Multiple Selectors in the Control of Simultaneously Emittable Responses

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Editor's Note: Occasionally, *Behaviorology Today (BT)* includes a piece that has gone through a full peer–review process. According to *BT* policy, when this is the case, a very clear notice to that effect is to be included with the piece. In compliance with this policy: **THIS PAPER HAS BEEN FULLY PEER REVIEWED.**

This paper extensively revises the author's report of an earlier research study (Ledoux, 1982a) to highlight the impact further research based on this study might have on the natural science understanding of complex human behavior. Initially, the earlier report was drastically shortened for submission to *Behaviorology*, the fully peer reviewed journal of TIBA (*The International Behaviorology Association*) for peer review. As a result of that review, in January 1995 the editor of *Behaviorology*, Carl Cheney, accepted the piece for publication pending revisions that essentially involved putting back in most of the material that had been removed. This was done but the result ended up being, predictably, too long for publication there. So the work appears here instead (although it had appeared in 1997 in virtually its present form in *Origins and Components of Behaviorology* [Ledoux, 1997/2002]).—Ed. ❧

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...There is no denying the importance of the methods and equipment which have been devised for long–sustained research, but there is also much to be said for an experiment that lasts half an hour—and for a quick and comprehensive look at the fine grain of the behavior in the cumulative record. (B.F. Skinner, 1976. "Farewell my LOVELY!")

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This paper improves and broadens the author's report of a past behaviorological research study (Ledoux, 1982a). In its present form this paper discusses (a) the question of complex behaviors, especially multiple operants, and (b) an experiment on such operants using a method involving multiple reinforcer sources which the author developed in 1982 to help study these operants. In addition the paper discusses (c) how this method makes possible a research project that replicates basic research on fundamental operant processes while extending that replication to more complex, multiple operants, and (d) how such a research project can be a systematic and purely inductive investigation and cataloging of what happens when various basic contingencies include complex behaviors of the multiple operant type.

This paper refers to many research studies related to simultaneously selectable or simultaneously emittable operants. These studies appeared in the literature of "behavior analysis" when that was the preferred name for behaviorological science. That was near the end of the time period during which this natural science temporarily shared a history with the non–natural discipline of psychology (see Ledoux, 1997a). The perspective of this paper respects that history as well as the evolutionary perspective shared by the different levels of life–science disciplines (see Glenn & Madden, 1995; also see Fraley & Ledoux, 1997, Ch. 6). As a practical result, this paper uses some terms that, while of more recent origin than the reported study, are still consistent with that history and perspective (e.g., "postcedents" and "selectors"; see Ledoux, 1997b; Vargas, 1985).

The simultaneous occurrence of operant responses is an aspect of the behavior of animals, especially humans. Operants regularly, although not always, operate on the environment in ways that provide the selectors that act upon these operants as their own selecting consequences. Since selectors affect any operant whose occurrence precedes them, an operant that occurs simultaneously, or even nearly so, with one or more other operants may be affected by the occurrence of any selectors following any of these operants. In addition, the operant that is producing a particular selecting consequence is sometimes discriminable, and at other times it may not be; this may also affect the selection processes. The effective understanding of why people do what they do, and what can be done about it, requires investigation of these phenomena.

In the dozen years since the research reported here on simultaneously selectable and simultaneously emittable multiple operants was done, the study of complex human behavior has little pursued work on such operants. Instead researchers have focused on other valuable research lines (e.g., on stimulus equivalence; see Sidman, 1994). Some possibly important discoveries must await research into the effects of simultaneous selectors on simultaneously emittable multiple operants.

Introduction

Sometimes complex behavior appears not to be "sensitive" to observed contingencies (i.e., it does not change in ways that observers of those contingencies would predict). Many reasons for this are possible. For instance, some possibly competing contingencies may not be visible to observers. The reasons in particular cases are often unknown. Research should focus on discovering and controlling for these reasons. But research should also do more.

Behaviorological research should develop and promote the use of procedures that improve the sensitivity of behavior to the contingencies in effect because the veracity of data–based conclusions relies on behavior being sensitive to those contingencies. This especially holds in studies of concurrent operants where interactions often occur that might confound the data. Thus, the search for procedures producing greater independent sensitivity of each operant in a multiple operant study is a continuing one. Research on parameters such as the length of change–over delays (CODs) exemplify this search (Allison & Lloyd, 1971; Fantino, Squires, Delbruck, & Peterson, 1972; Pliskoff, 1971; Stubbs & Pliskoff, 1969).

Efforts to enlarge the *range of behaviors* affected by sensitivity enhancing procedures should also increase. Unfortunately, this does not appear to have been the case with previous concurrent operant research where the application of sensitivity enhancing procedures has been limited to behaviors for which these procedures can establish response independence (from confounding schedule effects) *through response succession.*

The discussion in the next three sections reviews that situation, offers a possible explanation of why it occurred, and suggests a line of research using a new procedure to improve "sensitivity" (i.e., functional response independence) and reduce concurrent superstition, all without requiring response succession. This research line also seeks to expand the range of behaviors that show enough sensitivity to make studying them productive. One type of behavior that can be included in the expanded range is simultaneously reinforceable concurrent human operants. ("Simultaneously reinforceable" means that a response on one manipulandum can be selected at the same time that a response on another manipulandum is selected; this implies that the manipulanda are simultaneously available, and that the responses are simultaneously emittable.)

The pivot point for discussing the historical context, present status, and future behaviorological research possibilities with respect to simultaneously reinforceable concurrent operants is Charles Catania's book chapter "Concurrent Operants" (Catania, 1966). At the time the research reported in this paper occurred, this chapter was the seminal treatment of issues affecting research in concurrent operants, including formal aspects of programming, classification of concurrent operants, schedule effects, local interactions, quantitative relations, and various preferences. This book chapter set the pace for nearly all subsequent concurrent operant research. But that turned out to be, in some ways, a hindrance as well as a help.

Historical Background

One difficulty is that Catania's book chapter did not attempt to deal with *simultaneously reinforceable* concurrent operants. In addition, his discussions of procedures, subjects, and future lines of research were such as to reduce researchers' further interest in this type of concurrent operants. This section, after dealing with the issue of definitions, will review studies that *are* relevant to simultaneously reinforceable concurrent operants, and thereby expand on Catania's coverage.

Definitions. In *Schedules of Reinforcement,* Ferster and Skinner (1957) defined concurrent operants as:

> Two or more responses, of different topography at least with respect to locus, capable of being executed with little mutual interference *at the same time* or in rapid alteration, under the control of separate programming devices (e.g., responses to two keys present at the same time under separate schedules). (p. 724, emphasis added)

Catania quotes this definition on his first page, but he proceeds to say "In the case of concurrent operants, the organism's alternatives are…to emit one or another of the available operants" (p. 213). But for his definition to agree with the Ferster/Skinner definition, it would have to read "…to emit one or another *or both* of the available operants." This difference is significant; Catania's definition led, as will be seen, to constraints on the directions subsequent researchers were inclined to take.

The basis of this definitional omission, which pertains to the question of whether response succession is required or not for response independence, and why, will be detailed later. For now, successive responses, in Catania's view, *are* required as they make the occurrence of concurrent superstitions avoidable (Catania and Cutts, 1961, defined concurrent superstition as the accidental correlation of one operant with the reinforcement produced by a different operant; compare this with simple superstition which is a correlation of a response with accidental, non–contingent reinforcement). Catania (1966) further suggests that the use of a COD is the most reasonable way to obtain successive responses. But CODs may not be necessary because obtaining successive responses is only one way to generate independence of schedule effects.

Related research. Ferster (1957, 1959) follows the definition of concurrent operants that he published with Skinner. In his 1957 study, the responses were simultaneously emittable and simultaneously reinforceable. Chimpanzees pressed two keys, one with each hand. The schedule for the two keys was concurrent (CONC) variable interval (VI) 4′ fixed ratio (FR) 120 (i.e., CONC VI 4′ FR 120). These schedules were selected because, when presented singly, they generate quite different yet stable response patterns; so when presented concurrently, the researcher might more quickly notice changes in the response pattern under either schedule. Results showed only minor changes in schedule patterns from those typical of single schedules, and it would be difficult to attribute these changes solely, even mainly, to superstitious effects from simultaneous reinforcement of both responses by one or the other schedule. One interesting observation was that the subjects continued to operate the VI key, at the same rate as before, while eating food from the magazine with the FR hand.

Ferster (1957) preferred to use simultaneously reinforceable operants because "the time spent changing back and forth between the keys would interfere with the characteristic performance under the single schedule of reinforcement" (p. 1090). Ferster also points out the relevance of studying simultaneously reinforceable operants to such human behaviors as piano playing where sometimes each hand must deal with a different rhythm, as well as different notes. And he mentions an additional benefit from studying these operants. The rate from one key can be used to measure any emotional side effects from changes in the schedule on the other key.

Ferster's 1957 study was expanded in his 1959 study. This time the chimps were exposed to a variety of concurrent schedules, including fixed interval (FI) components in complex schedules that involved both concurrent and multiple (MULT) schedules like CONC VI 10′ MULT FR 475–FI 10′. While the data showed fairly consistent independence of schedule effects for each key, some observations were especially interesting. Virtually no scallops appeared during FIs; less responding occurred, from more pausing, on the VI key during FR runs; extinction on the VI key correlated with a small decrement in FI responding; and chimps do not usually sustain high FRs (e.g., FR 475), but these chimps did, perhaps due to minimal superstitious effects of occasional VI reinforcers, especially those occurring during an FR run. (Such an effect is worthy of research in its own right as a possible additional behavior maintenance procedure, or resistance to extinction procedure, in the technology of behavior control.)

Between the appearance of Ferster's two studies, Sidman (1958) published a study using simultaneously reinforceable concurrent operants *and more than one source of reinforcement.* (This was one of two such studies; the other was Hearst, 1961.) Actually, in Sidman's study, the use of dual reinforcer sources was forced by the nature of the schedules. Sidman investigated the effects of a superimposed pre–shock stimulus on concurrent schedules of avoidance and food reinforcement. He initially trained monkeys on CONC VI 4′, avoidance schedules, and included, in some phases, a "free" shock with a pre–shock stimulus. He then tested for any effects, on relative rates of lever pressing, from the superimposition of the free shock/pre–shock stimulus on the CONC VI, avoidance schedule. Even after making various parameter changes on the VI, avoidance schedule, his results consistently showed VI responding being highly controlled by the avoidance contingency. This superstition occurred regardless of whether the response topographies were the same (2 levers) or different (a lever and a chain). So Sidman then changed the VI components to FR components. From repeating the basic procedure with conc FR, avoidance schedules, his results indicated separation of each response class. Thus, Sidman's study exemplifies what will be seen to be a common problem. When results of using VIs as concurrent schedule components are compared with results from using components involving other schedules, the VI results are associated with a greater degree of concurrent superstition.

Five other studies (in the order discussed here: Segal, 1961; Lane, 1961; Hearst, 1961; Bruner & Revusky, 1961; Catania & Cutts, 1963) are relevant to the question of dealing with concurrent superstition, particularly in simultaneously reinforceable concurrent operants. Each will be described in turn, while the various reasons for their relevance will be summarized at the end of this section.

Segal (1961) was interested in demonstrating experimental control over DRL (differential reinforcement of low rate) timing behavior by setting up another response as the timing behavior itself, but on an independent schedule. She did this by training rats to press two levers on CONC VI 1′ DRL 18″. (The responses were not simultaneously reinforceable unless the rats could span the five inches that separated the levers.) Then, extinction (EXT) replaced one schedule component or the other (sometimes CONC EXT DRL; other times CONC VI EXT). Additional component combinations were also tested. The data showed that each concurrent component affected the other, at least initially when it was introduced. For instance, after being replaced by extinction, when the DRL component was re–introduced, the VI response pattern was temporarily disrupted, recovering within a few sessions. Thus, in this study, the occurrence of concurrent superstition, even with time–based schedules, was not a lasting effect.

Lane (1961) investigated the effects of various conc fr fr schedules on the chirping and pecking of chicks (responses which, in his view, were not incompatible in topography). While the responses were thus simultaneously reinforceable, he found that they were seldom emitted simultaneously. More importantly, he observed some superstitious relations between the two operants and their respective schedules. The rate of chirping changed in the same direction as the rate of pecking, when the pecking schedule was altered. Thus, in this study, while the responses seldom occurred simultaneously, concurrent superstition was still observed with ratio–based schedules; Lane suggested four possible reasons, but these are relevant to the present paper only as reminders that the sources of superstitious effects are many.

Hearst (1961) was interested in whether d–amphetamine would suppress operant response rates as it does consummatory responses. He found that it did so, in a dose–related manner, by exposing rats to different drug doses after they had been trained to press two levers concurrently (conc vi 2′ vi 2′). The relevance of this study to the present topic is mainly procedural, for while the levers were too far apart for responses to be simultaneously emittable, this study is the only other study besides Sidman (1958) to use two different reinforcer sources. As with Sidman's study, the use of two sources was forced by an aspect of the study; in this case it was forced because one reinforcer was food and the other reinforcer was water.

Bruner and Revusky (1961) wanted to make overt, and record, the "collateral" behavior occurring in the interval prior to the availability of a response–produced reinforcer on a drl schedule. They did this by having humans press four telegraph keys on a conc ext ext drl ext schedule. (The drl was >8.2″ but <10.25″.) The keys were simultaneously available but the responses were not officially simultaneously emittable (and therefore not simultaneously reinforceable) as instructions were used to generate response succession; the subjects had been instructed to press only one key at a time. The data clearly showed each subject emitting a respectively different but stereotyped pattern of superstitious behavior. Thus, this study also shows superstition with human subjects on time–based schedules, with responses that were successive rather than simultaneously reinforceable.

Catania and Cutts (1963), from an interest in controlling concurrent superstition, attempted to gain experimental control over button–press responses of human subjects on a conc vi 30″ ext schedule. In their procedure, some subjects experienced no cod; others had a full session with a cod; for still others, a cod began sometime in the session. Data showed that a cod decreased the amount of superstitious responding.

The work of Catania and Cutts (1963) represents a watershed for research bearing on the present topic prior to the appearance of Catania's 1966 book chapter. This study lays the foundation for saying that concurrent superstition must be avoided—and response independence generated—*through a procedure that separates responses in time* (i.e., generates response succession) such as a cod. Still, the authors go on to point out a number of characteristics about humans that may make even cods inadequate for this purpose. Furthermore, the subjects had been instructed to press only one button at a time, so even the responses of those subjects experiencing no cods were not officially simultaneously emittable. Other observations of Catania and Cutts (1963) are also worth noting. There was much variability in superstition across subjects who experienced no cod. On the other hand even subjects with cods for their full session showed various superstitions. These facts provide some good reasons to seek alternative procedures to cods for avoiding concurrent superstitions, especially with human subjects (and these reasons are in addition to the incompatibility of cods with simultaneously emittable, simultaneously reinforceable operants).

Historically, Catania's 1966 book chapter appeared before the last two studies to be discussed. But since its impact is felt mainly in the next section of this paper, it will be sufficient here to note that in the end, Catania advised researchers studying concurrent operants to avoid concurrent superstitions by generating response independence through the use of cods, making responses successive. With few exceptions, researchers have abided by Catania's advice. Two exceptions will be discussed (Striefel, 1972; then Harrison, 1979).

In Striefel's (1972) study, human subjects operated separate levers under different concurrent fr pairs. Ten different fr pairs were tested per subject. For all subjects the initial preference was always for the shorter of the pair of fr components. Then, a time–out period was introduced at the completion of each preferred component. This period was increased in one–second increments until the subject switched from the preferred but punished component of the pair to the previously non–preferred and unpunished component. After the number of completed "non–preferred" ratios had reached a criterion, a new concurrent fr pair was introduced. Data showed that as the difference between the components of the fr pairs increased, the time–out duration which generated switching also increased. Procedurally, while the levers were simultaneously available, the responses were not officially simultaneously emittable as the subjects were instructed to operate only one lever at a time. The study is pertinent to the present topic for this reason, as well as for not using any cod.

In Harrison's (1979) study, the responses were only potentially simultaneously reinforceable due to the trial–by–trial nature of the procedure (where the first response made ended the trial). Harrison trained rats to press one lever in the presence of sound from one speaker, and another lever in the presence of sound from another speaker. The discriminative stimulus (S^D) was the position of the sounding speaker. For some subjects, responding on the lever adjacent to the speaker that sounded was reinforced; for other subjects, non–adjacent responding was reinforced. Data showed that rats that were reinforced for adjacent responding learned the discrimination quickly and with very little non–adjacent responding. However, rats that were reinforced for non–adjacent responding learned much more slowly. Also, the latter rats started out responding on the non–reinforced lever (the lever adjacent to the sounding speaker) at a high rate which increased before extinguishing (though never completely) as responding on the reinforced lever (the non–adjacent lever) gained strength. Further experiments controlled for novelty and respondent conditioning explanations of this effect, which seems less reminiscent of concurrent superstition than of the type of behaviors observed in autoshaping studies (discussed by Staddon & Simmelhag, 1971).

Historical background summary. A review of some characteristics of the studies that have been considered here will help summarize their contents and highlight their relevant aspects. These characteristics fall into three categories: the species of the subject, the status of the particular operants involved regarding simultaneous reinforcement, and the presence and nature of any superstition.

The subjects in these studies fit four classifications: birds (Lane, 1961, with chicks); rodents (Harrison, 1979; Hearst, 1961; and Segal, 1961; all with rats); non–human primates (Ferster, 1957, 1959, with chimps; Sidman, 1958, with monkeys); and humans (Bruner & Revusky, 1961; Catania & Cutts, 1963; and Striefel, 1972).

Regarding the second category of characteristics, each study can be classified (a) as using actually simultaneously reinforceable concurrent operants, (b) as using concurrent operants whose status as being actually simultaneously reinforceable is ambiguous and in need of qualification, or (c) as using only potentially simultaneously reinforceable concurrent operants. While none of these studies used non–simultaneously reinforceable operants, qualifications to the status of the operants in most of these studies should be noted. (Non–simultaneously reinforceable operants are "biologically successive" operants such as pigeons make when faced with two keys to peck which they are genetically incapable of pecking simultaneously for they have but one head. Catania [1966] refers to these as incompatible operants.)

Three studies used actually simultaneously reinforceable operants. These are the studies by Ferster (1957, 1959) and by Sidman (1958).

For three other studies (Harrison, 1979; Lane, 1961; and Segal, 1961) the possible use of actually simultaneously reinforceable operants requires qualification. Segal's rats had to be able to span the five inches separating the two levers if their responses were to be simultaneously reinforceable, and Segal did not comment on whether or not the rats could or did accomplish this unlikely reach. Lane's chicks seldom emitted their responses simultaneously, and Lane offered no special comments about this phenomenon. And Harrison's trial–by–trial procedure made it difficult to say more about the responses he studied other than that they were procedurally simultaneously emittable.

The other four studies used potentially simultaneously reinforceable operants. They can be classified according to the manner in which their simultaneous reinforcement status came to be only potential rather than actual. One method to do this is to completely separate the responses through the structure of the apparatus; these responses might then be called "structurally successive" (as when Hearst, 1961, spaced the levers so far apart that they could not be pressed simultaneously). Another method that detracts from the simultaneity of the responses is the practice of instructing human subjects not to emit more than one response at a time; this makes the responses "instructionally successive" (as with Bruner & Revusky, 1961; Catania & Cutts, 1963; and Striefel, 1972). A third method involves the use of a COD contingency; this makes the responses "contingently successive" (as with Catania & Cutts, 1963).

The third category of characteristics shared by these studies concerns the presence and nature of superstitious effects, or their absence (i.e., response independence). Each study deserves separate comment on this matter as the particular schedules involved differ from one study to the next.

- Ferster (1957) found little or no superstition with CONC VI 4′ FR 120.
- Sidman (1958) found consistent concurrent superstition with CONC VI, avoidance schedules, but obtained separation of response classes with CONC FR, avoidance schedules.
- Ferster (1959) found fairly consistent independence of schedule effects with complex schedules like CONC VI 10′ MULT FR 475–FI 10′, though his chimps' sustaining of high FRs may be due to an adventitious schedule interaction.

- Segal (1961) observed initial but temporary superstitious effects when extinction replaced either component of a CONC VI DRL schedule.
- Lane (1961), using various FR FR schedules, found that chirping always changed in the same manner that pecking changed when only the schedule component for pecking was altered.
- Hearst (1961) saw little or no superstition with a CONC VI 2′ VI 2′ schedule and structurally successive responses. (For these VI components, using widely separated manipulanda—rather than CODs—generated response independence.)
- Bruner and Revusky (1961) obtained "elegant" (in the engineering sense) superstitious effects with a CONC EXT EXT DRL EXT schedule and responses made successive, but not independent, by instructions (and again, no CODs).
- Catania and Cutts (1963), using CONC VI 30″ EXT, and responses made successive by instructions, found superstition even with the use of a COD, though more was observed in the absence of a COD.
- Striefel (1972) did not report any superstition from using CONC FR pairs with an incrementing time–out period (to generate preference matching), and with responses made successive by instructions.
- Harrison (1979) observed superstitious effects with his trial–by–trial procedure, but these were not seen as appropriately tacted as "concurrent superstition."

Of all of these studies, only the last two were undertaken after the publication of Catania's influential 1966 book chapter. This phenomenon is significant for the next two sections which discuss why it happened and what might be done next.

Tentative Explanation

Between the appearance of Catania's 1966 book chapter and 1982 (when the present study was conducted) the literature offered no other studies that came any closer than Striefel (1972) and Harrison (1979) to dealing with the topic of simultaneously reinforceable concurrent operants. There are reasons for this paucity of research. What can be done about that will be addressed in the next section.

Catania (1966) himself provided some of the reasons for the paucity in research on simultaneously reinforceable concurrent operants. Catania was concerned with the possibility of concurrent superstition, which he defined in his book chapter as "the accidental strengthening or maintenance of one operant by reinforcement programmed for another" (p. 215). Researchers need to eliminate the possibility of such events occurring. But methods to do this that retained full response simultaneity were little examined. Instead, the most common methods used to try to avoid concurrent superstition involved trying to make responses independent by *not allowing them to occur simultaneously,* which makes the responses successive. However, making responses successive is not a guarantee that the responses will be independent.

Various procedures are successful at making concurrent responses successive (not simultaneously emittable/reinforceable), as has been seen with the studies already discussed. The two types of responses that these procedures encompass are those that are successive because they are incompatible (e.g., a pigeon's pecking responses to two separate, even if close together, keys), and responses that are compatible but also successive by virtue of some research technique. These techniques include (a) separating the response manipulanda physically so that the subject cannot operate them at the same time, (b) using instructions that allow the operation of but one manipulandum at a time, (c) using CODs, (d) using various combinations of these techniques, and (e) additional techniques not directly relevant to the present study such as the "Findley" procedure (Findley, 1958). Catania (1966) dealt briefly with most of these methods, but concentrated his efforts on the COD.

With good reason Catania prefers CODs as the technique of choice. Both before and after his 1966 book chapter, so much of the research on concurrent operants was using pigeons as subjects. Since their key peck responses, being biologically successive, cannot be simultaneous, there is no reason for researchers using pigeons to try to control concurrent superstition with a technique that allows response simultaneity. Yet these biologically successive responses necessarily involve switching from one key to the other, and the switching response itself can become a separate, superstitiously controlled operant. In this situation CODs are valuable because they lessen the chance of switching being adventitiously reinforced.

Also, CODs dovetail with the solution to another procedural problem that can arise with subjects whose responses are biologically successive. When the procedure involves concurrent ratio schedules, responding can be limited to the more favorable schedule; the subject does not contact the other schedule. The solution is to use interval schedules; each schedule requires but one response for reinforcement after the interval ends. Responses can be (and are) made on the less favorable key during the favorable interval, and some of these responses get reinforced. Thus, the nature of interval schedules (with researchers seeming to prefer VI schedules) brings the subject into contact with all the contingencies. However, responding on both alternatives with biologically successive responses under VIs necessarily involves switching, with its own problem (i.e., concurrent superstition, as already described, which is more likely with VIs as the discussion of Sidman's 1958 study noted) and its own solution (CODs).

Overall, then, when studying contingencies using biologically successive responses (like pigeons and key pecks), VIs and CODs work especially well together, as Catania suggests. The VIs generate responding on both alternative manipulanda while the CODs lessen the chance of adventitious reinforcement of switching. Thus, satisfactory independence of schedule effects (i.e., response independence) can be achieved.

However, those solutions are not helpful when studying contingencies involving simultaneously emittable/reinforceable responses. For instance, when Sidman (1958) could not get schedule effect independence using VIs, he achieved independence of schedule effects using FRs (rather than CODs, which would have eliminated the simultaneous reinforcement status of the responses). Unfortunately, the possibilities suggested by Sidman's findings received minimal treatment in Catania's book chapter. The findings of other relevant studies (already discussed) shared the same fate. Catania's treatment of the literature showed and encouraged a preference among researchers to avoid concurrent superstition by using incompatible operants (if possible) and then forcing further response succession—and hopefully independence—by using CODs.

Catania never said that incompatible responses and CODs were the only options for avoiding concurrent superstition. However, since the most common responses, in studies involving concurrent schedules, were pigeons' biologically successive key pecks, to which these options apply, it is not that surprising that so little work has been done with simultaneously reinforceable responses, to which these options do not apply.

Tentative explanation summary. There are several reasons to seek alternative procedures to CODs to avoid concurrent superstition, especially with human subjects. The research studies that have been reviewed here were discussed because few dealt with CODs or incompatible responses. Yet none of them could be properly described as being overwhelmed by superstition. Some of them even showed how CODs sometimes are not effective. Ferster (1957) stated a clear preference for simultaneously reinforceable responses, and he pointed out the relevance of these to human behavior. Catania and Cutts (1963) drew attention to some characteristics of humans that argue against the use of CODs with human subjects. And CODs simply do not allow study of more complex behavior in the form of simultaneously emittable and reinforceable responses because they force response succession. Other techniques that generate response succession, along with CODs, simply cannot be used with responses that reflect the complexity of behavior, especially human behavior; they are not adequate analogs of "real life" behavior patterns.

So, especially if human behavior is the behavior of concern, and/or if CODs and other response–succession techniques are inappropriate because simultaneously reinforceable responses are the object of study, then how can concurrent superstition be avoided? Fortunately, other techniques besides those leading to response succession seem to be available to generate sensitivity to contingencies.

Possible Resolution

One important characteristic of the studies already discussed has not yet received much attention. That characteristic is the number of reinforcer sources used in the research. All but two studies (Sidman, 1958; Hearst, 1961) used one reinforcer source, such as a single food magazine or hopper, *located between* the two manipulanda. Sidman, as well as Hearst used two sources because their respective procedures forced them to do so; the use of two sources was not the point of the research. Yet the orderliness of their data suggests that the use of multiple reinforcer sources is worthy of being studied for its own sake.

"Multiple sources" refers to the reinforcer or other selector sources in a situation in which each manipulandum has its own physically associated selector source (e.g., a separate food magazine or point counter or hand slapper located near each lever or chain or key). Multiple sources should be studied because the problem of concurrent superstition may actually be a problem of some ambiguity in the contingencies that results from having only one shared selector source (i.e., some concurrent superstition may be an artifact of the experimental apparatus). Multiple sources may prove to be more discriminable than one source with respect to which response produces any particular selector. If the contingencies used to compare single and multiple sources involve reinforcement for every response (continuous reinforcement frequency, or CRF) and extinction (EXT), then the potential for definitive results is increased; since these contingencies are maximally different, a single source of reinforcement has the most opportunity to control responding without superstitious effects. If greater superstitious effects are observed with single sources than with multiple sources, under these contingencies, then the multi–selector source procedure gains support. A whole area of behavior, complex behavior, particularly human behavior, may be exposed to more thorough investigation: the area of simultaneously selectable operants.

Possible resolution summary. What is desired is sensitivity to the contingencies. Successive responses may not be required to achieve this, and in any case are incongruent with simultaneously selectable operants. These operants comprise an inadequately studied, and potentially significant area in behaviorological science. Only more research will resolve the question of whether or not the use of multiple selector sources will be able to achieve the independence of schedule effects that would indicate experimental control over sensitivity to the contingencies.

The present study addressed that question by comparing the effectiveness of a single reinforcer source (a source that was shared by responses on two manipulanda) with the effectiveness of dual reinforcer sources (sources that were each physically associated with a different response manipulandum). This study assessed the relative effects of the single reinforcer source versus dual reinforcer sources for simultaneously emittable and simultaneously reinforceable responses using concurrent schedules involving CRF and EXT contingencies with human subjects.

Method

Subjects

From the many college students (in an introductory social science course) who volunteered to serve as subjects, the seven who participated were selected on the basis that their schedule matched the experimenter's laboratory schedule. Two subjects were right–handed males, aged 18 and 19, and five subjects were females, with ages between 18 and 25 (mean of 20.4). Of these five, one was left–handed.

All subjects were taking, as non–majors, their first college behavior–related course. They were all naive about the natural science of behaviorology in general and about this experiment in particular. The subjects knew that they would receive a small number of bonus points from their class professor for participating. They were also told, prior to volunteering, that it was possible for participants to earn a maximum of one dollar (US$1.00) from each of their four to eight experimental sessions, and that each session would be about 30 to 60 minutes long. Furthermore, they were asked not to discuss the experiment with other subjects or anyone else. (All subjects reported at the end of the study that they had complied with this request.)

All subjects experienced all levels of the independent variable, with a within–subjects design involving both within–session and between–session comparisons. However, two subjects did not complete all parts of the experiment. One of these (subject ES; subjects are referred to by code letters) became ill and was unable to return, after the within–session comparison, to participate in the between–session comparison. The other (subject FS) was a victim of a scheduling error, and so participated only in the between–session comparison. All five remaining subjects participated in both the within–session and between–session comparisons. All subjects were free to withdraw from the study at any time without penalty, and were so informed.

At the end of the study, all subjects were given the full amount of one dollar for each session that they completed, regardless of how many points–for–money they earned during each session (they had not been informed that this would occur). They were also fully briefed at this time about the purposes, procedures, results, and possible conclusions of the study.)

Apparatus

A room approximately 3.5 m long by 2.5 m wide by 3.5 m high served as the human operant chamber. The wall was painted navy gray, while the ceiling was black. The brick floor was unpainted and uncovered. A light fixture, with eight 48–inch–long florescent tubes, hung from the ceiling. A single door provided access. A two–way mirror, 60 cm wide by 110 cm high, was blocked off from the outside except for a 10 cm square section in a lower corner which could be used for observation during a session. A non–oscillating air–circulation fan was used to mask possible noises from adjacent rooms. A comfortable chair for the subject and a small table for the subject's stimulus/response/consequence panel were the only furnishings in the room. Figure 1 shows the typical arrangement of subject, chair, table, and panel during a session.

The subject's panel was made by putting a wooden, black face plate at a 45° angle (leaning away from the subject) onto a wooden, yellow box shell measuring 21 cm deep at the base, 22 cm high at the rear, and 48 cm across the front. The face plate measured 23 cm deep and 48 cm across. Two standard Acme telegraph keys extended out from the box, beneath the face plate. The center of each key was placed 7 cm from the side edge of the box. A force of 1.15±0.05 N (115±5 g) would displace either key through the 1±0.2 mm distance required to close its circuit.

The face plate contained various stimuli. Directly above each key, 6 cm from the bottom edge of the face plate, was a pair of lights. In the center of the face plate was another pair of lights on the same level as the two side pairs of lights. Each pair of lights was associated with a counter. The left light of each pair was one of three white lights used together as pacing lights. The right light of each pair was yellow and flashed when its associated counter was incremented as part of the occurrence of reinforcement. Above each pair of lights was its associated Veeder–Root, six–digit counter, model B–120506. When incremented, these counters would sound an audible click. No counter could be returned to zero except by the experimenter, for the reset knobs were removed during experimental sessions. A red light was placed 10 cm above each side counter. If this light was off, no consequence of any sort was programmed for the key on the corresponding side, as if the key was disconnected from the programming equipment. These are called "key–connected" lights. In the center, on the same level as the key–connected lights, was a green light used as a house light. A session was in progress so long as this light remained on. Below the house light was a circular switch. This was to be used as a panic switch with which a subject could end the session prematurely. (Its use, however, was not without consequences.)

The subject's panel was connected by cable to a computer, an interface, and two cumulative recorders (one for the responses made by each hand) located in another room across the hall. A Digital Equipment Corporation PDP 8A/620 computer controlled the programming of the sequence of events in each session automatically. Programming was supplied through SuperSKED software (Snapper & Inglis, 1979) operated through a SKED interface (provided by State Systems, Inc. of Kalamazoo, MI). By this arrangement data collection, including the operation of the cumulative recorders, was also automatic. Two G3100 Gerbrands cumulative recorders (Model C3) were used. Paper drive gears with a 2:1 ratio (commonly called "pigeon gears") were used to obtain a paper movement rate of 60 cm per hour.

Figure 2 shows (a) the arrangement of response manipulanda and stimuli on the subject's panel, and (b) the two cumulative recorders used for primary data collection.

Procedures

The basic experimental question was whether one source of reinforcement, or two sources of reinforcement, would be more effective—with less superstitious responding—in controlling simultaneously reinforceable concurrent human operants. In addressing this question, certain procedures were used.

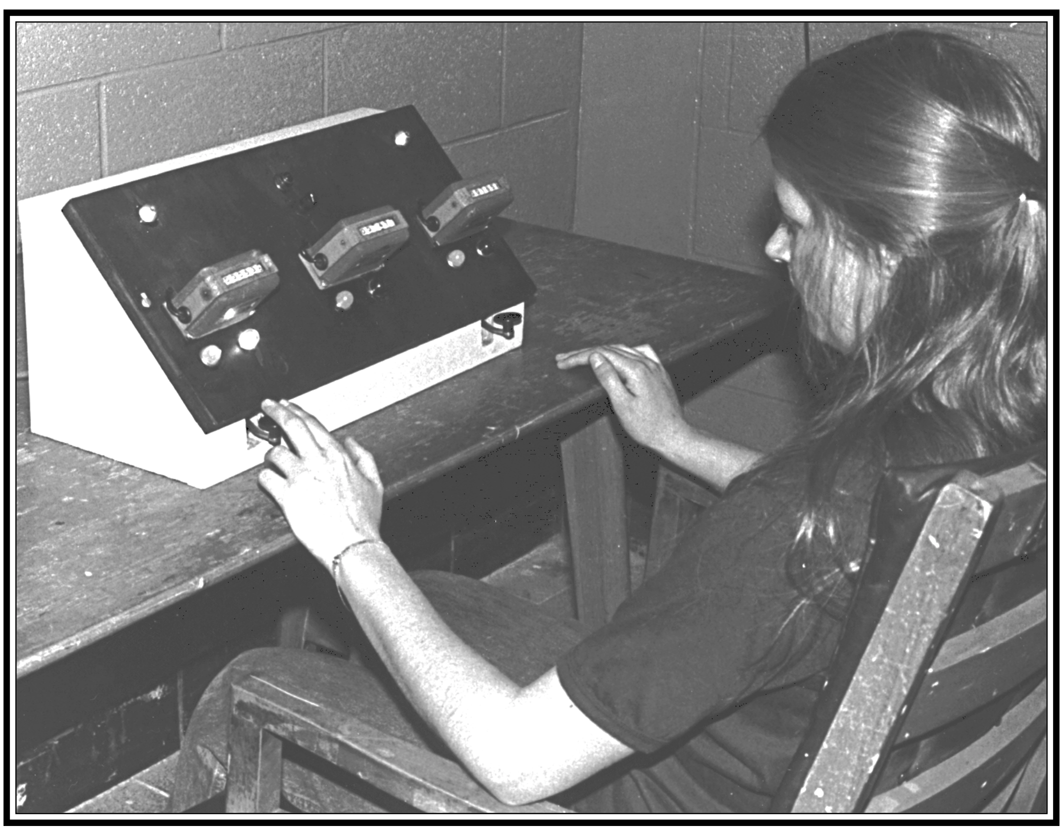

Photo by Stephen F. Ledoux

Figure 1. Typical arrangement of subject, chair, table, and panel.

General procedures. Instructions to the subjects concerned the operation of the panel, and their task. Regarding the operation of the panel, instructions included these:

❧ The session begins when the green light goes on, and ends when the green light goes off.

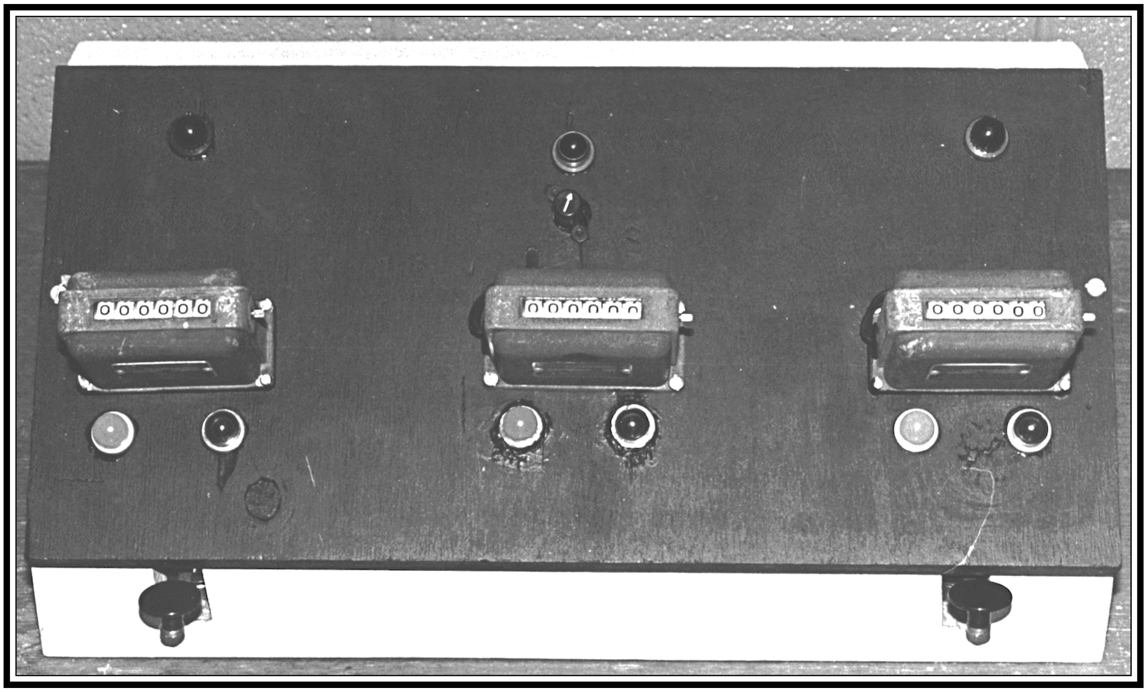

Photo by Stephen F. Ledoux

A. Arrangement of the subject's panel.

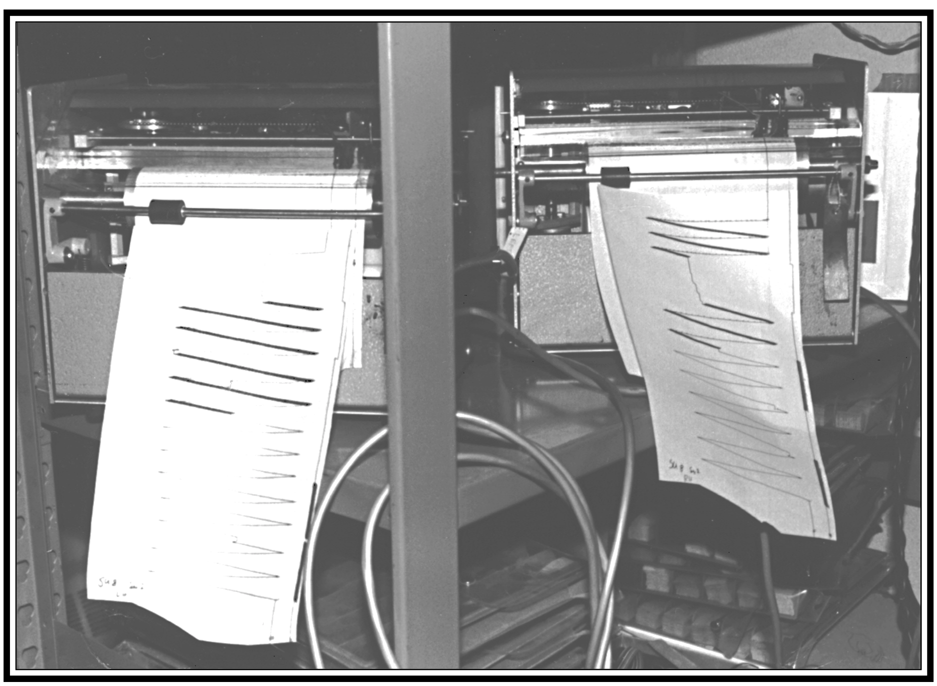

Photo by Stephen F. Ledoux

B. Arrangement of the cumulative recorders.

Figure 2. Arrangement of (a) response manipulanda and stimuli on the subject's panel, and (b) the two cumulative recorders.

- In the first session only one red light will come on at a time; work only on the key beneath the red light that is on. If the white lights [the pacing lights] flash, press the operating key at a speed such that the yellow light will flash whenever the white light flashes. After the first session, no white lights are ever used.
- In all subsequent sessions both red lights will either be on or be off together. When they are on, both keys are operating. This does not mean that both keys will necessarily be equally effective in producing points. With both red lights on, you may work on one or the other or both keys. When the red lights are off, it is a rest period and neither key will be operating. [No subject was observed to use a key whose associated red light was out.]
- Use the left hand with the left key and the right hand with the right key. [No subject was observed to do otherwise.]
- Sometimes key pressing produces points that are added up on a counter. Each point is accompanied by a flash of the yellow light below the counter. [Points and flashes were the anticipated and observed conditioned added reinforcers for key pressing responses.]
- Sometimes both the points produced by the left key and the points produced by the right key appear on the center counter only. At other times the points produced by left key pressing appear only on the left counter, and the points produced by right key pressing appear only on the right counter. Points never appear on all three counters at the same time.
- If, for any reason, you want to end the session before the green light goes off, you can do so by turning the knob located below the green light. However, if you do this, you forfeit 50% of your earned points for that session. [No subject ever used this panic switch.]

Regarding the subject's task, instructions included these:

- Points equal money! The more points you generate, the more money you earn. Since a fixed amount of money is available for each session ($1.00), while the number of points available for each session varies, the amount of money you receive will be that percent of the money available that equals the percent you earned of the possible points.
- Your task is to generate as many points as possible, working on one or the other or both keys. While working on both keys, press both keys at the same time. [Responses were simultaneously emittable and, without bringing any other special contingencies to bear, it was preferred that they be emitted simultaneously.]

The daily routine for each subject began with her or his arrival at the laboratory. Each was asked for his or her watch as watches were not allowed in the experimental room. The instructions were then reviewed and the session began. When the session was over, the subject was given a receipt which stated that she or he had earned up to one dollar for that session, and that all earnings would be paid at the end of the study.

The four sessions planned for each subject included (a) a training session, (b) a session of one versus two reinforcer sources as a within–session comparison, (c) a session with only one reinforcer source throughout as the first part of a between–session comparison, and (d) a session with two reinforcer sources throughout as the second and last part of the between–session comparison. Table 1 depicts the sequence of sessions received by each subject. Several abbreviations, which are used in the table as well as in later text, are introduced here: Subjects are designated by letters (AS through GS). The two different types of training sessions are represented by T1 and T2. The within–session comparison session is represented by W. The two sessions of the between–session comparison are represented by B1 (using one reinforcer source) and B2 (using two reinforcer sources). Subjects AS and BS also experienced two other sessions, represented by A1 and A2, that were part of another study that assessed one versus two reinforcer sources on variable ratio (VR) schedules (reported in Ledoux, 1982b). These sessions occurred after the T1 and W sessions, but before the B1 and B2 sessions.

Each session lasted about 40 minutes. Each subject was to participate in each of the four planned sessions on the basis of one session per day. However, due to scheduling concerns, two of the seven subjects had two of their sessions on the same day. Subject CS had the last two sessions (B1 and B2) on the same day, some hours apart, while subject GS had the first two sessions (T2 and B1) on the same day, back to back.

In addition to the separate cumulative records for each hand, data collection included recording the number of responses and reinforcements for each hand during each component pair, as well as the duration of each component pair. From these, response and reinforcement rates could be calculated for each hand under each component pair. (A component pair is a pair of schedules, one for each hand, in effect concurrently, that comprises one of six components in each session.)

Training sessions. The T1 training session had been originally designed for both an earlier study (Ledoux, 1982b) as well as for the present study, even though two VR schedules were among its component pairs. However, the initial response rates of early subjects showed too much variability, perhaps partly due to early fatigue for some subjects who were observed to press the keys at a high rate initially. The use of some of the panel lights as "pacing lights," along with the instructions regarding their use, in the training session was predicted to help decrease the variability of subjects' initial response rates. So the T2 training session was designed and successfully used with the pacing lights, and also, for the rest of the present study, without the VR schedules.

In T1 the single, central counter served as the reinforcer source throughout the session. The subject operated each hand alone, alternating with the other hand, with a 15 second time–out between schedules. At first each hand was under CRF for 1000 reinforcements, then each hand was under VR 5 for 200 reinforcements, and finally each hand was under VR 20 for 50 reinforcements.

In T2 the subject also operated each hand alone, alternating with the other hand after a 15 second time–out every 500 reinforcements. The illumination of one or the other key–connected light indicated which key—and thus which hand—to use. At first each hand worked while the pacing lights flashed every 0.4 of a second, with reinforcements accruing on the center counter. Then each hand worked without the pacing lights operating, and with the reinforcements still accruing on the center counter. Next each hand worked with the pacing lights again operating, but reinforcements accrued on the side counter associated with the key in use. Finally each hand again worked without the pacing lights operating, and with reinforcements still accruing on the side counter associated with the key in use.

Experimental sessions. Each of the three experimental sessions involved both hands being able to operate their respective keys at the same time throughout a sequence of six component pairs where one hand was on

Subject	Session Sequence					
	1	2	3	4	5	6
AS	T1*	W**	A1***	A2	B1	B2
BS	T1	W	A1	A2	B1	B2
CS	T1	W	B1	B2		
DS	T2	W	B1	B2		
ES	T2	W				
FS	T2	B1	B2			
GS	T2	B1	W	B2		

***** Different types of training sessions are represented by T1 and T2.
****** The within–session comparison session is represented by W.
******* The between–session comparison sessions are represented by A1 and A2, and by B1 and B2. (A1 and A2 are parts of another study; see text.)

Table 1. Sequence of sessions received by each subject.

CRF while the other hand was on either CRF or EXT. The component pairs were separated by a rest period (time–out) of 15 seconds duration. For all experimental sessions the rest period, and thus the change from one pair of schedules to the next, occurred as soon as one or the other hand had produced 1000 reinforcements. Table 2 depicts the number of reinforcement sources, and the sequence of component pairs, used in the three experimental sessions.

During the W session (the within–session comparison session) the first three component pairs used the single reinforcer source (i.e., the center counter). The remaining three component pairs were sequenced exactly as the first three but used the dual reinforcer sources (i.e., the side counters).

The B1 and B2 sessions (the between–session comparison sessions) followed a course similar to the course of the W session. During the B1 session (the first of the two sessions comprising the between–session comparison) the single reinforcer source of the center counter was used throughout the series of six concurrent component pairs. During the B2 session (the second of the two sessions comprising the between–session comparison) the dual reinforcer sources of the side counters were used throughout a repetition of the series of six concurrent component pairs used in the B1 session.

Results

The basic dependent variable in this study was the rate of response for each hand during each component pair. In general, while the response rate was high for the hand on CRF irrespective of the number of reinforcer sources, the rate was low for the hand on EXT under two separate sources but high for the hand on EXT under one source.

Session Type	Component Pair Sequence*		# of Reinforcer Sources per component pair
	Left Hand	Right Hand	
W Session (within–session comparison)	CRF	CRF	1**
	CRF	EXT	1
	EXT	CRF	1
	CRF	CRF	2***
	CRF	EXT	2
	EXT	CRF	2
B1 Session (first part of the between–session comparison)	CRF	CRF	1 (one source used throughout)**
	CRF	EXT	
	EXT	CRF	
	CRF	CRF	
	EXT	CRF	
	CRF	EXT	
B2 Session (last part of the between–session comparison)	All component pairs repeat B1 sequence.		2 (two sources used throughout)***

***** Read down for sequence of pairs.
****** "One source" always refers to the center counter/light.
******* "Two sources" always refers to the side counters/lights.

Table 2. Number of conditioned reinforcer sources, and sequences of component pairs, for within–session and between–session comparisons.

Figures 3, 4, 5, 6, and 7 show the left and right hand cumulative records for some subjects from each of the three experimental sessions. These examples are typical of the data of all the subjects. In these records, the cumulative recorder pens are not used the same way under both single–source and dual–source conditions. The pens are used in the usual manner under the two–source condition; the hatch marks of the response pen indicate reinforcements (making a thick black line, due to the CRF schedule) along the slope of the response line, while changes from one component pair to the next are noted by the offset or reset of the event pen across the bottom of each record. However, under the single–source condition, pen use is reversed with respect to reinforcer hatch marks and component–change marks; reinforcements are shown as hatch marks (again making a thick black line, due to the CRF schedule) but along the flat of the event pen line, while changes from one component pair to the next are noted by the offset or reset of the response pen on the slope of the response line.

A further reason for using the recorder pens in those ways is that, by doing so, the records could graphically depict whether or not reinforcements appeared on a source associated with the hand/key that produced those reinforcements. Under two sources the record shows each reinforcer hatch mark right on the pen step for the response that produced that reinforcer. However, under one source, while the reinforcer hatch marks still appear on the record of the hand that produced them (along the event pen line of that record) they do not appear with the actual responses that produced them. This is a way of showing that under one source the reinforcements appeared on a counter not physically associated with either key (the center counter), while under two sources each reinforcement does appear on a counter physically associated with one or the other key (the counter on the same side as the key that produced the reinforcement).

Figure 3 shows the left hand and right hand cumulative records for subjects BS and GS during the W session. The response rates are high and steady for each hand of both of these subjects under the single–source condition regardless of whether the contingency involves a CRF

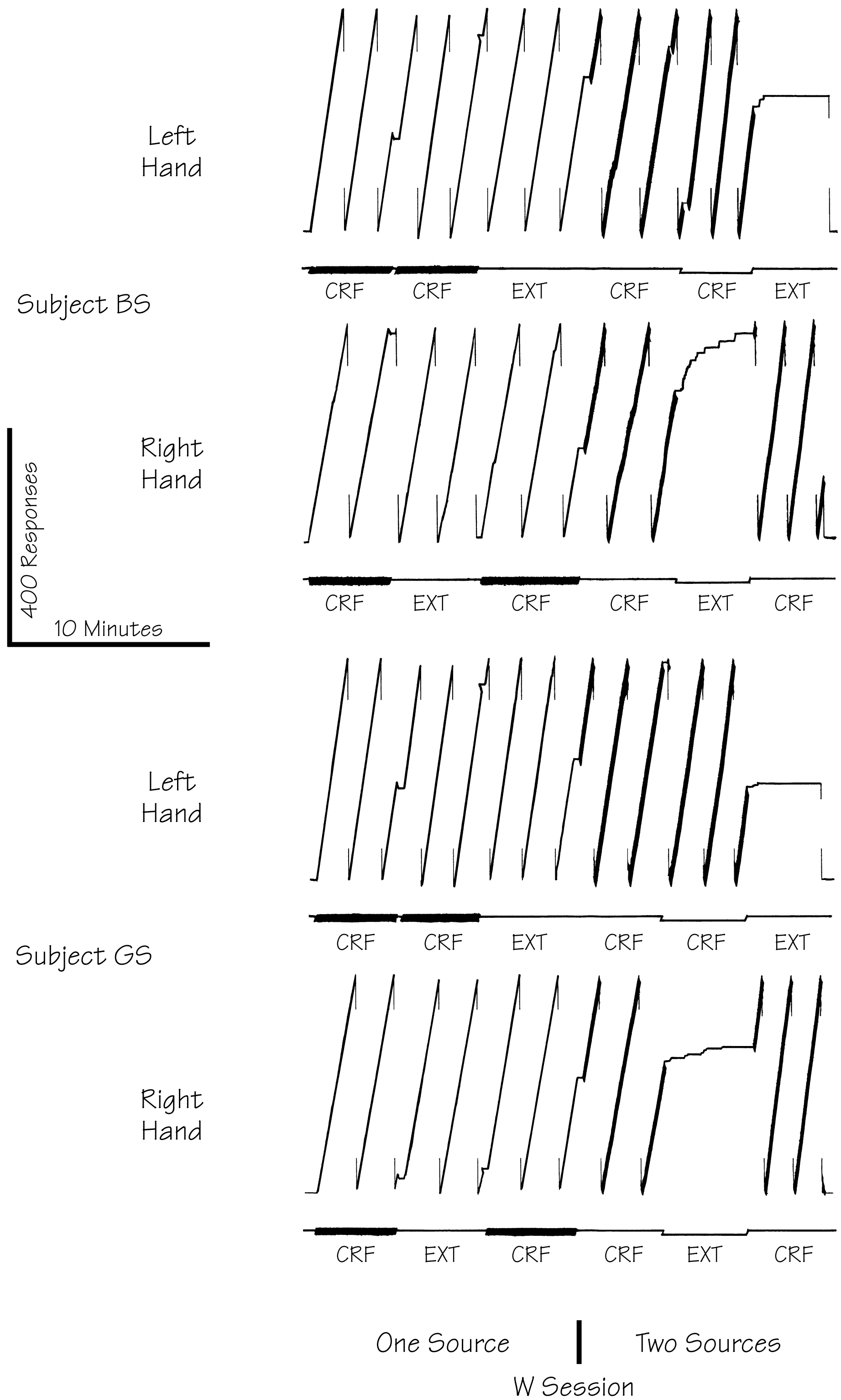

Figure 3. Cumulative records of left and right hand responding for subjects BS and GS during the within–session comparison session (W).

schedule or EXT. Under the dual–source condition, their response rates remain high and steady under CRF, and decrease to zero under EXT. The extinction curve of the right hand of BS under the dual–source condition, as aesthetic as it might be, is not typical of most other subjects. The right hand, dual–source extinction "curve" of GS is more typical of other subjects' "curves" under the first occurrence of a dual–source EXT contingency.

Figure 4 shows the left hand and right hand cumulative records for subjects ES and DS during the W session. For ES, rates under all CRF contingencies are high and steady. However, the initial single–source EXT contingency was effective in eliminating right hand responding. Yet in the next component, the EXT contingency on the left hand was ineffective, as shown by the persistence of a high and steady rate. Subject ES reported that responding did not begin in this component until after an extra minute or so of "rest" had been taken. Subject ES was the only subject who, after being affected by an EXT contingency under the single–source condition, was unaffected by that same contingency in the subsequent single–source CRF/EXT component in the same session. For subject DS the record shows a high and steady response rate under all CRF contingencies, as well as under the initial, single–source EXT contingency (on the right hand). However, under the remaining EXT contingencies, including the second single–source EXT contingency, responding is eliminated.

Figure 5 and Figure 6 show the left hand and right hand cumulative records for subjects GS and BS, respectively, during the B1 and B2 sessions. The response rates are high and steady for each hand of both of these subjects during the single–source B1 session irrespective of whether the contingency involves CRF or EXT. During the dual–source B2 session, their response rates remain high and steady under CRF, and decrease to zero under EXT. Although Figure 5 is too reduced to show it well, throughout all dual–source EXT contingencies, subject GS made a single testing–like response on the EXT key after each 100 points earned on the CRF key. No other subject displayed this type of pattern (a professor, examining this pattern, expressed the hope that this reality–testing student would apply for graduate school).

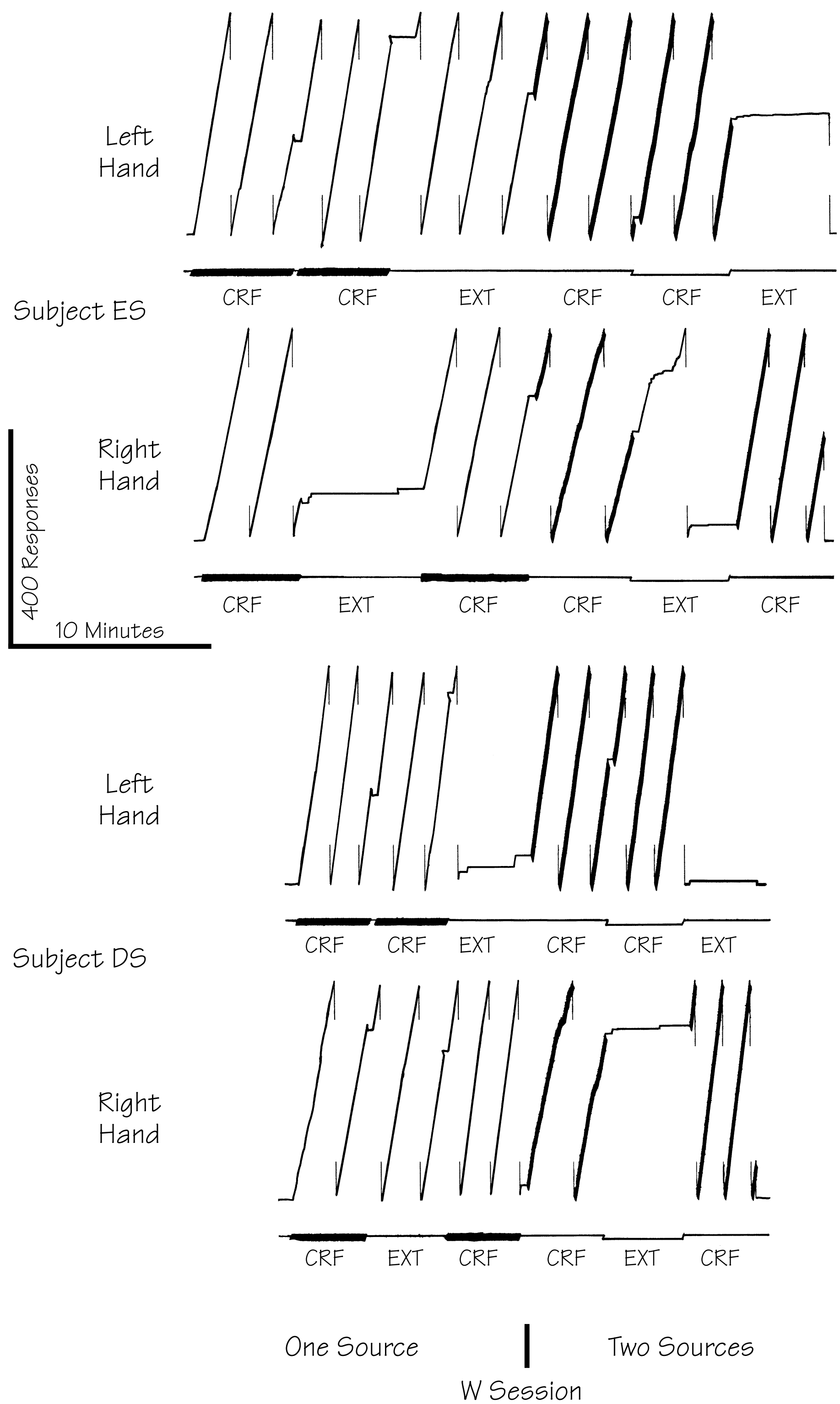

Figure 4. Cumulative records of left and right hand responding for subjects ES and DS during the within–session comparison session (W).

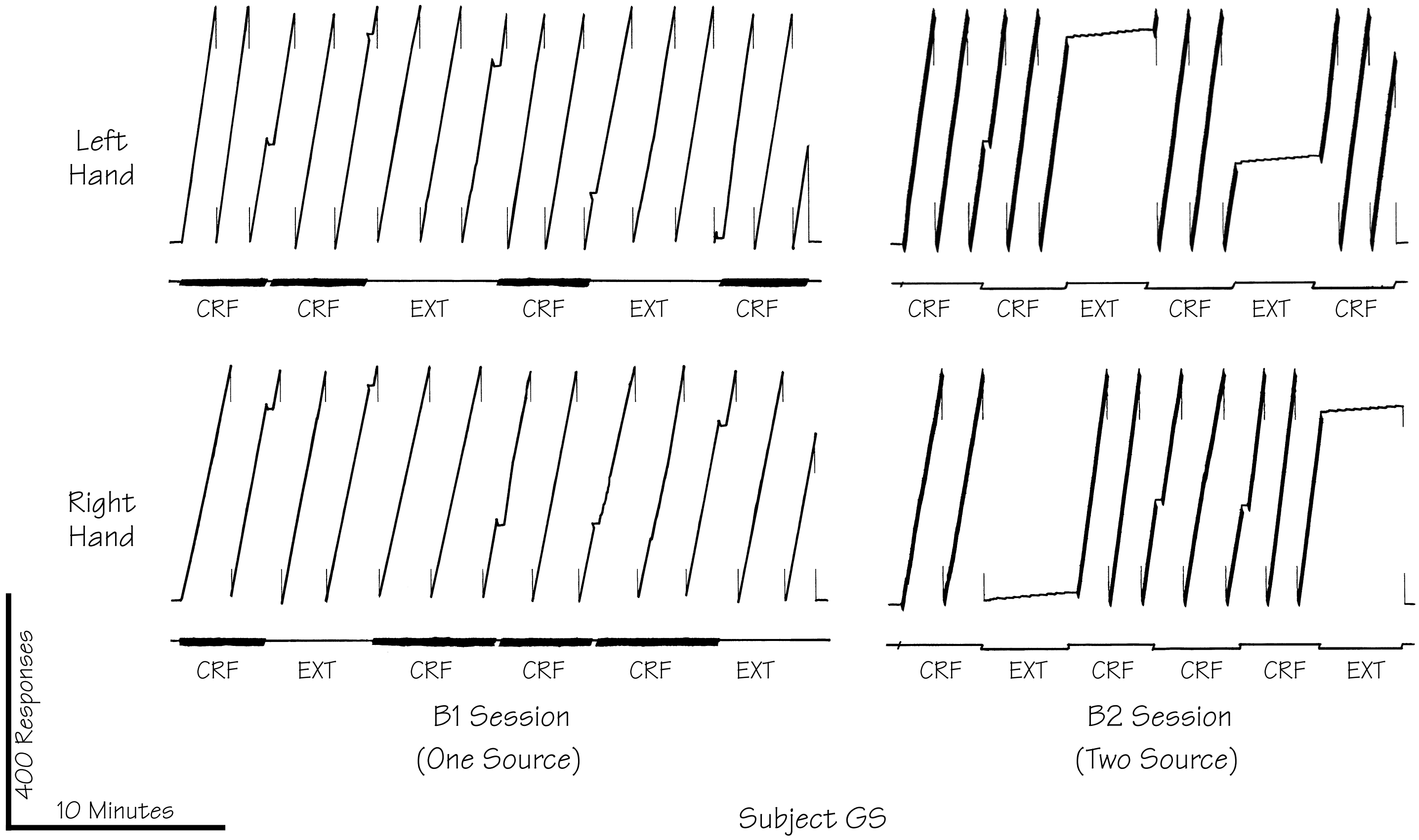

Figure 5. Cumulative records of left and right hand responding for subject GS during the between–session comparison sessions (B1 and B2).

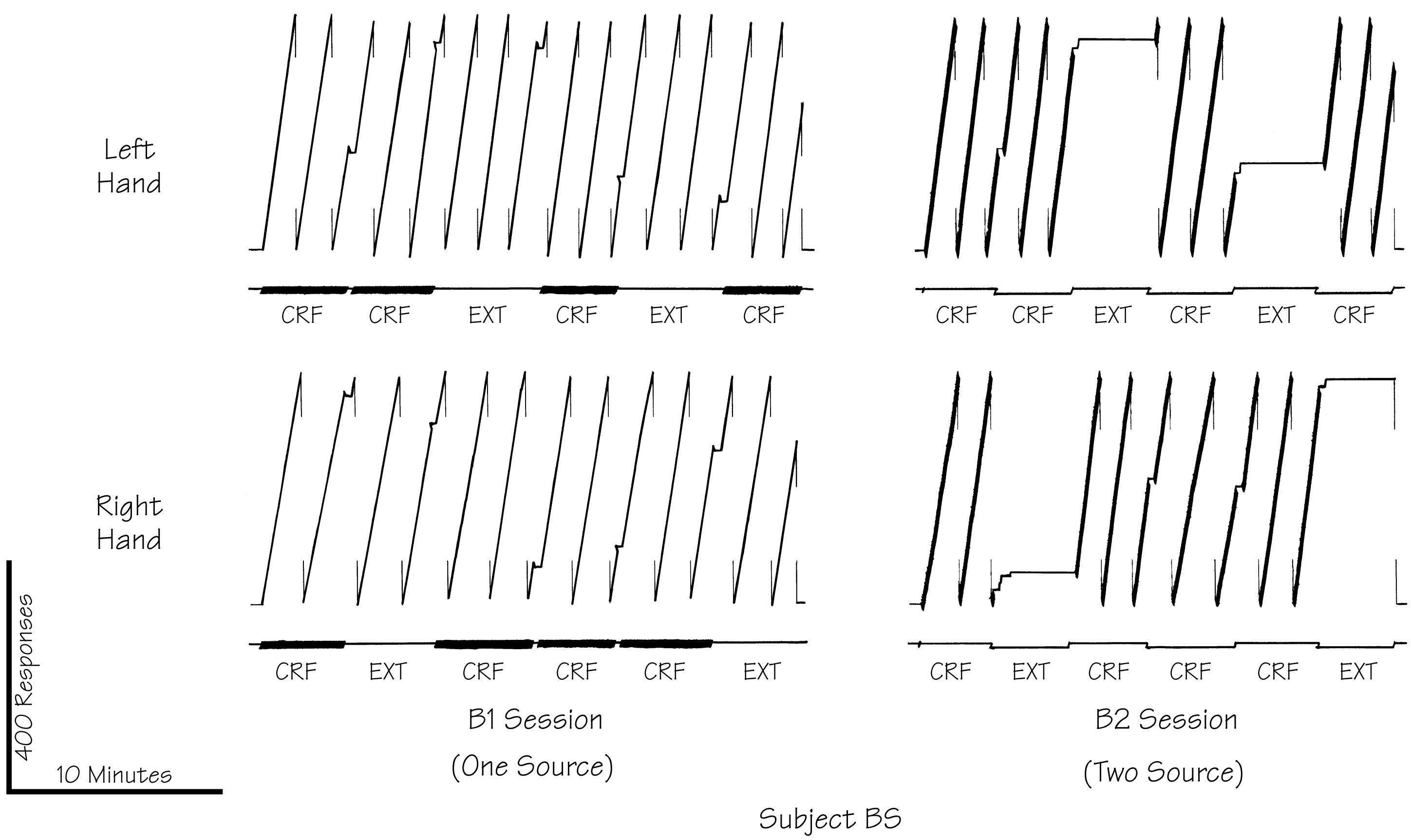

Figure 6. Cumulative records of left and right hand responding for subject BS during the between–session comparison sessions (B1 and B2).

Figure 7 shows the left hand and right hand cumulative records for subject DS during the B1 and B2 sessions. Regardless of whether the condition in effect is single–source or dual–sources, the response rates for both hands are high and steady under CRF. However, with the exception of one single–source EXT contingency, whenever a hand is under EXT, the response rate drops to zero. The one exception is the first single–source EXT contingency, on the right hand, where the response rate remains high and steady throughout. Also, more responding can be seen as having occurred at the beginning of the other EXT contingencies under the single–source condition before abruptly ceasing, than under the dual–source condition.

The data for subject DS is particularly relevant as it shows that some subjects do come under some control of EXT contingencies even in the single–reinforcer source condition. Yet for *all* subjects responding is eventually if not immediately eliminated by any EXT contingency under the dual–reinforcer source condition. This comparative result between the single–source condition and the dual–source condition is the most reliable, salient and significant result of the study.

An elaboration of the number of responses made in extinction, both during the W session and during the B1 and B2 sessions, allows further comparison between the single–source condition and the dual–source condition. Tables 3 and 4 list the actual number, for all subjects, of responses on keys that were programmed with an EXT contingency.

Table 3 depicts the number of responses in extinction for each subject during the W session. In this table, the reference to the conditions (single–source or dual–source) is a column heading.

Table 4 depicts the number of responses in extinction for each subject during the B1 and B2 sessions. However, in this table, the reference to the conditions (single–source or dual–source) is a row heading.

Comparisons between the single–source condition and the dual–source condition yield two basic observations. In most cases, *the number of responses made on the EXT key under the single–source condition is of the same magnitude as the number of responses made on the CRF key,* which had to be pressed 1000 times before the components would change. Where this is not the case, a glance at the single–source components of the cumulative record (or Tables 3 or 4) would reveal an example in which responding on the EXT key had ceased sometime during the single–source component. The W session data

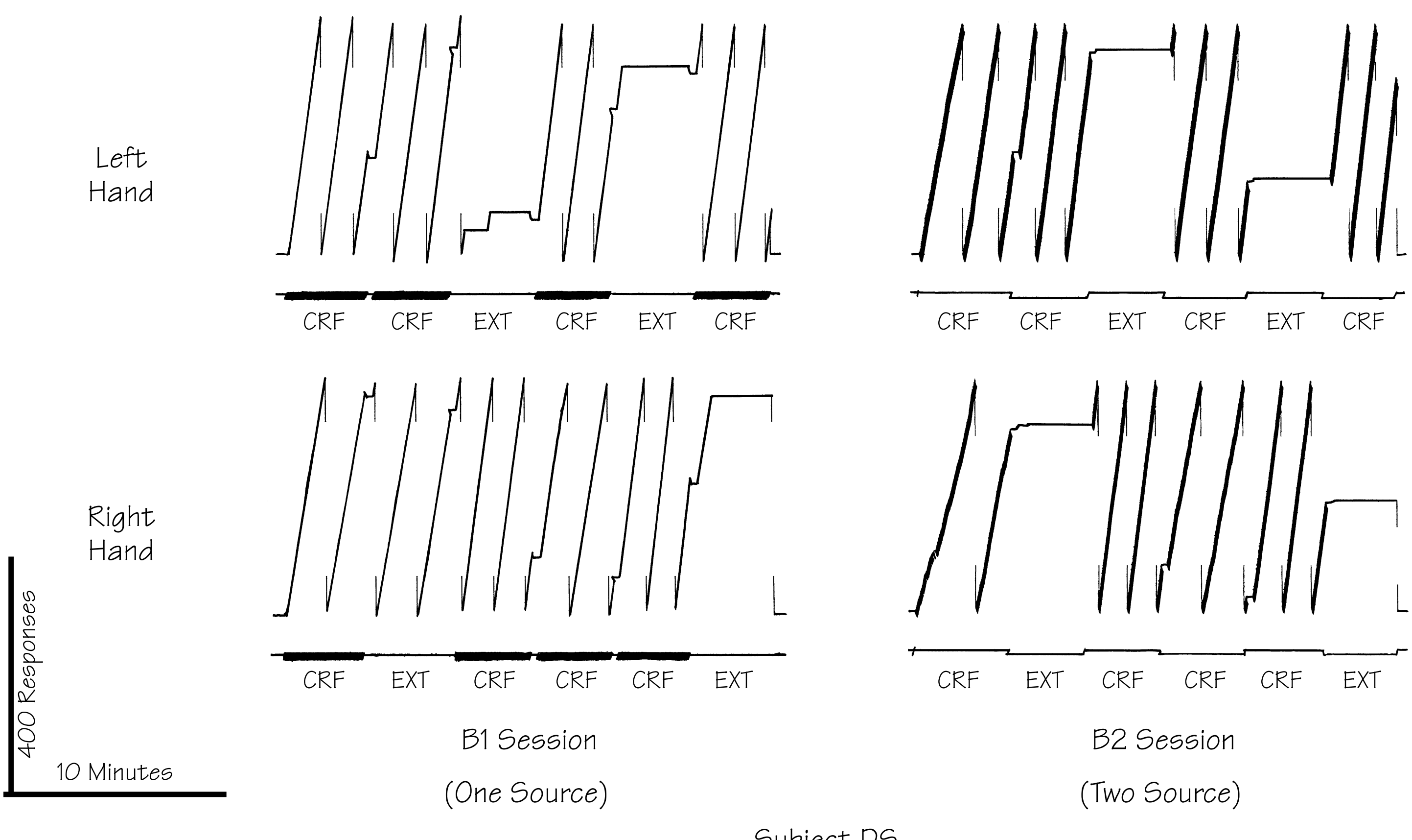

Figure 7. Cumulative records of left and right hand responding for subject DS during the between–session comparison sessions (B1 and B2).

show only two cases out of 12 possible cases where responding under a single source was sensitive to EXT. The B1 session data show only seven cases out of 24 possible cases that fit this description. All of these cases are marked with an asterisk in Tables 3 and 4. Contrast this information with the fact that *the number of responses made on the* EXT *key under the dual–source condition is always less than one–third of the 1000 responses required of the hand operating the* CRF *key to change components.* The cumulative records show responding on the EXT key under the dual–source condition to have always ceased during the component. In summary, under the single–source condition, subjects were sensitive to EXT in 9 of 36 cases; under the dual–source condition, they were sensitive in 36 of 36 cases (i.e., under the single source 27 of 36 cases were *in*sensitive to EXT, while under dual sources none of 36 cases were *in*sensitive to EXT).

Rate of response data corroborates number of response data. Table 5 presents rate of response data for each hand of each subject in each component of the W session. Table 6 presents rate of response data for each hand of each subject in each component of the B1 and B2 sessions. (For both tables, minutes were rounded to whole numbers.)

Discussion

This research addressed the question of how to obtain sensitivity to contingencies with multiple operant behaviors that are simultaneously emittable and simultaneously reinforceable. In this study the effectiveness of a single reinforcer source (a source that is shared by responses on two manipulanda) was compared with the effectiveness of dual reinforcer sources (sources that are each physically associated with a different response manipulandum). Multiple operants that simultaneously produced reinforcers from multiple sources, each physically associated with a different response manipulandum, showed no responding that could reasonably be labeled superstitious, while multiple operants that produced reinforcers from single, shared sources showed considerable superstitious responding. This was the case even though the single–source condition in this study had the greatest possible chance to control responding without superstitious effects due to the concurrent use of two schedules, CRF and EXT, that are maximally different in terms of the availability of reinforcement under each.

The data indicate that when human subjects' simultaneously emittable responses (here, key pressing) are simultaneously reinforceable under CRF and EXT contingencies, the operant under EXT is seldom sensitive to that contingency when the setting involves a single source of reinforcement not physically associated with any of the manipulanda. On the other hand, these subjects were always sensitive to the EXT contingency when the setting involved two sources of reinforcement, each physically associated with a different manipulandum. These results suggest, in comparison with the usual single source of reinforcement, that, for multiple operants, multiple sources of reinforcement are (a) more discriminable with respect to which response produced any particular reinforcer, and (b) more effective in generating sensitivity to the contingencies.

Facing Extinction–Contingency Sensitivity

However, the responding of three of the subjects in this study was sensitive to an EXT contingency under the single–source condition in one or more of the CRF/EXT

Subject	Sequence of extinction contingencies in the W session*: Single reinforcer source		Dual reinforcer sources	
	1st EXT	2nd EXT	3rd EXT	4th EXT
AS	973	1061	332	21
BS	843	1155	111	19
CS	918	978	10	6
DS	778	107**	14	3
ES	18**	1266	232	10
GS	842	1094	28	6

* Each row presents the data for *one* session.
** See text.

Table 3. Number of responses in extinction for all subjects during the within–session comparison session.

components in one or both of the sessions that involved single–sources. One subject (ES—see Figure 4) was sensitive to the EXT contingency in the first of the two CRF/EXT components in the first half of the W session. Another subject (DS—see Figures 4 and 7) was both (a) sensitive to the EXT contingency in the second of the two CRF/EXT components in the first half of the W session, and (b) sensitive to the EXT contingency in the second, third, and fourth (of four) CRF/EXT components in the BI session. The third subject (FS—see Table 4) was sensitive to the EXT contingency in all four of the CRF/EXT components in the BI session. In suggesting explanations for these occurrences, a number of factors can be considered; any of these may have operated singly or in combinations in any particular instance of EXT sensitivity.

One possible explanation of some of the instances of single–source effectiveness of an EXT contingency is the change in reinforcement density from one component pair to the next. When a CRF/CRF component is followed by a CRF/EXT component, a 50% reduction in reinforcement density for simultaneous responding occurs (as will be seen, this reduction may be irrelevant if responding is alternating rather than simultaneous). Although, under the single–source condition, all reinforcements accrue on the shared, center counter, this reduction may still have made the density in the CRF/EXT component discriminable (in the usual functional sense, not in any "agency" sense; see Baum, 1995 [Also, see Fraley, in press.—Ed.]) from the greater density of the preceding CRF/CRF component, ultimately resulting in the EXT contingency effectively controlling EXT key responding (eliminating that responding) for some subjects. The responding of subject ES (Figure 4) in the first single–source component of the W session, and subject DS (Figure 7) in the third single–source component of the BI session, and subject FS (Table 4) in the first and third single–source component of the BI session, provides examples of the possible effects of the reinforcement–density change.

The second single–source CRF/EXT component of the W session for subject ES, however, also needs explaining. In this component, the only remaining single–source CRF/EXT component in the W session, the already reduced reinforcement density remained the same, and EXT did not eliminate responding on the EXT key. (Even though such insensitivity is basically unsurprising, its occurrence after an EXT–sensitive CRF/EXT component is a curiosity demanding attention.) This component and the preceding component were identical *except for the reversal of the hand producing reinforcement.* Perhaps in this case the lack of sensitivity to extinction occurred due to a sequence effect. The reinforcement density on each key would have reversed, with one hand changing from every response being reinforced to none being reinforced, while the other hand changed from no responses being reinforced to every response being reinforced. However, all reinforcers continued to accrue only on the center, single source. The key on which responding in extinction occurred in this second CRF/EXT component was actually the key for the hand on which *the opposite con-*

Subject	# of Sources	Session*	Sequence of extinction contingencies in the B1 and B2 sessions: 1st EXT	2nd EXT	3rd EXT	4th EXT
AS	1	B1	839	1187	1215	814
AS	2	B2	71	80	67	61
BS	1	B1	768	1239	1204	848
BS	2	B2	31	14	17	12
CS	1	B1	841	985	861	933
CS	2	B2	7	9	8	2
DS	1	B1	786	139**	77**	151**
DS	2	B2	8	6	7	2
FS	1	B1	61**	17**	22**	8**
FS	2	B2	144	59	29	51
GS	1	B1	855	1448	1408	834
GS	2	B2	16	13	12	10

* Each row presents the data for *one* session (B1 or B2).

** See text.

Table 4. Number of responses in extinction for all subjects during the between–session comparison sessions.

tingency had produced all of the reinforcers—but on the center, single source—in the preceding component. The relevance of this possibility needs further research, and the matter is not considered to have been given an adequate account here.

Subject DS (Figures 4 and 7) and subject FS (Table 4) often differed from subject ES. The responding of both subject DS (in the second single–source CRF/EXT component of the W session and the second and fourth single–source CRF/EXT components of the BI session), and subject FS (in the second and fourth single–source CRF/EXT components of the BI session), provides examples in which a single–source EXT contingency *was* effective in a CRF/EXT component that was preceded by a CRF/EXT component, regardless of whether or not the EXT contingency had been effective in that preceding component. The explanation of these subjects' responding being sensitive to the EXT contingency under most single–source CRF/EXT components is incomplete. It may involve yet another possible explanation of single–source effectiveness of an EXT contingency. This explanation concerns some subjective observations. Those subjects who were sensitive to single–source EXT contingencies (e.g., subject FS) were often observed to emit pressing responses on the two keys in a noticeably alternating pattern—first one hand, then the other hand, then the one hand, and so on—that made their responses sequential and successive rather than simultaneous (potential reasons offered by subjects for this pattern included keeping time with hummed music and avoiding fatigue). However, those subjects who were *not* sensitive to single–source EXT contingencies (e.g., subjects BS and GS) were observed to emit pressing responses in a simultaneous pattern, each hand pressing its key essentially at the same time as the other hand, rather than sequentially. Is this an observation of a functional relationship? This question needs to be researched, although generating response succession (e.g., through CODs) is a standard practice for reducing concurrent superstition even though it eliminates response simultaneity.

In studying that question the effect of equipment functioning on response patterns needs to be considered. Due to the constraints of computer functioning and logic, no two responses could be *measured* as simultaneous. They could, however, still be considered functionally simultaneous; for instance, they could occur during the same clock tick (on the order of one to five nanoseconds). Yet even if they actually occurred simultaneously, the computer necessarily dealt with them in a sequential manner, according to state table priority rules. In essence, any pair of actually or functionally simultaneous responses had an artifactual, enforced delay (a sort of minimal COD).

That delay did not seem to play any noticeable part in the contingencies. Subjects who were observed to respond "simultaneously" (i.e., whose responding approximated the artifactual delay) were not sensitive to single–source EXT contingencies. On the other hand subjects who were observed to respond "sequentially" (i.e.,

Subject	Component pairs in the W session											
	Single–source condition						Dual–source condition					
	CRF-LH	CRF-RH	CRF-LH	EXT-RH	EXT-LH	CRF-RH	CRF-LH	CRF-RH	CRF-LH	EXT-RH	EXT-LH	CRF-RH
AS	219	181	207	201	225	212	239	238	226	75	6	266
BS	269	217	274	231	250	217	236	218	379	36	6	316
CS	267	266	275	252	283	289	285	233	287	3	2	314
DS	295	217	299	232	32	296	276	192	305	4	1	322
ES	216	194	238	4	226	178	217	162	235	55	2	235
GS	267	229	278	234	272	248	259	223	279	8	2	315

Table 5. Each hand's number of responses per minute in *each component* of the W session for *each subject*.

whose responding contained delays, between the alternating responses in any pair of responses, that were considerably longer than the artifactual delay, possibly on the order of 0.1 to 0.5 seconds) were sensitive to single–source EXT contingencies. A parametric study to assess the effects of very short CODs (0.001 to 1.0 seconds) may determine a minimal COD duration at which one reinforcer source *can* be effective in generating sensitivity to contingencies with simultaneously reinforceable responses. The important point for the present study, however, is that the two–source procedure was *always* effective in controlling responding, regardless of whether the subjects emitted sequential or simultaneous responses. While previously no procedure seemed adequate to the task, the two–source procedure enables the further study of simultaneous operants.

One additional curiosity should be mentioned. While the EXT key responding of subject DS was superstitious in the first single–source CRF/EXT component in the W session, it did extinguish under the EXT contingency in the second and only remaining single–source CRF/EXT component in this session. At the later BI session, responding on the EXT key again occurred in the first single–source CRF/EXT component (although in all other CRF/EXT components in this session, EXT key responding extinguished). This *reappearance* of responding under EXT in the first single–source CRF/EXT component in the later BI session is an example reminiscent of spontaneous recovery. This possibility also needs further research.

Under the single–source condition, no surprise occurs when EXT key responding is insensitive to the EXT contingency, though some related circumstances can arouse further curiosity. The potential explanations for EXT key responding being sensitive to an EXT contingency under the single–source condition can be summarized. (a) When a CRF/CRF component was followed by a CRF/EXT component in which EXT–key responding was sensitive to EXT, one possibly responsible factor may have been the reduction in reinforcement density. (b) When a CRF/EXT component, in which EXT–key responding was sensitive to EXT, was followed by another CRF/EXT component in which EXT–key responding was not sensitive to EXT, one possibly responsible factor (though such insensitivity is basically unsurprising) may have been a sequence effect. And (c) when a CRF/EXT component, regard-

Subject / # of / Session / Sources /			Component pairs in the B1 and B2 sessions											
			CRF-LH	CRF-RH	CRF-LH	EXT-RH	EXT-LH	CRF-RH	CRF-LH	CRF-RH	EXT-LH	CRF-RH	CRF-LH	EXT-RH
AS	1	B1	220	167	235	197	251	212	143	247	222	183	241	196
AS	2	B2	282	234	274	19	23	288	264	225	20	302	280	17
BS	1	B1	269	211	285	219	297	239	305	261	293	243	301	255
BS	2	B2	316	272	323	10	4	318	287	232	5	298	320	4
CS	1	B1	310	239	311	262	269	273	304	245	254	295	284	265
CS	2	B2	273	241	274	2	3	296	282	181	2	300	294	1
DS	1	B1	287	267	301	237	44	314	317	246	25	321	310	47
DS	2	B2	244	178	316	3	2	327	293	224	2	319	343	1
FS	1	B1	273	245	231	20	6	344	312	267	8	373	331	3
FS	2	B2	257	221	317	46	20	341	314	288	10	329	324	17
GS	1	B1	268	201	245	209	282	195	251	204	274	194	268	224
GS	2	B2	282	235	294	5	4	306	286	234	4	310	307	3

Table 6. Each hand's number of responses per minute in *each* component of the B1 and B2 sessions for *each subject*.

less of whether EXT–key responding was sensitive to EXT or not, was followed by another CRF/EXT component in which EXT–key responding was sensitive to EXT, one possibly responsible factor may have involved responses being emitted in a distinctly alternating, sequential manner rather than simultaneously. These and other factors, such as the possible occurrence of some sort of spontaneous recovery, deserve further investigation.

Other Considerations and Improvements

During the study a number of other factors had the potential to affect the results. These factors included (a) the subjects' age, sex, and handedness, (b) the two different types of training sessions, (c) the occurrence of the extra sessions involving VR schedules for another study, (d) the occurrence, for some subjects, of two sessions on the same day, and (e) the occurrence, for one subject, of the W session between the B1 and B2 sessions. While these factors were not explicitly assessed for their effects, no aspect of the data seemed to be systematically related to any of them.

Overall, the dual reinforcer source procedure used here makes the study of simultaneously reinforceable operants viable by generating adequate schedule–effect independence—and thereby limiting the concurrent superstition commonly present when only one reinforcer source is used—without, by definition, requiring response succession. Consequently, a whole category of complex behavior, the category of simultaneously emittable, simultaneously selectable operants, is opened to more effective study.

Some improvements that would facilitate further research must be mentioned. Two of these concern the manipulanda and the point counters used in the present study. Manipulanda that are more controllable than telegraph keys would be preferred. The resulting capability of precisely adjusting the response requirement, in terms of both force and duration, would enhance the resolution of both the experimenter's control of the variables and the analysis of the results. Similar advantages would accrue from the use of digital, or computer generated and displayed, counters whose speed and accuracy are greater than the electro–mechanical counters used in this study.

The problem with the use of electro–mechanical counters was that they required an electrical impulse a full tenth of a second in duration to guarantee their consistent operation. This was quite slow and raised the possibility of some reinforcers being skipped during high rate response bursts. The state table avoided this by counting reinforceable responses in a variable and decrementing that variable for each delivered reinforcer. This was cumbersome for two reasons. First, delays became possible between a response and the occurrence of the reinforcer it produced; while these were extremely short, they were nonetheless longer than the virtually instantaneous changes normally expected from computer–controlled equipment. Secondly, the necessity of this state–table technique (caused by using the available but old electro–mechanical counters) put constraints on the types of parametric manipulations that could be made, especially with regard to reinforcement parameters (e.g., reinforcer magnitude). Fortunately, the primary concerns of this study were molar in nature and so showed no problematic effects from these equipment limitations. More molecular and necessary experimental analyses will not likely be as fortunate, and so should be undertaken only with more appropriate equipment.

Another class of independent variables, relevant to both the present study and future studies, concerns subjects. Humans typically bring to experiments verbal repertoires and differential histories with respect to both instructions and "self–instructions" (rules and rule–governed, or verbally–mediated, behavior). The latter may be especially relevant to the present study to the extent that it bears on functional relations. A subject might behave differently depending on his or her history regarding verbal rules and self–instructions particularly with respect to experience with the workings of equipment such as might comprise experimental apparatus. For instance, a history that results in a subject stating to herself or himself that "equipment either works or doesn't work" could predispose that subject to continue pressing both keys under one reinforcer source in spite of a change from CRF on *both* keys to EXT on one key. The present study held instructions consistent across conditions; it did not apply any other control procedure with respect to any aspect of subject history.

Instructions and history variables would also be likely to generate behavior that differs from the behavior other animals might emit under the same contingencies. One aspect of the data, while not relevant to the overall conclusions of the present study, implies that those variables may indeed have been operating. Different subjects showed different response patterns in extinction. Only one subject showed an extinction curve similar to those typically generated by other animal subjects; this was subject BS (see the right hand record in Figure 3). Another subject made simple testing–like responses on the EXT key after each 100 points, or so, was earned on the CRF key; this was subject GS (see the B2 session records in Figure 5). After a burst of responses under the EXT contingency, the other subjects were more likely simply to stop EXT key responding completely, with virtually no "curve" at all (although each pattern is slightly different). On a speculative level, it may be possible that these different types of extinction curves are due to the different and unanalyzed verbal repertoires and histories that the subjects brought to the study.

Due to those possibilities caution would be appropriate in considering the extension of the multiple reinforcer source procedure to non–human subjects. The extent to which the present data are a function of the verbal repertoires and instructional and rule–stating/following histories of human subjects rather than a function of more basic processes has yet to be determined.

The consistency of results between the within–session and the between–session comparisons suggests that the use of both may be unnecessarily redundant. However, retaining both types of sessions for each subject provides a source and crosscheck for clues to understanding whatever is discovered in the data. Additional sessions with each subject, either under the same controlling variables, or under different ones (providing data on history effects), can only benefit the fine–tuning and further use of the multi–reinforcer source procedure in the study of complex, especially human, behavior.

Later data may show that the results reported here are typical of performances only early in the subject's exposure to the contingencies. Given more time, stable, *sensitive* responding might occur even under the single–source condition (though one would still have to ask: Why then and not earlier?). The relevant questions, though, are still these: Which generates more sensitivity to contingencies, the single–source condition or the multiple source condition? And which of these conditions is more analogous to the contingencies experienced in everyday reality? Only more research will tell.

Conclusion

Complex human behavior involves both simultaneous and sequential/alternating response patterns, and both need attention from researchers. Even though simultaneous responses may be more resistant to analysis, they may also more accurately characterize reality. The multiple reinforcer source procedure reported here may make possible a research project that replicates basic research on fundamental operant processes by extending the study of these processes to more complex, multiple operants. Such a research project can be a systematic and purely inductive investigation and cataloging of what happens when various basic contingencies include complex behaviors.

Before developing that kind of project, replication of the present study is needed. This replication should include both variations in the number of selector sources, and other factors (e.g., different rest periods—or none—between the component pairs in a session, other types of selectors, additional sessions that run dual/multiple sources first instead of single sources first, variations in instructions, and variations in contingencies—since sensitivity to the maximally different contingencies of CRF and EXT is no guarantee that sensitivity will hold under contingencies that are more similar). If that replication shows the multiple reinforcer source procedure to be reliable, then this procedure might evolve into a more general *multiple selector source procedure,* and additional variables can be investigated, singly or in combination. The investigation of some of these variables will benefit from the continued comparison of single and multiple selector sources; other variables may be addressed adequately with only multiple sources. Many antecedent and postcedent variables are worthy of study including (a) establishing operations, (b) stimulus discrimination, (c) generalization, (d) reinforcement schedules, (e) punishment control, (f) schedule–induced effects, (g) competing selectors (e.g., reinforcers and/or punishers of different magnitudes), and (h) multiple or varying selectors (sometimes the same type and sometimes different) for each separate, simultaneously emittable operant.

Most of those additional variables would be worthy of study both with and without the presence of discriminative stimuli in the contingencies. With some of those additional variables various selector parameters can also be researched. Such parameters could include added and subtracted (see Ledoux, 1997b) reinforcers and punishers, and primary and secondary reinforcers and punishers, as well as the latency, duration, and magnitude (a) of one or more reinforcers and punishers, and (b) of one or more response topographies. And any or all additional variables can be studied, for instance, (a) with and without instructions or variations in instructions, (b) with three or more, rather than two, simultaneously emittable responses, (c) with response–independent selectors (e.g., playing back non–contingently what the subject just produced contingently), and/or (d) with and without known or provided or (with younger subjects) short histories.

To answer those questions could take several decades (probably more) of work by many researchers. Additional, more complex or more detailed questions, worthy of attention from candidates or holders of M.A. and Ph.D. degrees, will undoubtedly arise from the data of the basic studies, as they have even from the present study.

A research project of this type can also provide a level of research effort that is especially suited to the training of behaviorological scientists by involving undergraduate as well as more advanced students and experienced researchers. The conceptual and technological levels of the basic research program are well within the reach of undergraduate students who are training in behaviorological science. Undergraduates in particular can benefit from participation in this research. They could experience early in their training (a) the requirements of study, patience, and careful planning, (b) the thrill of discovery when their efforts answer research questions, (c) the satisfaction of making an original contribution to a growing body of knowledge about complex, especially human, behaviors, and (d) the further satisfaction when they find ways to apply those answers to concerns in the world at large. These are educational consequences valuable to both the student/researcher and the culture at large, expecially since simultaneous responses and multiple selector sources may characterize notable portions of reality and so should be thoroughly analyzed.

At this point, one cannot predict what important discoveries await research expansion into the effects of simultaneous selectors on simultaneously emittable multiple operants. One can reasonably predict, based on the beneficial results that have come from previous basic behaviorological research efforts, that beneficial results will also accrue from the research proposed here. ❧

Endnotes

Parts of this work were presented at the eighth annual convention of the Association for Behavior Analysis in Milwaukee, WI, May 1982, and at the ninth annual convention of the Association for Behavior Analysis in Milwaukee, WI, May 1983, and at the fifth annual convention of The International behaviorology Association in Little Compton, RI, March 1993. The paper was then revised for inclusion in *Origins and Components of Behaviorology* (Ledoux, S.F. [1997]. Canton, NY: ABCs.).

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References

Allison, T.S. & Lloyd, K.E. (1971). Concurrent schedules of reinforcement: Effects of gradual and abrupt increases in changeover delay. *Journal of the Experimental Analysis of Behavior, 16,* 67–74.

Baum, W.M. (1995). Radical behaviorism and the concept of agency. *Behaviorology, 3* (1), 93–106.

Bruner, A. & Revusky, S.H. (1961). Collateral behavior in humans. *Journal of the Experimental Analysis of Behavior, 4,* 349–350.

Catania, A.C. (1966). Concurrent operants. In W.K. Honig (Ed.). *Operant Behavior* (pp. 213–269). New York: Appleton–Century–Crofts.

Catania, A.C. & Cutts, D. (1963). Experimental control of superstitious responding in humans. *Journal of the Experimental Analysis of Behavior, 6,* 203–208.

Fantino, E., Squires, N., Delbruck, N., & Peterson, C. (1972). Choice behavior and the accessibility of the reinforcer. *Journal of the Experimental Analysis of Behavior, 18,* 35–44.

Ferster, C.B. (1957). Concurrent schedules of reinforcement in the Chimpanzee. *Science, 125,* 1090–1091.

Ferster, C.B. (1959). A complex concurrent schedule of reinforcement. *Journal of the Experimental Analysis of Behavior, 2,* 65–80.

Ferster, C.B. & Skinner, B.F. (1957). *Schedules of Reinforcement.* New York: Appleton–Century–Crofts.

Findley, J.D. (1958). Preference and switching under concurrent scheduling. *Journal of the Experimental Analysis of Behavior, 1,* 123–144.

Fraley, L.E. (2008). *General Behaviorology: The Natural Science of Human Behavior.* Canton, NY: ABCs. [Excerpts from later chapters of this 30–chapter book have appeared regularly in the pages of this journal, beginning with the Fall 2003 issue: volume 6, number 2.—Ed.]

Fraley, L.E. & Ledoux, S.F. (1997/2002) Origins, status, and mission of behaviorology. In S.F. Ledoux. (2002). *Origins and Components of Behaviorology—Second Edition* (pp. 33–169). Canton, NY: ABCs. Reprinted (2006−2008) in five parts in *Behaviorology Today:* Chs. 1 & 2: *9* (2), 13–32. Ch. 3: *10* (1), 15–25. Ch. 4: *10* (2), 9–33. Ch. 5: *11* (1), 3–30. Chs. 6 & 7: *11* (2), 3–17.

Harrison, J.M. (1979). The control of responding by sounds: Unusual effect of reinforcement. *Journal of the Experimental Analysis of Behavior, 32,* 167–181.

Hearst, E. (1961). Effects of d–amphetamine on behavior reinforced by food and water. *Psychological Reports, 8,* 301–309.

Glenn, S.S. & Madden, G.J. (1995). Units of interaction, evolution, and replication: Organic and behavioral parallels. *The Behavior Analyst, 18,* 237–251.

Lane, H. (1961). Operant control of vocalizing in the chicken. *Journal of the Experimental Analysis of Behavior, 4,* 171–177.

Ledoux, S.F. (1982a). *Control of Simultaneously Reinforceable Concurrent Human Operants by a Multiple Reinforcer–Source Procedure.* Doctoral dissertation, Western Michigan University, Kalamazoo. Reprinted, with extensive revisions, as "Multiple selectors in the control of simultaneously emittable responses" in (1997/2002) S.F. Ledoux. *Origins and Components of Behaviorology—Second Edition* (pp. 205–241). Canton, NY: ABCs.

Ledoux, S.F. (1982b, May). A procedure to control simultaneous concurrent human operants. Report presented at the eighth annual convention of the Association for Behavior Analysis, Milwaukee, WI.

Ledoux, S.F. (1997a/2002). An introduction to the origins, status, and mission of behaviorology: An established science with developed applications and a new name. In S.F. Ledoux. (2002). *Origins and Components of Behaviorology—Second Edition* (pp. 3–24). Canton, NY: ABCs. Reprinted (2004) in *Behaviorology Today, 7* (1), 27–41.

Ledoux, S.F. (1997b/2002). Increasing tact control and student comprehension through such new postcedent terms as added and subtracted reinforcers and punishers. In S.F. Ledoux. (2002). *Origins and Components of Behaviorology—Second Edition* (pp. 199–204). Canton, NY: ABCs. Reprinted (2010) in *Behaviorology Today, 13* (1), 3–6.

Pliskoff, S.S. (1971). Effects of symmetrical and asymmetrical changeover delays on concurrent performances. *Journal of the Experimental Analysis of Behavior, 16,* 249–256.

Segal, E.F. (1961). Behavioral interactions under concurrent spaced–responding, variable–interval schedules of reinforcement. *Journal of the Experimental Analysis of Behavior, 4,* 263–266.

Sidman, M. (1958). By–products of aversive control. *Journal of the Experimental Analysis of Behavior, 1,* 265–280.

Sidman, M. (1994). *Equivalence Relations and Behavior: A Research Story.* Boston, MA: Authors Cooperative.

Skinner, B.F. (1976). Farewell, my LOVELY! *Journal of the Experimental Analysis of Behavior, 25,* 218.

Snapper, A.G. & Inglis, G.B. (1978). *The SKED Software System: SUPERSKED.* Kalamazoo, MI: The SKED Users Group.

Staddon, J.F.R. & Simmelhag, B. (1971). The superstition experiment: A re–examination of its implications for the principles of adaptive behavior. *Psychological Review, 78,* 3–43.

Striefel, S. (1972). Timeout and concurrent fixed–ratio schedules with human subjects. *Journal of the Experimental Analysis of Behavior, 17,* 213–219.

Stubbs, D.A. & Pliskoff, S.S. (1969). Concurrent responding with fixed relative rate of reinforcement. *Journal of the Experimental Analysis of Behavior, 12,* 887–895.

Vargas, E.A. (1985). The ABP noncontingency: A reply to "The ABP contingency." *The Behavior Analyst, 8,* 131–132.

Quoted

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[This quote originated as the only footnote, and its source, in Chapter 10 of the author's *General Behaviorology* book (see Fraley, L.E. [2008]. *General Behaviorology: The Natural Science of Human Behavior* [p. 338]. Canton, NY: ABCs.). That chapter, on graphs and graphing technique, needed a footnote when pointing out the usefulness of a battery of coordinated graphs. The responses at the end of this footnote—which are relevant to one of the major objectives of the book—have applications in contexts far wider than just this chapter; for this reason the footnote and its source are quoted here.—Ed.]

… *I*t proves easier to tease out the interrelations among the variables when different kinds of data are graphed in this time–coordinated way.[1] … This example illustrates that coordinated graphs afford a more complete and comprehensive analytical profile of the situation under investigation by making relations among different dependent variables easier to see. Behaviorologically, we would say that the presentation of such an arrangement of graphic stimuli, which makes relations among various dependent variables more salient, facilitates those relations acquiring functional control over certain critical neural body parts of the viewer.

[1] The reader will note that the text in this chapter, like that in others, is stylistically written in a combination of (a) common agential language and (b) language crafted to reflect the naturalistic behaviorological perspective. The agential language is comfortably familiar to most readers, and its appearances represent a compromise that facilitates reading behavior at the expense of technical correctness. The agential language typically appears in passages where, if uncritically accepted, it may not perplex the reader. On the other hand, to the extent that its appearances begin to evoke the critical attention of the reader, the book is succeeding in one of its major objectives. For instance, those who may be annoyed by the expressed implication that interrelations revealed in a set of coordinated graphs are "teased out" by some kind of proactive environment–appreciating agent within the viewer are to be congratulated on their maturing scientific sensitivity. They may also enjoy exercising those powers on the preceding acknowledgment of their achievement, and then, in turn, on this invitation to do so.