitivity to schedule contingencies, schedule components were repeatedly reversed between the two buttons. Pressing rates were consistently higher in ratio than in interval components even when feedback for guesses was discontinued, demonstrating sensitivity to the difference between ratio and interval contingencies. The question was whether this sensitivity was based directly on the contingencies or whether it was rule-governed. For two students, when multiple RR RI schedules were changed to multiple RI RI schedules, rates became low in both components of the multiple RI RI schedule; however, subsequent prevention of point deliveries for the first few responses in any component produced high rates in that component. For a third student, response rates became higher in the RI component that provided the lower rate of reinforcement. In each case, performance was inconsistent with typical effects of the respective schedules with nonhuman organisms; it was therefore plausible to conclude that the apparently contingency-governed performances were instead rule-governed.

Key words: rule-governed behavior, contingency-governed behavior, sensitivity to contingencies, verbal behavior, multiple schedule, random ratio, random interval, button press, undergraduates

In experimental analyses of behavior, continuity between human and infrahuman performances has often been implicitly assumed; despite anatomical and other differences between species, similar processes are expected to operate. The assumption is contradicted when human performances are not comparable to those of other organisms. Perhaps this is why the relative insensitivity of human performance to reinforcement schedules has commanded attention. In human performances, interval and ratio schedules have sometimes not maintained different rates, fixed-interval schedules have sometimes failed to maintain characteristic response patterns, and responding has sometimes continued at high rates during extinction (e.g., Baron & Galizio, 1983; Buskist & Miller, 1982; Lowe, 1979). Although it seems implausible that human performances should be immune to such fundamental properties of the environment as the contingent relations between responding and its consequences, human schedule-maintained responding, which presumably should dem-

onstrate such sensitivity, is often either insensitive or sensitive in different ways from that of nonhuman organisms.

One test for sensitivity has been to change contingencies, either across sessions (e.g., Shimoff, Catania, & Matthews, 1981), or within sessions, as in a multiple schedule (e.g., Catania, Matthews, & Shimoff, 1982); if performances vary with the contingency changes, the behavior is said to be sensitive to the shifts in contingencies. For example, when undergraduates' button presses were maintained by multiple random-ratio (RR) random-interval (RI) schedules, shaped contingency descriptions were reliably accompanied by contingency sensitivity but shaped performance descriptions were not (Matthews, Catania, & Shimoff, 1985).

Even when behavior changes do accompany contingency changes, however, the sensitivity may not be like that observed in infrahuman performances; the performances themselves may be under the control of instructions (cf. Hayes, Brownstein, Haas, & Greenway, 1986). For example, a person could be told how to perform in particular situations; under such conditions, following the instructions produces an apparent contingency-governed

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performance that in fact is rule-governed. To the extent that the performance is only indirectly determined by the contingencies, this rule-governed sensitivity might be regarded as a second type of sensitivity; to the extent that it insulates human performances from some of the characteristic effects of contingencies, it might even be called pseudosensitivity.

The present experiment used procedures similar to those reported in Catania *et al.* (1982) and in Matthews *et al.* (1985) to produce performances that appeared contingency-governed. After some verbal behavior relevant to reinforcement schedules was established, the responding of each student was maintained by a multiple RR RI schedule, and the student occasionally provided written descriptions of the schedules (the procedure differed from the earlier work in that feedback on these guesses was not maintained throughout the experiment). Once performance was well established, contingency reversals were consistently accompanied by appropriate changes in response rates, as if the performances were contingency-governed. But the pseudosensitive nature of the performances was revealed by further changes in the contingencies.

METHOD

Subjects

Three UMBC undergraduates participated in sessions at 2- to 4-day intervals as an option in satisfying Introductory Psychology course requirements.

Apparatus and Procedure

Presession training. To ensure that the students were familiar with the types of contingencies in effect during the sessions, each was given the following instructions (a schedule lesson) before each session:

Imagine that you can earn points by pressing a button. A computer decides whether a press earns a point according to one of two rules:

1. The computer lets your press earn a point after a RANDOM NUMBER OF PRESSES. The more presses you make, the more points you earn. The best thing to do is to press fast.
2. The computer lets your press earn a point after a RANDOM TIME INTERVAL.

The number of presses does not matter, so there is no reason to press fast. The best thing to do is to press slowly.

After the student had read the schedule lesson, the lesson was removed and the student was required to answer the following questions in writing:

Imagine that you can earn points by pressing a button. A computer decides whether a press earns a point according to one of two rules. These rules are:

The computer lets your press earn a point after a random ____.

The computer lets your press earn a point after a random ____.

After correctly answering these questions, the student was given a separate sheet with the following questions:

If the computer works only after a random number of presses, you should press ____.

If the computer works only after a random time interval, you should press ____.

Finally, the student was required to answer the following questions, presented on a separate sheet of paper:

If the computer works only after a random time interval, you should press ____.

If the computer works only after a random number of presses, you should press ____.

If errors were made, the student was given an opportunity to review the schedule lesson and was then again required to answer all the questions. Thus, before each session each student had described ratio and interval contingencies and had specified rates of responding that were, according to these lessons, appropriate to each schedule. (Strictly, the response rate specified for random-interval contingencies should take account of the duration of the shortest interreinforcement interval, but that level of detail was not regarded as appropriate to the present procedure.) Presession training always took place in a room adjacent to the cubicle containing the response console.

Schedules. Following the presession schedule lesson, each student was seated facing a console and a set of "guess sheets" on a table in a sound-attenuating cubicle. The upper portion of the console contained a point-counter, two green lamps, and a small black button. The lower portion of the console con-

tained two 2.4-cm diameter red buttons, each beneath a blue lamp and operable by a minimum force of 15 N. White noise was presented through headphones to mask extraneous sounds; when the blue lamp above either button was lit, presses on that button briefly interrupted the masking noise.

An Apple® II computer controlled the experiment and recorded data. Timing was accomplished with an independent free-running internal clock; a machine language program sampled responses 20 times per second. Inputs and outputs were arranged through a John Bell Engineering 6522 parallel interface.

Presses on the red buttons occasionally turned off the blue lamp above the button, lit the green lamps, and allowed a press on the black button to add a point to the counter. This constituted the nominal reinforcement cycle (nominal because the findings raise questions about the extent to which the point deliveries functioned as reinforcers).

Throughout most of the experiment, presses on one button produced points according to an RR schedule that selected responses eligible for points with a probability of .025 (RR 40). Point deliveries were produced by presses on the other button according to an RI schedule with a probability of .20 sampled once per second (RI 5-s, with $t = 1$ and $p = .20$). Under some circumstances, an RI 10-s schedule was arranged ($t = 1$ and $p = .10$). These parameter values were chosen so that typical response rates on the two schedules would provide a higher rate of point delivery on the RI than on the RR schedule; actual point-earnings throughout the experiment approximated the schedule values except when rates on the interval schedules were so low that available points were not collected (rates of point delivery for each student's responses are summarized in Table 1).

The left-button and right-button lamps lit alternately for 1 min each (excluding reinforcement cycles), and sessions always began with the left button. The two lamps were never lit simultaneously, and presses on the button beneath an unlit lamp had no scheduled consequences. After 1 min of each schedule, both blue lamps were turned off, marking the beginning of a guess period. The assignment of schedules (RR 40, RI 5-s, or RI 10-s) to buttons varied across different conditions of the experiment (the number of cycles for each stu-

Table 1
Reinforcement rates.

Student	Multiple RR 40		RI 5-s schedules	
	RR 40 points/min (mean)	Range	RI 5-s points/min (mean)	Range
X	5.9	2-9	7.1	4-13
Y	4.8	0-11	8.6	6-12
Z	6.1	3-8	10.1	7-13

Student	Multiple RI 10-s		RI 5-s schedules	
	RI 10-s points/min (mean)	Range	RI 5-s points/min (mean)	Range
X	4.4	2-8	6.4	5-9
Y	4.6	3-6	7.6	6-11
Z	5.7	4-7	9.7	7-12

dent, the schedules, and other details are summarized in Figures 1 and 2).

Guesses. An ample supply of guess sheets was available next to the console. Each guess sheet had six sentences to be completed, three for each button. Each sentence was of the form "The computer will let your press turn on the green lights depending on:" (the multiple responses allowed on each guess sheet provided more opportunities for differential feedback during shaping). Students were instructed to pass the completed guess sheets through an 8-cm hole in the wall next to the console. Initially, guess sheets were returned to students with guesses awarded 0 to 3 points, depending on the accuracy of the guess (see Matthews et al., 1985). After the student returned the guess sheet through the hole in the wall, the light above the left button was lit and the next multiple-schedule cycle began. Once schedule descriptions were established, sheets were no longer returned; a note was passed through the hole stating "From now on, we will no longer be returning the graded guess sheets. You will still be getting points for correct guesses."

Instructions. After the pre-session schedule lesson was completed, the student was escorted to the cubicle in which the console was located. The following instructions were mounted on the wall above the console:

Each point you earn is worth 1 cent. For example, if you earn 300 points you will be paid \$3.00.

You have two ways to earn points: (1) by

pressing the RED BUTTONS, and (2) by GUESSING.

RED BUTTONS. At the lower center of the console are two red pushbuttons. At any time, only one of the two red buttons will work (the blue lights above the buttons will tell you which one is working).

If you press in the right way: (1) The GREEN LIGHTS next to the counter will light up, and (2) when the green lights come on, you can add 1 point to your total by pressing the small BLACK BUTTON next to the counter.

GUESSING. Every few minutes, the console will shut off for about two minutes. During this time you may fill in as many blanks as you wish on the GUESS SHEET.

When you have written as many guesses as you wish (don't take longer than about 2 minutes altogether), roll up the guess sheet and SLIDE IT THROUGH THE HOLE IN THE WALL just to the left of the console.

The sheet will come back with your point earnings written in red. Each guess can earn 0, 1, 2, or 3 points.

After you have seen your points for guessing, PASS THE SHEET BACK AGAIN, and the console will come on.

Do not remove your headphones once the experiment is under way.

Schedule-discrimination lesson. For one student (Y), rate differences were not consistently maintained after feedback was discontinued for the guesses. The student's session was interrupted at the end of a schedule cycle, and the following schedule discrimination lesson was given:

To tell which rule the computer is using, you should WAIT FOR A WHILE WITHOUT PRESSING.

If your next press makes the green lights come on, the button is probably working after RANDOM TIME INTERVALS, and there is no reason to press fast.

If the next press does not make the green lights come on, the button is probably working after RANDOM NUMBERS OF PRESSES, and the faster you press the more you will earn.

After reading the schedule discrimination lesson, the student was required to answer the following question in writing:

Sometimes the computer lets your press turn on the green lights after a random number of presses, and sometimes after a random time interval.

What can you do to find out which way the computer is working?

After the student had answered the question appropriately, the session was restarted.

RESULTS

Data for Student X are presented in the top frame of Figure 1. Left-key (RR) rates were substantially higher than right-key (RI) rates for most of the first session. Verbal schedule descriptions became accurate by the fourth cycle and remained so, with few exceptions, throughout the remainder of the experiment.

The second session began with RR assigned to the left-key (first arrow), and then six schedule reversals (*a* through *f*) were arranged in that session. Guesses continued to be accurate except for cycles 13 (when the interval schedule was identified as ratio) and 17 (when neither schedule was correctly identified). Feedback for guesses was discontinued after cycle 17 (asterisk), with no disruption of accuracy. Thus, Student X's verbal reports were under the control of contingencies on pressing. Throughout all the reversals, pressing rates were appropriate to the difference between ratio and interval contingencies; regardless of key assignments, ratio rates were consistently higher than interval rates.

The third session began at *g* with the RI schedule assigned to the left key, and schedule assignments were reversed (*h*) for cycles 30 and 31; response rates and presses continued to be appropriate to the schedules. Thereafter (dashed vertical line), the left key produced points according to RI 5-s and the right key according to RI 10-s; rates in both components became low and approximately equal. These schedule assignments were reversed at *i*, and rates remained low in both components.

Perhaps the performance was indeed contingency-governed. But Student X's performance could have been generated by compliance with the following rule: "At the start of each component, wait a few seconds and then press; if the press produces a point press slowly for the remainder of the component, but otherwise press fast." To test this possibility, an additional contingency was imposed (by manually disconnecting an input line) for left-key presses at *j*; the first six responses were not eligible for reinforcement. When this contingency was imposed, left-key rates approximated those maintained by a ratio schedule, and Student X identified the schedule as a

Fig. 1. Button-pressing rates over successive multiple-schedule cycles for Students X and Y. Random-ratio rates (RR: circles) were higher than random-interval rates (RI: squares) over several schedule reversals (*a-h* for X and *a-f* for Y). But when the schedules were changed from RR RI to RI RI (dashed vertical lines), both rates became low until a condition in which point deliveries were prevented for the first few responses of a component (probes at *j* and *k* for X and *h-k* for Y), which produced high rates. A return to RR RI and an additional reversal, at *g*, were arranged for Y. Along the *x* axis for each student, arrows without asterisks mark session boundaries and the first asterisk marks the discontinuation of feedback for guesses; for Y, the second asterisk marks the presentation of a verbal exercise on schedules. Details in text.

ratio in the subsequent guess period. In the next cycle (with the additional contingency no longer in effect), left-key rates were low but right-key rates were high, and the right-key schedule was identified as a ratio. At *k*, when the first six responses on the left key were again ineligible for reinforcement, left-key rates again became high and X identified the left-key schedule as a ratio. The same relative rates and schedule identifications occurred in the following cycle, even though the additional contingency was not reimposed.

For Student Y (bottom frame of Figure 1),

the first session also began with the RR schedule assigned to the left key; schedule-appropriate rate differences appeared by cycle 7. Guesses describing the schedules became accurate by the 10th cycle of the first session.

The second session (arrow) began with the RR schedule continuing to be assigned to the left key. Response rates were appropriate to the RR and RI schedules and remained so when the schedules were reversed at *a* and again at *b*. But when feedback for guessing was discontinued (first asterisk), right-key (RI) rates increased and Y identified the right-key

Fig. 2. Button-pressing rates over successive multiple-schedule cycles for Student Z. After reversals of RR and RI schedules at *a* through *h*, during which higher rates were maintained by the RR than by the RI schedule, the schedules were changed to RI 5-s and RI 10-s (dashed vertical line). Even after the reversal at *i*, higher rates were consistently maintained by RI 10-s than by RI 5-s. Along the *x* axis, arrows without asterisks mark session boundaries and the asterisk marks the discontinuation of feedback for guesses.

schedule as ratio. Appropriate pressing and guessing were reestablished when feedback was given for guesses three cycles later, and remained appropriate in the absence of feedback in the next two cycles. But when the schedule assignments were reversed for the last cycle of the session (*c*), rate differences were minimal and Y identified both schedules as ratios.

At the start of the next session, the RR schedule was assigned to the left key (*d*), but rates were relatively high on both keys and Student Y identified neither schedule correctly in the guess period. Without feedback for guesses, Y was unable to identify the schedules consistently. The session was stopped (second asterisk) and Y, still seated at the console, was given the schedule discrimination lesson describing "waiting and then pressing" as a method of testing the difference between interval and ratio schedules. Her description of "how to find out which way the computer is working" was: "You can wait for a while without pressing to determine if you have to press as fast as possible or as slow as possible." After the schedule discrimination lesson,

the session continued, first with RR (to *e*) and then with RI (at *e*) and then again with RR (at *f*) assigned to the left key. Guesses remained accurate despite the absence of feedback, and rates were consistently appropriate to the schedules.

After cycle 35 (dashed vertical line), the left key produced points according to RI 5-s while the right key produced points according to RI 10-s. Rates in both components were low and approximately equal, and Student Y identified both as interval schedules. The fourth session (last arrow) began with the RI 5-s schedule assigned to the left key and the RR 40 schedule assigned to the right key, with schedule assignments reversed at *g*; pressing rates were appropriate to the schedules, and guesses were consistent with these rates. In the next three cycles (after last dashed vertical line), the RI 5-s schedule was assigned to the left key and the RI 10-s schedule to the right key; rates were low on both keys, and Y again identified both as interval schedules.

Like those of Student X, these performances could have been contingency-governed, but they could equally well have been governed

by a rule similar to that proposed for X and described in Y's schedule discrimination lesson: Test each component by seeing whether the first press after a pause produces a point. At *h* and *i*, the first five right-key responses were not allowed to produce points; right-key rates became high, and Y identified the schedule as a ratio. At *j* and *k*, the first five left-key responses were not allowed to produce points; left-key rates became high and Y identified the schedule as a ratio. In the last three cycles, the RI 5-s and RI 10-s schedules remained on the left and right keys, respectively, with no additional contingencies; rates were low on both keys, and Y identified both as interval schedules.

Data for Student Z are presented in Figure 2. In the first part of the first session, the RR schedule was assigned to the left key, and left-key rates were consistently higher than right-key (RI) rates. Schedule descriptions were accurate following the fifth guess period and remained accurate throughout the rest of the experiment. The schedules were reversed at *a* and again at *b*; response rates remained appropriate to the schedules, with RR rates consistently higher than RI rates. Reversals of schedule assignments did not disrupt Z's verbal behavior; Z correctly identified the schedules on the first guess period following each reversal (before feedback was provided), indicating that the verbal reports were under the control of the schedules rather than of the points assigned to guesses.

In the second session (arrow), schedule reversals continued (*c* through *g*). Even after feedback for guessing was discontinued (asterisk), performances remained appropriate to the schedules and guesses remained accurate.

The third session (last arrow) began with the RI schedule assigned to the left key; at *h*, the schedules were again reversed. By this time it was obvious that pressing was sensitive to the difference between ratio and interval contingencies, with verbal reports controlled by the contingencies on pressing. The schedules were then changed to RI 5-s for the left key and RI 10-s for the right (dashed vertical line). If the performances were contingency-governed, rates on both keys should have become relatively low, with left-key rates somewhat higher because of the higher reinforcement rate. In fact, left-key (RI 5-s) rates were low, but right-key (RI 10-s) rates were approxi-

mately equal to those previously maintained by the RR schedule. At *i*, the schedules were again reversed, with RI 10-s assigned to the left key and RI 5-s to the right; the left-key RI 10-s schedule maintained high "RR-like" rates. For Student Z, the longer RI schedule maintained the higher response rate.

DISCUSSION

All 3 students showed multiple RR RI performances that appeared contingency-governed; over several schedule reversals, ratio rates remained consistently higher than interval rates. Yet other changes in the schedules suggested that these rate differences were generated as rule-governed behavior.

For example, when Student Z was exposed to a pair of RI schedules, the schedule with the lower rate of reinforcement produced the higher response rate; a pigeon would never behave that way. The different rates of point delivery might have come to exert discriminative control over Z's response rates (see Table 1), but the rapidity of the reversal at *i* suggests a more local determinant of the differential responding. The rule might have been of the form: "If most 3- or 4-s waits followed by left-key presses produce points at the start of a cycle, continue slow left-key pressing and then press fast on the right key; otherwise, press the left key fast and then press the right key slowly." Such a rule would have effectively governed the multiple RR and RI performances, and with RI 5-s assigned to the left key, low-rate left-key pressing would have been followed consistently by high-rate right-key pressing even if right-key pressing then produced points according to RI 10-s. If RI 10-s came first, however, as after the reversal at *i*, most left-key presses would not have produced points after these pauses and high left-key and low right-key rates therefore would have followed. Asking Z to describe the rule would not have resolved the issue, because the correspondence between Z's within-session private verbal behavior and Z's postsession verbal report would have remained unknown. But the specification of the rule is not critical to the present argument; it is sufficient to conclude that this behavior had rule-governed rather than contingency-governed properties.

Regardless of whether the particular rules that have been suggested in fact corresponded

to some part of the students' private verbal behavior, the performances implied that the rules for the behavior of Students X and Y differed from those for Z. The sensitivity of the pressing to schedule contingencies was indirect, presumably mediated by this verbal behavior. As rule-governed behavior, it topographically resembled but was not functionally equivalent to contingency-governed performance.

When operant experiments with human subjects are simplified by instructing the subjects . . . , the resulting behavior may resemble that which follows exposure to the contingencies and may be studied in its stead for certain purposes, but the controlling variables are different, and the behavior will not necessarily change in the same way in response to other variables. (Skinner, 1969, pp. 150–151)

This experiment involved only 3 subjects and cannot be regarded as supporting any particular theory of the relation between human verbal and nonverbal behavior. Furthermore, taken alone, it does not demonstrate that the observed rates of button pressing were controlled by verbal behavior. But the procedure differed from others previously reported (e.g., Catania *et al.*, 1982; Matthews *et al.*, 1985) only in verbal interventions such as the schedule lessons, and it is therefore plausible to conclude that verbal behavior was involved in the outcome.

When human nonverbal behavior is directly under the control of contingencies, it is appropriate to speak of contingency-governed responding. But sometimes, as in the present instances, the sensitivity to contingencies is rule-governed. It may be appropriate to expand our behavioral taxonomy by distinguishing such verbally mediated sensitivity from that observed in the absence of verbal behavior (e.g., as with nonverbal organisms or in special human cases; see Hefferline, Keenan, & Harford, 1959). Furthermore, when changed contingencies show that the sensitivity is restricted to a narrow set of contingencies, perhaps because the verbal behavior was established only with respect to a few special cases, it is tempting to speak of pseudosensitivity rather than sensitivity. But, like the term *pseudoreflex* (Skinner, 1935), this term is perhaps ill-suited for an enduring role in the vocabulary of behavior.

The main point of the present study is simply to demonstrate some constraints operating on the analysis of human nonverbal behavior. The caution implied by it is that no general test can distinguish direct sensitivity to contingencies from rule-governed sensitivity; each case must be analyzed in its own terms. There is also the possibility that in nonverbal human performances, rule-governed sensitivity is the rule rather than the exception. If that is so, pseudosensitivity to contingencies could be a pervasive property of human nonverbal behavior.

Studies of human schedule performance often have been designed to show similarities to properties of infrahuman performance (e.g., response patterns under fixed-interval schedules, quantitative effects of schedule parameters, differences between interval and ratio schedules, etc.). The success of such attempts may be limited only by the experimenter's resourcefulness. Given appropriate instructions, it should be possible to teach undergraduates to produce classic fixed-interval scallops, to conform to the matching relation, to respond at higher rates when ratio rather than interval schedules are in effect, and so on. But such demonstrations do not imply that human performance is sensitive to contingencies in the same way as infrahuman performance. (Analogous questions are raised by the distinction between the implicit learning of grammatical rules and formal knowledge of such rules; self-generated rules may be involved even in implicit learning [Dulany, Carlson, & Dewey, 1984].)

Trying to develop an approximation of infrahuman contingency sensitivity in verbal humans is like trying to make a computer pass the Turing test (Turing, 1950). That challenge is to write a computer program that answers questions in such a way that a human conversing through a keyboard cannot determine whether the answers are coming from another human or from a computer. But the Turing test is ultimately an exercise in deception; it determines not whether the artificial intelligence advocate can, through algorithmic alchemy, turn a computer into a behaving organism, but whether one human can write a computer program that will fool another human (see Skinner, 1969, p. 149).

It is possible to design experiments in which the sensitivity of human behavior to contingencies appears similar to that of infrahuman

behavior. Such demonstrations must include one of two characteristics: (a) the responding of interest is unaccompanied by any verbal behavior, overt or covert (Lowe, 1983), or (b) the sensitivity is ensured by training procedures, much as in the present multiple RR RI schedules. In the latter case, the behavior is only indirectly sensitive to the contingencies; with sufficient experimental ingenuity, it should be possible to create conditions in which its pseudosensitivity can be demonstrated and to show that verbal underpinnings of the nonverbal behavior are still present. If verbal behavior determines substantial segments of human nonverbal behavior, the goal of an experimental analysis should be to examine how it does so rather than to eliminate it as an annoying interference.

REFERENCES

- Baron, A., & Galizio, M. (1983). Instructional control of human operant behavior. *Psychological Record*, *33*, 495-520.
- Buskist, W. F., & Miller, H. L., Jr. (1982). The study of human operant behavior, 1958-1981: A topical bibliography. *Psychological Record*, *32*, 249-268.
- Catania, A. C., Matthews, B. A., & Shimoff, E. (1982). Instructed versus shaped human verbal behavior: Interactions with nonverbal responding. *Journal of the Experimental Analysis of Behavior*, *38*, 233-248.
- Dulany, D. E., Carlson, R. A., & Dewey, G. I. (1984). A case of syntactical learning and judgment: How conscious and how abstract? *Journal of Experimental Psychology: General*, *113*, 541-555.
- Hayes, S. C., Brownstein, A. J., Haas, J. R., & Greenway, D. E. (1986). Instructions, multiple schedules, and extinction: Distinguishing rule-governed from schedule-controlled behavior. *Journal of the Experimental Analysis of Behavior*, *46*, 137-147.
- Hefferline, R. F., Keenan, B., & Harford, R. A. (1959). Escape and avoidance conditioning in human subjects without their observation of the response. *Science*, *130*, 1338-1339.
- Lowe, C. F. (1979). Determinants of human operant behaviour. In M. D. Zeiler & P. Harzem (Eds.), *Advances in analysis of behaviour: Vol. 1. Reinforcement and the organization of behaviour* (pp. 159-192). Chichester, England: Wiley.
- Lowe, C. F. (1983). Radical behaviorism and human psychology. In G. C. L. Davey (Ed.), *Animal models of human behavior* (pp. 71-93). Chichester, England: Wiley.
- Matthews, B. A., Catania, A. C., & Shimoff, E. (1985). Effects of uninstructed verbal behavior on nonverbal responding: Contingency descriptions versus performance descriptions. *Journal of the Experimental Analysis of Behavior*, *43*, 155-164.
- Shimoff, E., Catania, A. C., & Matthews, B. A. (1981). Uninstructed human responding: Sensitivity of low-rate performance to schedule contingencies. *Journal of the Experimental Analysis of Behavior*, *36*, 207-220.
- Skinner, B. F. (1935). Two types of conditioned reflex and a pseudo type. *Journal of General Psychology*, *12*, 66-77.
- Skinner, B. F. (1969). An operant analysis of problem solving. In B. F. Skinner, *Contingencies of reinforcement* (pp. 133-157). New York: Appleton-Century-Crofts.
- Turing, A. M. (1950). Computing machinery and intelligence. *Mind*, *59*, 433-460.

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