To the Graduate Council:

I am submitting herewith a dissertation written by Kenneth Martin Steele entitled "Quasi-reinforcement and Behavioral Contrast." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Psychology.

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John C. Malone, Jr., Major Professor

We have read this dissertation and recommend its acceptance:

Accepted for the Council:

Vice Provost
and Dean of The Graduate School

QUASI-REINFORCEMENT AND BEHAVIORAL CONTRAST

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Kenneth Martin Steele

June 1985

ACKNOWLEDGMENTS

Any large project is not accomplished alone. It gives me pleasure to acknowledge here the contributions of others toward this work. I thank first the chairman of my committee, John C. Malone, Jr. Mentor, the adviser of Odysseus, has come to symbolize the wise and faithful counselor. John's influence can be described only in a similar fashion. I thank the members of my committee, William Calhoun, Neil Greenberg, and Howard Pollio, for their prompt consideration and helpful comments on this work.

I thank Carlene Malone for her preparation of the final figures. With good humor, she accurately completed the over 100 segments necessary for the finished products. I thank several friends and colleagues who have contributed insights over the years. These include Greg Barker, Bruce Batts, Alice Gordon, Jay Gill, Henry Molina, and David Rowe. In particular, I thank my fellow lab-dweller, Larry Crawford. Graduate school would have been a much duller experience without his presence.

I thank my parents, Robert M. and Lou P. Steele. The work here would never have been done without their love and support over the years. I thank my wife, Robin Hunt. She had to endure the life of a graduate student without its official compensations. To these three, I give my greatest thanks.

ABSTRACT

The quasi-reinforcement effect occurs when a stimulus, produced in the same manner as a current reinforcer, produces a reinforcement effect. The effect is of interest since the quasi-reinforcer is explicitly nonpaired with the current reinforcer. The traditional account of acquired or "conditioned" reinforcement is based on close spatio-temporal pairing of a stimulus with a current reinforcer. Hence, the effect suggests an alternative account of the genesis of acquired reinforcement.

The procedure to produce the quasi-reinforcement effect is one member of a class termed second-order reinforcement schedules. The common view of second-order schedule reinforcement effects is that the contingent event functions not as a genuine reinforcer but produces discriminative effects on performance that only resemble reinforcement.

The specific purpose of the present experiments was to provide a test that would differentiate between these two views: the quasi-reinforcer as a reinforcer versus only a discriminative signal. It was proposed that, if the quasi-reinforcer was a reinforcer, then it should show other functional properties of reinforcers beyond its immediate control of the temporal pattern of responding. These experiments examined whether the manipulation of the presence of a quasi-reinforcer in a multiple schedule would

produce positive behavioral contrast, an effect often found, for example, with changes in the rate of food-reinforcement.

The results showed that the quasi-reinforcer did produce positive behavioral contrast effects. Contrast effects were obtained with two types of response requirements. This showed that the results were not dependent upon a particular response requirement. An experiment showed that it was the second-order schedule relationship between the quasi-reinforcer and food that was critical to the effects. Neither reinforcement nor positive behavioral contrast effects were obtained with a conjoint reinforcement schedule, which provided both the same quasi-reinforcer and food at the same rate but lacking the second-order relationship. Another experiment manipulated food rate. The results showed the same pattern of contrast effects as occurred with the quasi-reinforcer alone.

The results were consistent with the view that the quasi-reinforcer functioned as a genuine reinforcer. The general significance of the pigeon's sensitivity to the differences in these complex schedule relationships was emphasized in the discussion.

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INTRODUCTION

Reinforcement is said to have occurred when the probability or rate of a response increases following the introduction of some event contingent upon that response (e.g., Skinner, 1938). This observation that the consequences of an act influence its future probability is a pervasive principle in the description of living beings and, rightfully, has become of major importance in psychology. Because of the form and historical context of the most well-known introduction of this observation into psychology, both research and theory on the conditions characterizing reinforcement were prematurely constrained. In particular, certain assumptions were made about the basis of the reinforcement effect in order to use the effect as an explanatory construct. The first part of the introduction will briefly recount this history. This will be followed by a more detailed discussion of recent research which illustrates the change in approach to the topic and provides the basis for the research reported here.

A Brief History of the Reinforcement Concept

The work of E. L. Thorndike provides a convenient and important starting place. Thorndike's monograph (1898) was an analysis of "the nature of the process of association in the animal mind"; and was done within the context of a popular interpretation of the

implication of Darwin's theory of evolution via inherited variation and natural selection. The argument at that time was that Darwin had demonstrated that there was physical continuity among species. Since humans have a "mental life," the argument for continuity suggests that other closely related species also should show similar capacities in some form. In other words, there should be demonstrable instances of "mental continuity" to parallel the "physical continuity." Much early research in animal behavior was based on the search for good demonstrations of human-like mental "faculties" such as "foresight." Parenthetically, it is interesting to note that the same arguments and concerns have become popular once again with many researchers (Griffin, 1978, 1981; Roitblat, Bever, & Terrace, 1984; Wasserman, 1981).

Thorndike was dismayed by the prevalent descriptions of animal behavior at that time. He described the work as "eulogy," rather than psychology. By this he meant that too much emphasis was placed on extraordinary feats, rather than on a detailed analysis of ordinary behavior. In particular, he was opposed to explanations of action based on the association of "ideas." For example, when we call our cat inside for food, does the cat hear the sound of our call which results in a "memory-image" of food which leads to a feeling of "I will run in"? For Thorndike, the answer was a definite "No." He was determined for once and for all "to give the coup de grace to the despised theory that animals reason." Instead he was to argue that the more likely fact was that animals have "no images or

memories at all, no ideas to associate" (emphasis in original).

The basis of learning in animals was a connection between situation and "impulse." Impulse was defined as the consciousness of doing, as distinguished from the feeling of one's self doing, or the sight of one's self doing, or the motive to be doing. He considered the term "act" as the best synonym for impulse. The performance of an act in a situation connects the two. "Pleasure" (his terminology until 1913) contributes to the predominance of certain associations by "burning in" the connection between situation and act.

In the 1911 book publication of the monograph, an appended chapter codifies these views into their more famous forms of the Law of Effect and the Law of Exercise. The Law of Effect now assumed the preeminent position concerning acquired behavior. A second major change was that both laws were now considered sufficient to explain learning for all; that is, the analysis now applied to humans. At that point, the Law of Effect was stated in the following manner:

> The Law of Effect is that: Of several responses made to the same situation, those which are accompanied or closely followed by satisfaction to the animal will, other things being equal, be more firmly connected with the situation, so that, when it recurs, they will be more likely to recur; those which are accompanied or closely followed by discomfort to the animal will, other things being equal, have their connections with that situation weakened, so that, when it recurs, they will be less likely to occur. . . . By a satisfying state of affairs is meant one which the animal does nothing to avoid, often doing such things as attain and preserve it. By a discomforting or annoying state of affairs is meant one which the animal commonly avoids or abandons.

The above quotation gives an important and practical descriptive principle governing the life of organisms. Many questions immediately arise: How do such "states of affairs" come to be? How consistent are such states of affairs for an individual across situations? How consistent are such states of affairs across the lifetime of an individual? How consistent are such states of affairs for members of the same species, and across species?

But such a program of research was not to emerge in mainstream psychology because Thorndike (and others) used the law of effect in two ways: as a descriptive principle and as an explanatory principle. Not only are the consequences of responding important, but the law of effect also "explains" apparent instances of "inference" by organisms. The law of effect was used as a theoretical primitive, and, as such, was subjected to critiques that prematurely constrained work on reinforcement as a phenomenon.

The criticism focused on Thorndike's use of terms such as "satisfiers" and "annoyers." Given the previous use of terms like pleasure in the same context, the use of such terms seemed to be in agreement with the more explicitly hedonistic theories of Spencer (1896) and Bain (1868, 1876). Wilcoxon (1969) and Boakes (1984) documented the close parallel between Spencer's and Thorndike's theory of learning, and, more importantly, showed that such a parallel, or confusion, was perceived between the two theories at that time (e.g., Cason, 1932) and for a long time thereafter (e.g., see Carr's opening statement in Carr, Tolman, Thorndike,

Culler, Dashiell, & Muenzinger, 1938). There were, however, important differences. For example, when Spencer argued for the control of actions by the consequences of pleasure and pain, they were defined as feelings which we seek to bring into or repel out of consciousness. This was different from Thorndike's view, but writers at the time were not sure that it was very different.

The second popular critique was that the law of effect was circular. This followed from the first critique since circularity is generally considered to be one of the major weaknesses of hedonistic viewpoints. The problem arises in the following manner.

Hedonism is the ancient doctrine that the pursuit of pleasure and the avoidance of pain is the ultimate goal toward which many living things strive. Now, if we take this as a proposition to be proved, an important problem arises. Assume that our position-to-be-proved is that the consequence chosen by a person is that which maximizes pleasure. How do we demonstrate a proof of the proposition? Obviously, we cannot use the current choice in proving the thesis. But it is also inappropriate to use prior choices by that person, or similar choices made by others, as defining the consequence that maximizes pleasure. The reason is the same for all cases. At some point the truth of the proposition is assumed in order to prove the proposition. This is the problem of circularity. An independent a priori definition of pleasure is needed to solve the problem of circularity.

The important point here is not to disentangle the rightness or

wrongness of these charges against Thorndike, but to realize that these were prominent concerns at the time. The philosophical problem of circularity does not apply necessarily to the concept of reinforcement in psychology. One could take Skinner's (1938) tack and define reinforcement as the observed change in behavior (i.e., an effect). In this case, there is no problem of circularity since reinforcement simply becomes the name for a certain observed class of phenomena and is no more inappropriate than labels for other phenomena such as force or gravity. One is in the clear as long as one does not fall into the trap of saying, for example, the animal works for food because it is reinforcing; then the problem of circularity would apply. It is worth noting in this context that Skinner never really examined the question of predicting when or how events became reinforcers. His major empirical work has been on schedules of reinforcement (e.g., Ferster & Skinner, 1957), an exploration of the effects of intermittency of consequences.

The mainstream of experimental psychology, however, was to take a different path. The law of effect was to be the explanatory cornerstone for some general theories of behavior. Hence, the potential or perceived problem of circularity was important. The solution was to be found in an independent determination of the nature of satisfiers and annoyers. Two such solutions, that of Hull (1943) and of Meehl (1950), are particularly important because of their general influence.

Hull's theory of reinforcement grew out of what he considered a

Darwinian perspective. The primary task for any organism is survival. Survival depends upon the maintenance of a set of optimal conditions. Deviation from this optimal set of conditions or commodities results in a state of primary need. Reinforcers are those events which result ultimately in need reduction or, technically, the reduction in the drive-receptor response associated with that need. Thus, Hull was able to use reinforcement as an explanation of behavior since he had given an a priori definition of what constituted reinforcement.

Hull also made popular a further distinction, that between primary and secondary reinforcement. The temporal period over which the effect of reinforcement extended in terms of making "receptor-effector" connections was termed the gradient of reinforcement. In Hull's view, this period lasted only for about 20-seconds. Consequently, this type of process was inadequate to account for much known data. For example, food would not be a primary reinforcer in most experiments because of the above time criteria. In fact, Hull's examples of primary reinforcement involved escape from electric shock. What Hull needed was a mechanism to temporally extend the effects of reinforcement; this was the purpose of secondary reinforcement.

An event which is consistently and closely associated with need-reduction acquires the power of reinforcement; it becomes a secondary reinforcer. The procedure that exemplified the establishment of a secondary reinforcer was Pavlovian conditioning.

Hull argued that, in principle, the transfer of reinforcement power could be extended in a chain of stimuli whose length was limited only by the conditions which bring about repeated and consistent association. It is worth noting that it was known at the time that Pavlov and his colleagues were not able to produce stable effects beyond the second or third order of pairing. Hull accounted for this by suggesting that Pavlov's experimental failures to extend such chains were due to "the highly artificial nature of their experimental procedures" (Hull, 1943, p. 97).

Secondary reinforcement was a critically important process within Hullian theory; it mediated almost all learning. Yet, the characteristics of that class, and its relation to primary reinforcement, were never very clear. For example, it was unclear to Hull whether the two types of reinforcement were the same or different in an ultimate analysis. Secondary reinforcement appeared to be associated with an increase in stimulation (e.g., pressing a bar to produce the click of the currently empty feeder), whereas primary reinforcement effects were associated with cessation of stimulation. Secondary reinforcement depended upon the initial presence of primary reinforcement, but its power would not necessarily extinguish if the support of primary reinforcement was withdrawn from the situation.

Hull's legacy is large and pervasive. Most present discussions of reinforcement still follow his basic distinctions. The reinforcement effect is due to the properties of the contingent

event. These events can be broken into two classes: primary and secondary. Primary reinforcers are events distinguished by important biological effects or are effective at birth (e.g., shiny objects); secondary reinforcers are events that have been explicitly paired in space and time with primary reinforcers. The interested reader should consult any major review on reinforcement or "conditioned" (secondary) reinforcement to see this framing (i.e., Fantino, 1977; Hendry, 1969; Kelleher, 1966; Longstreth, 1971; Mackintosh, 1974; Nevin, 1973; Wike, 1966).

Meehl's contribution was to advance a general argument that was congruent with Hull, but was not dependent on the correctness of Hull's specific assumptions. In his 1950 article entitled "On the circularity of the law of effect," a scheme is introduced to allow reinforcement to be used as an explanatory construct. The critical feature is that reinforcers are <u>transituational</u>.

The argument of transituationality is as follows. An event is classified as a reinforcer dependent on its action in a particular situation. If we use that particular result to classify the event as a reinforcer and then go on to show that the same event can be used successfully as a reinforcer in another situation, then we have an independent classification of the event as a reinforcer prior to the second situation. The prior result allowed us to "predict" that the event will be a reinforcer. Hence the way to break the problem of circularity (and make the law of effect an explanatory construct) is to assume that reinforcers are transituational; that is, events

called reinforcers have properties which exert their effects across many different situations.

An obvious question is how many? To make the scheme usable, Meehl was cornered into taking the bold step of saying that if an event was a reinforcer in one situation, then it must be a reinforcer in all situations. This was termed the "Weak Law of Effect" and would be invalidated by a single exception, although the strength of the effect would vary, for example, as in manipulating the amount of food deprivation. His "Strong Law of Effect" was that all significant behavioral phenomena were explained by the "Weak Law of Effect"; no other explanatory constructs were needed to explain learning. Meehl's argument freed theorists from the onus of having to identify the specific properties that made an event a reinforcer prior to using reinforcement as an explanation.

The critical point of this brief historical survey is at hand. Reinforcement has served double-duty: a description of an effect and an explanatory device. Because of the manner in which Thorndike introduced the law of effect, it was seen, rightly or wrongly, to be a slight variation on the doctrine of hedonism with that doctrine's concomitant problems (i.e., circularity). For many of those (e.g., Hull) who were to use the law of effect as an explanatory device, the potential problem of circularity was an important problem. This problem was met by the philosophically acceptable step of giving an a priori definition of reinforcement. This definition was either given explicitly (e.g., tissue-need reduction) or stated to be

discoverable in principle (e.g., events with certain properties which exert effects in all situations). Definitions like these explained reinforcement in terms of immanent properties of the events. The unfortunate consequence of this approach was to constrain work on reinforcement as an effect. Although theories, such as Hull's, fell into official disrepute, their basic conception of reinforcement persisted (e.g., the distinction between primary and secondary or conditioned reinforcement).

The Return of the Original Problem: Morse and Kelleher's Work

The problem, which has become increasingly apparent over the years, is that the cart has been put in front of the horse. The phenomenon that is called reinforcement is still a basic problem, and not yet the solution to other problems. One important example, because of the confusion it typically engenders and its relevance to the work reported here, arises from the work begun by Morse and Kelleher at the Harvard Medical School (for a recent summary, see Morse & Kelleher, 1977). This work has been not so much in the form of "experiments" (in the typical hypothesis - test tradition) as it has been demonstrations. One example from Kelleher and Morse (1968) will suffice, since the implications are important, although the procedural details are complex.

Each session consisted of 10 components (i.e., stimulus-defined periods) and each component was 10-minutes in duration. The components were separated by 1-minute time-outs (TO); a TO refers to

a period during which responding is ineffective in producing the scheduled consequence(s) and a signal is absent which is normally present when responding is effective. The subject was a squirrel monkey, and, in the initial condition, lever-pressing was established by the response-produced presentation of liquid-food. The food was made available according to a variable-interval 2-minute (VI 2-min) reinforcement schedule. Training was continued until the typical low but steady pattern of responding under VI schedules was clearly established.

Following this condition, an additional schedule of electric-shock presentation was superimposed on the VI food schedule. The first response following the passage of 10 minutes from the beginning of the component resulted in a strong electric shock to the tail of the squirrel monkey. The duration of each component was extended by one minute, and if no response occurred during that single minute, the TO began. This allowed the squirrel monkey the opportunity to avoid shock entirely by not responding during the last minute of the component. This portion of the schedule is termed a fixed-interval 10-minute schedule with a limited hold of 1-minute (FI 10-min lh 1-min).

In a typical experiment using food as the contingent event under an FI schedule, responding is suppressed or absent during the first 1/3 to 1/2 of the interval and increases at a positively-accelerated rate through the rest of the interval. Because of the appearance of this pattern of responding on a cumulative recorder,

it is referred to as an "FI scallop." This pattern of responding, the FI scallop, is proportionately constant over a wide range of intervals, from those lasting a few minutes to intervals of over a day in length (Dews, 1970). On the other hand, electric-shock presentation usually results in a suppression or lack of responding as the opportunity becomes imminent. In fact, electric shock is usually presented as the ideal experimental punisher (e.g., Azrin & Holz, 1966).

Morse and Kelleher found that the addition of the electric-shock schedule to the situation resulted in the development of FI scalloping, i.e., the pattern of responding seen for a positive reinforcer. The subsequent elimination of food from the situation resulted in clearer scalloping as responding for food was eliminated from the early portions of the component. Decreasing the intensity of the shock resulted in lower rates of responding; increasing the intensity of the shock resulted in higher rates of responding. The removal of shock resulted in the cessation of responding (food having been eliminated from the experimental sessions for several months), and reinstatement of the contingent shock resulted in a recovery of responding. In other words, for all manipulations electric shock meet the criteria for a positive reinforcer.

One final manipulation is of importance. Electric shock was also made available under a fixed-ratio 1 (FR 1) schedule during the 1-min period intervening between the end of the FI and the TO. Every response produced the same intensity shock that occurred at the end

of the FI. Shock suppressed responding during this portion of the schedule. In other words, during one portion of the schedule (FI 10-min) electric shock was a positive reinforcer and, during another portion of the schedule (the subsequent minute), electric shock was a punisher.

The original finding was serendipitous, according to Morse and Kelleher. But since that time there have been close to 50 such experiments reported showing that under a variety of conditions electric shock can be a positive reinforcer. In fact, the complaint now is that electric shock has been shown to be a positive reinforcer under such a variety of conditions that no easy summary of procedures is possible (Malagodi, Gardener, Ward, & Magyar, 1981).

While many may view this finding as creating chaos out of order, there are important implications. First, this single experiment serves as a striking disconfirmation of Meehl's Weak Law of Effect; that reinforcers are events which have particular effects on behavior that must be transituational. Kelleher and Morse's results are particularly clear since, within the same session, the same event serves to both enhance and suppress the rate of responding, depending upon the manner in which it is scheduled (see Barrett & Stanley, 1980, for a similar demonstration). Second, as Morse and Kelleher (1977) stress, such results shift the the focus of the interaction between behavior and environmental events toward behavior itself. In other words, it is the manner in which the

behaving subject produces/encounters the event that is a "fundamental determinant" of the "nature" of the event.

The Morse and Kelleher position is in agreement with the more well-known position of Premack (1965, 1971) in emphasizing that events are not immutable members of mutually exclusive categories (such as reinforcers and punishers); but there are important differences. For Premack, events/activities can be ranked on a dimension of value/preference by noting the amount of time, or probability, of engaging in that activity given unconstrained access. When one activity is made contingent upon a second (instrumental) activity, the effect on the rate of the instrumental activity is given by the relationship of the probabilities of the two activities. The consequence will serve as a reinforcer if it is the more probable activity, and will serve as a punisher if it is less probable than the instrumental activity. Dunham (1977) reviewed the difficulties in assessing response probabilities and discussed subsequent modifications of the Premack formulation. In contrast, the Morse and Kelleher position emphasizes the ongoing pattern of behavior when an event is encountered. Thus, in the previous example from Kelleher and Morse (1968), shock served both as reinforcer and punisher dependent upon the manner of production by the subject.

The general thrust of the Morse and Kelleher position on the phenomenon of reinforcement is clear. The "how" or "why" of reinforcement will encompass a set of descriptive principles emphasizing the manner in which events are produced/encountered.

Hence, one important task of research is to identify and examine those conditions in which there is a change in the functional significance of an event as a consequence of its manner of production. One such set of findings comes from an experiment by Neuringer and Chung (1967) in which events became "quasi-reinforcers." The results of their experiment formed the basis for the specific experiments to be reported in the present work.

Neuringer and Chung's Quasi-reinforcement Effect

Neuringer and Chung's experiment was an exploration of an effect reported by Ferster and Skinner (1957). Ferster and Skinner showed that a pigeon's performance under an FR schedule was not disrupted when food-reinforcements were intermittently replaced by long periods of blackout (BO, i.e., the total darkening of the experimental chamber). The term "percentage reinforcement" was used to describe the schedule in which completion of the response requirements produced either food or BO in a mutually exclusive fashion. Neuringer and Chung also used the term, percentage reinforcement schedule, but I shall use a slightly different terminology that is closer to that presently used.

In their experiment, pigeons were initially trained to peck a key under a VI 1-min schedule of food-reinforcement. Following exposure to this condition for several sessions, the response requirement was changed from a single keypeck to the completion of a small <u>set</u> of requirements or "unit." The overall food-rate schedule

was maintained from the prior condition, such that food followed completion of these units approximately 15% of the time. In one condition, the response requirement was tand FR 1 FI 5-sec. Under this requirement, a single peck (the FR 1 portion) is necessary to initiate the FI portion of the schedule, which, in turn, is satisfied by the first peck following 5-seconds. The completion of the FI requirement produced either food or a 1-sec BO (but never both at the same time). The "tand" refers to the condition that the transition from the FR to the FI portion is not explicitly signaled.

In present terminology, this procedure is termed a second-order schedule. A second-order schedule is one in which the behavior specified by some schedule contingency is treated itself as a unitary response that is reinforced according to a another schedule (Kelleher, 1966). The above procedure is termed VI 1-min (tand FR 1 FI 5-sec) and is read: the behavior specified by (tand FR 1 FI 5-sec) is treated as a unitary response (the formal equivalent of a single keypeck) which is reinforced by food according to VI 1-min. Since completion of the unit resulted in either food or BO but never both, Snp (Stimulus nonpaired) is added to the notation and it becomes VI 1-min (tand FR 1 FI 5-sec:Snp). See Gollub (1977) for some of the more excruciating details in attempting to prescribe a notational system for such procedures.

Neuringer and Chung found that when the schedule was changed from the simple VI 1-min to the second-order schedule, overall response rates doubled, although the rate of food-reinforcement

remained approximately the same. Further, the pattern of responding was the same as occurred under a condition in which (tand FR 1 FI 5-sec) always resulted in food-reinforcement. This was a pause of a few seconds from the end of the prior unit and a quickly accelerated rate of responding throughout the FI 5-sec segment. In other words, the BO produced a reinforcement effect in the same manner as would be seen if food were always the consequence.

The characteristics of the situation were manipulated across various conditions to determine the critical aspects of the effect. There was no disruption of the effect when either the duration of the Snp or type of Snp (BO or buzzer) was changed. Changing the unit schedule to (FR 11:Snp) still resulted in the same type of reinforcement effect, showing that the effect was not due to the particular schedule. Eliminating the Snp, while maintaining the second-order schedule requirements, produced a return to the pattern of responding seen under the simple VI. This showed that the response requirements of the second-order schedule alone were not responsible for the development of the pattern of responding. Similarly, imposing noncontingent BO's on the VI 1-min schedule did not produce an increase in response rate or a difference in the pattern of responding from the simple VI. This showed that the effect was not due to some type of simple disruption effect. This set of manipulations showed that no single aspect of the stimulus or the response requirement was responsible for the reinforcement effect.

Two final conditions from the experiment are important to the

interpretation of the results. In these conditions the unit schedule was (FR 11:Snp). In one condition the schedule configuration was second-order, VI 1-min (FR 11:Snp). Both overall response rates and the temporal pattern of responding came under control of the Snp as before. In the other condition, the same two schedules were allowed to run simultaneously and independently such that each single keypeck by the pigeon contributed simultaneously to both the FR 11:Snp and to the VI 1-min:food schedules. Both could be satisfied independently, with the provision that both the Snp and food could not occur together following the same keypeck. Thus, the pattern of behavior that produced the Snp, FR 11, was not the same as was required to produce food, a single keypeck under VI 1-min. This second condition is called a <u>conjoint</u> schedule and is termed: conjoint VI 1-min FR 11:Snp. Under the conjoint schedule, the rate and pattern of responding were <u>no</u> different than that observed under the simple VI 1-min:food schedule. In other words, it was almost as if the FR 11:Snp portion of the schedule was not even there.

The interpretation of these results is relatively straightforward. Under the second-order schedule, the Snp produced a reinforcement effect in the same manner as did food. In a series of conditions, it was shown that the effect was not due to any particular characteristic of the Snp alone nor was it due to the response requirements of the second-order schedule alone. The final two conditions showed that the control of responding by the Snp was due to the fact that both the Snp and food were produced by the same

behavior. In other words, an event which was produced by the subject in the same manner as an already existing reinforcer also became a reinforcer. The critical determinant was how the subject produced the event in relation to how other events were being produced.

An interesting historical aside which is relevant to the earlier discussions in this chapter is that Neuringer called these events quasi-reinforcers. After much argument (Neuringer, personal communication) he was able to introduce this neologism into a journal noted, at that time, for its antipathy toward new terminology. The interested reader may wonder why these results were not simply classified as a case of secondary or conditioned reinforcement. The reason is that, by definition, this is not an example of conditioned reinforcement.

The point of the earlier historical discussion was that research on the phenomenon of reinforcement was prematurely constrained because of a priori commitments to a particular view of the basis of the effect. Hull introduced a distinction between two types of reinforcement (primary and secondary) because of the peculiar requirements of his theory (e.g., the scanty 20-second span of the habit-assembling action of tissue-need reduction). The necessary and sufficient conditions for the effect were tied to classical conditioning procedures. While Hull's theory may have been officially abandoned, his distinctions still live. Hence, conditioned reinforcement refers to an effect arising from a specific procedure, the close spatio-temporal pairing of some event

with a reinforcer (for the typical definition, see Nevin, 1973; Mackintosh, 1974); and, as was pointed out in the description of the Neuringer and Chung procedure, food and the Snp were explicitly non-paired. The importance of the repetition of this point will become evident shortly in the discussion of Stubbs (1971).

It is unfortunate that Neuringer and Chung's results have generally been forgotten, for the finding was quite important. Their results clearly pointed to one mechanism, or set of conditions, responsible for an event becoming a reinforcer. An event will become a reinforcer when it is produced in the same manner as a current reinforcer.

Even broader significance to the finding is apparent if we step back from focusing on the results solely in terms of the issue of reinforcement. The different effects of the Snp under the second-order and conjoint schedules represented a difference in the <u>functional status</u> of the Snp. The phrase, functional status, refers to the fact that the Snp had a different <u>meaning</u> under the two schedules. Thus, in a very broad sense, the different effects under the two schedules may suggest some basis for the manner in which events come to have meaning.

The topic of meaning is seen often as distinct from that of reinforcement. One common reason is that reinforcement issues are expressed as questions about biological or hedonic value alone. The earlier portions of this chapter reviewed the reasons for this conflation. A second reason is that meaning is seen as a question

for perceptual or cognitive theories. The utility of the distinction between perception and action (i.e., "stimulus" versus "response") has been argued against for a long time (e.g., Dewey, 1896). The most influential current position which questions this distinction is that of Gibson (1979). His writings have led to experimental work which stresses the commonality of the two domains (Shaw & Bransford, 1977).

Several reasons account for why Neuringer and Chung's experiment has been forgotten. First, as discussed above, their procedure was not technically a conditioned reinforcement procedure. This meant that it was not likely to be included in literature reviews of the area; which is what has happened. Second, the topic of conditioned reinforcement had become passé. This was due, in part, to the generally weak, transient, and arguable nature of such effects (Mackintosh, 1974; Wike, 1966; Zimmerman, 1957). Another major reason has been the elimination of the theoretical importance of contiguity, the sine qua non of conditioned reinforcement. Contiguity has been replaced by an emphasis on correlation, following several experiments which contrasted the two conditions (e.g., Herrnstein & Hineline, 1966; Hineline, 1970; Rescorla, 1967, 1968). Finally, in the operant conditioning literature, an alternative explanation of such second-order schedule effects was advanced fairly quickly by Stubbs (1971).

Stubbs' Alternative Explanation

Stubbs (1971) examined performance on what he termed the three "classes" of second-order schedules: (a) those in which a brief stimulus terminated all components and was intermittently paired with food (paired brief stimulus, Sp); (b) those in which a brief stimulus terminated all components except those ending in food (nonpaired brief stimulus, Snp); and (c) those under which completion of the unit schedules resulted in no programmed stimulus change (tandem). He found no difference between the effects of paired and nonpaired stimuli on response patterning over a wide range and variety of reinforcement schedules, e.g., FI 600-sec (FI 60-sec) versus FR 4 (FR 20). Nor was there very much difference in the effectiveness of various types of stimuli, e.g., keylight versus houselight changes. He also found, like Neuringer and Chung, that no patterning occurred when the two schedules were allowed to run independently (i.e., a conjoint schedule).

Stubbs distinguished between three general classes of explanation of the lack of difference of the pairing operation: "reinforcement," "macroresponse," and "discriminative." The first two types of explanation are closely related, the first being attributed to Morse and Kelleher (1966) and the second to Neuringer and Chung. These two positions would argue that the brief stimuli were reinforcers. The reason that Stubbs distinguished between the two was that the Neuringer and Chung position emphasized the common

relationship between the behavior sequence leading to food and the stimulus.

The third position is quite different, and argues that the pattern of responding seen with nonpaired stimuli merely resembles that of a reinforcement effect but is produced by an entirely different process. According to this view, response rates are maintained solely by food-reinforcement. When brief stimuli occur in a second-order schedule, the presentation of the stimulus is associated with a period of nonreinforcement (i.e., extinction [EXT]). Hence, for example, under a VI 360-sec (FI 60-sec:Snp), the outcome of each FI, whether or not it results in food according to the VI schedule, still predicts that there is another 60-sec before the next event can happen. Thus the Snp serves a discriminative function, predicting that food is not available for the moment. In other words, the nonpaired stimulus is not a reinforcer; rather, keypecks are maintained by intermittent food and brief-stimulus presentations simply serve to produce pauses in responding because they are extinction stimuli, predicting nonreinforcement for some time period.

Research on brief stimuli in second-order schedules has followed two related lines of inquiry following Stubbs' experiment: further comparisons of the effectiveness of pairing, and analysis of the discriminative effects of nonpaired stimuli. Stubbs made the suggestion that pairing of brief stimuli and food might have had an effect, but it may have been obscured or masked by the stronger

discriminative effect of the brief stimulus as an S-. The first line of research has been concerned with finding out whether pairing, per se, does produce an effect (e.g., Cohen, Calisto, & Lentz, 1979; Cohen, Hughes, & Stubbs, 1976; de Lorge, 1971; Malagodi, De Weese, & Johnston, 1973; Rose & Fantino, 1978). The results of the various experiments suggest that the effects found are more closely tied to the type of stimuli, the particular schedules, and the prior experimental history of the subject than to simple pairing.

Work on the discriminative effects of nonpaired stimuli has involved further demonstrations of the effect (e.g., Cohen & Stubbs, 1976) and the question of whether the brief stimulus also interferes with the "memory" of when food was last presented (Rose & Fantino, 1978; Squires, Norberg, & Fantino, 1975; Staddon, 1974; Starr & Staddon, 1974; Stubbs, Vautin, Reid, & Delehanty, 1978). The relevance of this last concern is the so-called "conditioned confusion" view of second-order schedules (Fantino, 1977). According to this view, what is interesting about second-order schedule effects is the subjects inability to "track" food rate, in that the effects remain fairly constant despite changes in food-rate per session. Memory "interference" would serve to explain, for some, why responding was often uninfluenced by the manipulation of food rate per session.

Since Stubbs (1971), the effect of the nonpaired stimulus has been viewed generally as a control condition against which to assess the putative effectiveness of the procedure of pairing in producing

a conditioned reinforcer (Fantino, 1981). The effects produced by the nonpaired stimulus are considered to constitute the discriminative component of the effects of stimuli in second-order schedules. The whole affair is quite ironic, given the official disparagement of Hullian theory in operant conditioning circles.

Few have considered seriously the proposition that the nonpaired brief stimuli are also reinforcers. There is a clear difference in the two viewpoints, since the discriminative interpretation suggests that the Snp is a response-produced EXT period, and is therefore an aversive event (Dinsmoor, Brown, & Lawrence, 1972). The one experiment to explicitly test for a reinforcement effect using the schedule of Neuringer & Chung was by Arnett (1972).

Arnett's Preference Test

Arnett (1972) conducted a "preference" test using a concurrent-chains procedure. This involves two chain schedules in which the initial links of each chain are concurrently (i.e., simultaneously) available. Responding during the initial link produces access to the final, or terminal, link. Once responding in a particular initial-link has resulted in entering a particular terminal-link, access to the other chain is prohibited and the subject remains in that particular terminal-link until some criteria has been met (e.g., food-presentation). Following this, the concurrent initial-links of the chain are made available, and the cycle begins again.

Preference is the proportion of responding in a particular initial-link out of total initial-link responding.

In Arnett's study, the initial-links were both VI 1-min schedules and the terminal-links were VI 1-min (tand FR 1 FI 5-sec). In one terminal-link food and the Snp occurred, while in the other link only food was presented. Once either terminal-link had been entered, the subject stayed in it until the first food presentation, and then the concurrent initial-links were reinstated. Hence, the comparison was between terminal-links which either contain or do not contain the Snp, with food schedules equated.

Arnett found that responding in the terminal-link with the Snp was much higher than in the terminal-link without the Snp, but that proportionately the terminal-link with the Snp was entered less often. The results indicate that the addition of the Snp to the schedule made it a less preferred schedule to enter. The interpretation of her results is less clear.

It is not the case that the results could be due only to the aversiveness of the Snp. Another explanation for her results was that response rates in the terminal-link with the Snp were much higher than in the terminal link without the Snp. High rates of responding are often aversive. It has already been shown that pigeons will choose a terminal-link which involves lower rates of responding when food rate is equated for the links (Fantino, 1968; also see the general review by Fantino, 1977). In addition, Schneider (1968) found no preference between terminal-links of

VI 1-min and VI 30-sec when, in the latter link, 50% of the food-reinforcements were replaced by blackouts. Schneider's experiment involved no strong differences in response rates between the terminal-links. It may be that the magnitude of the reinforcing effect of the Snp was not enough to overcome other aversive properties of the schedule.

A more important problem concerns the common view of the meaning of results from concurrent chains procedures. Essentially, the view assumes that the initial links are just equally-weighted "gates" through which the animal chooses to enter the terminal-link. Whatever the value of events in the terminal-link, it is assumed to exist in the same manner from the vantage of the initial-link. But is this assumption justified? In the previous discussion of Kelleher and Morse's work, it was pointed out that electric shock was a positive reinforcer under one portion of the schedule and a punisher under a second portion of the schedule. Thus, the value of the event under one set of conditions was different under another set of conditions during the same session. When their results are applied to the concurrent chains procedure, they suggest that there may be an important difference between being in a situation and choosing to enter a situation. A direct demonstration of the relevance of this point comes from an experiment by Heyman and Bouzas (1980) on schedule-induced drinking.

Schedule-induced drinking refers to the observation that rats will, if given the opportunity, ingest large quantities of fluid

while responding under an intermittent food-reinforcement schedule (Falk, 1961). Such drinking is reinforcing in that rats will barpress to obtain access to water (Killeen, 1975). Cohen (1975) exposed rats to a simple concurrent VI VI schedule. The same food schedule was used for both VI's, but one also provided the opportunity to drink. He found that the rats spent more time on the schedule that also provided water. Hence, the presence of water made that schedule the preferred schedule.

Heyman and Bouzas arranged a concurrent chain schedule in which the two terminal-links provided food on identical fixed-time schedules and one terminal-link also provided the opportunity to press a button that operated a water dipper. They found that when the rat was in the terminal-link that provided water, it would press to drink and that the rate of pressing was a function of food rate. This showed that the reinforcing properties of water were strongly bound to the presence of food. But they found that there was <u>no</u> difference in response rates in the initial-links of the chains. In other words, there was no preference during the choice phase of the schedule although the effects in the terminal-link replicated Cohen's results. The reinforcing aspect of water was clearly restricted to the context of the terminal-link. Applying this to Arnett's study suggests that there may be a critical difference between being under the second-order schedule and choosing to enter the second-order schedule.

The above points have the following import. If the Snp is a

positive reinforcer, two aspects must be considered in demonstrating this: (a) testing the effect in the establishing context, and (b) using a sensitive indicator. The first point emphasizes that some arbitrary transituationality cannot be assumed. As in the Heyman and Bouzas study, the effectiveness of a reinforcer may be limited to a particular context within the session. Hence, the examination should focus on the context in which the Snp is producing the effects. The second point emphasizes that we cannot make assumptions about the "strength" of the Snp as a reinforcer. Therefore, the best approach is to use an indicator that is both general and sensitive. For these reasons, the effect termed behavioral contrast was chosen as a good indicator of whether the Snp also functioned as a reinforcer.

Behavioral Contrast as an Indicator of Value

This effect reflects the general observation that the rate of responding in an unaltered component will be changed by altering the schedule of reinforcement in a different component. The change is termed <u>contrast</u> when the directions of the changes in responding in the two components are in the <u>opposite</u> direction. For example, in a prototypical situation (i.e., Reynolds, 1961a), responding is reinforced according to the same VI 3-min schedule in two components which occur successively in a random or alternating sequence; this is termed a <u>multiple schedule</u>, in this case a multiple VI VI. Following exposure to this condition for several sessions, food is no longer made available in one of the components (i.e., extinction,

and the schedule is termed a multiple VI EXT schedule). The common result is that response rate decreases in the altered (extinction) component, and increases in the unaltered (VI) component. This increase is termed positive behavioral contrast. Positive behavioral contrast is defined as an increase in the rate of responding in an unaltered component of a multiple schedule accompanying a decrease in response rate or reinforcement rate in another altered component.

Positive behavioral contrast is a relatively easy effect to produce, and analogous effects have been long noted (e.g., Pavlov, 1927). However, a precise description of the necessary and sufficient conditions is still lacking. In fact, research on the relevant conditions renders the above definition barely adequate. For example, Brethower and Reynolds (1962) showed that the change from a multiple VI VI schedule to a multiple VI VI-plus-shock schedule produced positive behavioral contrast in the unaltered VI component although food-reinforcement rate remained the same in the altered component. Similarly, Terrace (1968) showed that changing from a multiple VI VI to a multiple VI DRL (differential reinforcement of low rates of responding) resulted in positive behavioral contrast in the VI component, although food rate was equated for the two schedules. Both of the above experiments showed that contrast would result if responding were reduced, while maintaining the previous reinforcement rate. However, responding may be reduced in a component and not result in positive behavioral contrast in the

other component. For example, one may change the reinforcement schedule within a component from response-contingent to a response-independent reinforcement schedule. This will result in a decline in responding in that component but no positive behavioral contrast in the other component (Halliday & Boakes, 1974).

Recent accounts of contrast effects have focused on models of specific situations. For example, a currently popular explanation is that of "additivity" theory (Schwartz & Gamzu, 1977). This is designed to account for the situation of pigeons and keypecking. According to additivity theory, contrast effects are due to the addition of elicited responses ("autopecks") to operant responding. The source of this effect is the classical conditioning relationship between keylight stimuli and reinforcement. Such models run into trouble even in their own narrow domain; for example, Malone's demonstrations of the independence of behavioral contrast effects from the local patterns of responding required by such theories (Malone, 1976; Malone & Staddon, 1973). McSweeney, Ettinger, and Norman (1981) have reviewed the other difficulties faced by various versions of additivity theory.

Perhaps the most general account of the conditions that result in contrast effects was that of Bloomfield (1969), although perhaps only because of its vagueness. Bloomfield argued simply that any procedural change which "worsens" conditions will result in contrast and that any procedural change which does not worsen conditions will not result in contrast. The vagueness of Bloomfield's account is not

due solely to a case of inarticulateness on his part, but is instead a recognition of the variety of conditions which result in contrast effects (also, see Mackintosh, 1974).

Bloomfield's sentiment has been echoed in the most recent review of contrast effects, that by Willliams (1983). Williams argued that a single variable underlies contrast effects, relative reinforcement rate. However relative reinforcement rate does not necessarily correspond, for example, to relative food rate, as evidenced by the above results of Brethower and Reynolds or Terrace. He concluded that we still have not developed a precise way to specify this "primordial variable." His usage of the term, relative reinforcement rate, was essentially synonymous with, and no more specific than, Bloomfield's account.

Paradoxically, this argues for behavioral contrast effects as an indicator of "value." It is our inability to restrict the necessary and sufficient conditions which produce contrast to a small category that suggests the appropriateness of using the occurrence of contrast as an indication of a change in the value of a component. In other words, it is the variety of manipulations that result in a worsening of conditions that suggests a fair and sensitive test of whether the Snp is a reinforcer is the type of contrast effects produced when the presence of the Snp is manipulated.

A Test of the Snp as Positive Reinforcer

Consider a multiple schedule in which responding in each component is reinforced according to the second-order schedule used by Neuringer and Chung. Following the development of stable patterns of responding, the Snp is removed from one component of the multiple schedule, although the same response requirements remain in force and food is still available in that component. If the Snp is a positive reinforcer in that situation, then its removal (all other things remaining equal) should worsen conditions and hence result in positive behavioral contrast in the other (unaltered) component. On the other hand, if the Snp controls responding solely due to its discriminative property of signaling nonreinforcement, then elimination of a signal for extinction should certainly not worsen that component but should actually increase its value (Dinsmoor, Brown, & Lawrence, 1972). In this case, positive behavioral contrast would not be observed in the unchanged component.

This is the general procedure employed in the research to be reported here. Does an event encountered in the manner of the Neuringer and Chung second-order schedule become a reinforcer such that its elimination from one component of a multiple schedule worsens that component and results in the appearance of positive behavioral contrast in the unaltered component? Second, Neuringer and Chung suggested that control by the Snp resulted when the Snp and food were produced according to the same pattern of behavior and

not when the food and the Snp were produced according to independent (i.e., conjoint) schedules. If this is correct, then elimination of the Snp from one component of a multiple schedule, in which responding within components is reinforced according to a conjoint schedule of food and Snp, should not result in a worsening of conditions and hence not in positive behavioral contrast in the unaltered component. Note that this condition also serves as a "control," in that it tests for other aspects of the Snp to produce contrast effects besides being embedded in the second-order schedule. Finally, the Neuringer and Chung procedure is not a common one and has never been used in a typical behavioral contrast paradigm. It would be important to be able to compare the above effects with the more typical manipulation of removing food.

CHAPTER II

EXPERIMENT I

The first experiment examined whether there was a functional parallel between the effects of a quasi-reinforcer and a typical reinforcer, such as food. A quasi-reinforcer is defined as a non-food-paired stimulus (Snp) which is made available according to a second-order reinforcement schedule (Neuringer & Chung, 1967). The specific question was whether positive behavioral contrast would occur in the unaltered component of a multiple schedule following elimination of a quasi-reinforcer from the other (altered) component. The occurrence of positive behavioral contrast in the unaltered component would show that the removal of the Snp in the other component represented a worsening of conditions for the altered component, as would occur if the frequency of food-reinforcement was decreased. This would show that the Snp did not function merely as a response-produced extinction period (as proposed by Stubbs, 1971), but had acquired some positive value as a result of being presented in a second-order schedule.

Subjects were initially exposed to a multiple schedule in which responding in each component was reinforced according to the second-order schedule VI 1-min (tand FR 1 FI 5-sec). This reinforcement schedule was one used in the original report of the quasi-reinforcement effect by Neuringer and Chung (1967). Completion of the response requirements of the unit schedule, (tand FR 1

FI 5-sec), intermittently resulted in food-presentation but was otherwise unsignaled. Following exposure to this condition for several sessions, a nonpaired brief stimulus was introduced and marked completion of those units which did not result in food-presentation. Response rates and cumulative records were examined to see if a reinforcement effect occurred as was reported by Neuringer and Chung. Following exposure to this condition, the Snp was removed from one component of the multiple schedule to see if positive behavioral contrast would result in the unaltered component of the multiple schedule. In the next condition, the Snp was reinstated in the altered component to show whether changes that occurred during the previous condition were due to the removal of the Snp. In the final condition, the Snp was removed from both components of the multiple schedule to establish that the changes in responding in the second condition were due to the introduction of the Snp.

Contrast effects under FI schedules (Reynolds & Catania, 1961; Staddon, 1969) or FR schedules (Crossman, 1968; Reynolds, 1961b; Richards & Blackman, 1981; Shuster, 1959) are seen ordinarily as changes in pause duration. Positive contrast effects occur as reductions in the duration of pausing. Previous parametric work by Shull (1970) on the general class of schedules (tand FR 1 FI X-sec), where X is a variable, suggested that the schedule was functionally closer to an FR than an FI schedule in the pattern of responding that emerges. The distinction between the two is that the transition from pausing to responding under an FR is abrupt

(a "break and run" pattern), whereas the transition from pausing to responding under an FI schedule is smooth (a scallop). Once responding has begun under small to moderate size FR requirements, response rates tend to be relatively constant throughout the completion of the ratio (Mazur & Hyslop, 1982). For these reasons, the measure of responding was overall response rate (total number of responses/programmed session time). A reduction in pause duration coupled with a relatively constant rate of responding should produce an increase in overall response rates if positive behavioral contrast occurs.

Method

Subjects

Four adult Tumbler pigeons were maintained at approximately 80% of their free-feeding weights. All subjects had previous experimental histories of varying kinds, involving variable-interval reinforcement schedules signaled by line-orientations or colors. None of the subjects had previous experimental experience with second-order schedules.

Apparatus

The experimental chamber consisted of a 39.5 by 33 by 35.5-cm (length by width by height) plywood box with a metal face on the side where the response key and grain hopper were located. The

translucent response key was located in the center of the wall, 25-cm above the floor and 20-cm above the middle of the 6 by 6-cm opening in which grain was presented. The response key was illuminated by an inline stimulus projector with either a 90° (vertical) or 0° (horizontal) black line on a white background. The solenoid-operated grain hopper provided 3-sec access to mixed grain. A 28-volt light with a translucent red plastic cover was located in the center of the Plexiglas top of the chamber but was illuminated only under special conditions, as described in the Procedure section. Otherwise no general illumination of the chamber was provided. The chamber was wholly enclosed in a sound-resistant box. White noise was present in the box and in the experimental room. All experimental conditions were controlled by solid-state and eletromechanical equipment in an adjoining room. Data were recorded by eletromechanical impulse counters and a Gerbrands cumulative recorder.

Procedure

After preliminary hand-shaping, baseline training consisted of responding reinforced according to mult VI 1-min (tand FR 1 FI 5-sec) / VI 1-min (tand FR 1 FI 5-sec). This is read in the following manner: a multiple schedule in which responding in each component is reinforced according to the second-order schedule, VI 1-min (tand FR1 FI 5-sec). Under this schedule, (tand FR 1 FI 5-sec) behavior is treated as a unitary response which is reinforced according to a

VI 1-min schedule of food-reinforcement. In practice, a peck (the FR 1 requirement) initiated a 5-sec interval with no scheduled consequences for responding during the interval; the first peck following passage of the 5-sec interval completed the unit. If the VI 1-min schedule had programmed food-presentation during the interval, then the peck which completed (tand FR 1 FI 5-sec) also resulted in food-presentation. During the food-presentation cycle, the stimulus on the response key was not turned off. If the VI 1-min tape had not programmed food-reinforcement, then no scheduled consequences occurred in the chamber following completion of the unit. This condition was continued for 20 sessions.

The two portions of the multiple schedule were signaled by the 0^{o} and 90^{o} lines. Each successive presentation of one of the lines is termed a component and lasted for 1-min. There were 60 components per session. The sequence of components per session occurred in a pseudo-random fashion such that the components appeared equally often and there was an equal number of each type of transition between components (i.e., 0^{o} -> 0^{o} , 0^{o} -> 90^{o} , 90^{o} -> 0^{o} , and 90^{o} -> 90^{o}). Transitions between components involved a brief (1-sec) blackout of the chamber and the resetting of the response requirements. Each session lasted approximately 61-min and sessions ordinarily were conducted seven days per week.

Following the initial condition, the reinforcement schedule was changed in the following fashion. The first peck to terminate the 5-sec interval resulted in one of two mutually exclusive events. If

the VI 1-min tape had scheduled food-reinforcement during the interval, then food was presented as before. If food-reinforcement was not scheduled, the peck which completed the unit produced illumination of the red houselight and the darkening of the response key for 1-sec. This reinforcement schedule in both components is termed VI 1-min (tand FR 1 FI 5-sec:Snp), where Snp refers to a stimulus change that is explicitly unpaired with food presentation. Responding had no scheduled consequences during either the Snp or food cycle. In practice, the Snp cycle was present also during the initial condition with the sole difference being that there was no scheduled stimulus change in the experimental chamber during the Snp cycle. The presentation of the Snp in both portions of the multiple schedule was continued for approximately 25 sessions.

The next condition was the Contrast Condition. The Snp was eliminated from one portion of the multiple schedule for approximately 20 sessions. The Snp was eliminated from the components signaled by 90^{o} for two of the birds and from the components signaled by 0^{o} for the other two birds. This was followed by the reinstatement of the Snp to both portions of the multiple schedule for another 20 sessions. The Snp was then removed from both portions of the multiple schedule in the final condition.

The recording of responding by the eletromechanical counters and the cumulative recorder was done in two fashions. Response rates were determined using the counters. For this reason the counters were disabled during both the food and Snp cycles. The disabling

during the Snp cycle occurred under all conditions, whether there were scheduled stimulus changes in the chamber or not. Hence, responding during these periods never contributed to response counts during the experiment. This allowed a straightforward comparison of response rates between conditions involving the presence or absence of the Snp, since responding would not be expected during the presentation of a Snp when the response key was dark momentarily. The cumulative recorder was never disabled during the session in order to determine whether there was responding during the Snp cycle.

Results

Table 1 shows the results of the experiment for each subject. The data are response rates per minute during a component, averaged over 5 consecutive days. Data were averaged from the final days of a condition with the exception of the Contrast Condition. For the Contrast Condition the middle 5 sessions were used because these data were more representative of the changes in response rates during this condition. The stimulus component labeled as S+ refers to the component which remained unaltered during the Contrast Condition. The particular line-orientation which served as the S+ is indicated in parentheses in the table.

Table 1 shows that the results of the experiment fell into two classes, according to whether or not overall response rates showed the quasi-reinforcement effect of Neuringer and Chung. For Birds 92 and 99 the quasi-reinforcement effect was replicated. The

Table 1

Response Rates Per Minute Per Component (5 Day Average)

Bird	#92		#99		#94		#65	
Component	S+(0°)	S-	S+(90°)	S-	S+(0°)	S-	S+(90°)	S-
Condition								
(1) No Snp	21	28	80	101	26	36	23	29
(2) Snp Both	76	78	109	109	23	27	23	27
(3) Contrast	95	23	119	112	33	29	18	34
(4) Snp Both	67	62	110	116	45	40	19	17
(5) No Snp	21	27	77	85	38	38	34	39

introduction of the Snp into the schedule produced an increase in overall response rates, and the elimination of the Snp from the schedule in the final condition resulted in a decline to the former levels of responding. The effect of the Snp on response rates was more clearly evident for Bird 92, which initially began at a lower level of responding. The effect of the Snp on overall response rates was different for Birds 94 and 65. For these birds, the introduction of the Snp into the schedule produced little change, or a small decline, in response rates. The elimination of the Snp from the schedule in the final condition produced little change in overall response rates in the case of Bird 94 and resulted in an increase for Bird 65.

Table 1 shows also that the occurrence of positive behavioral contrast in the Contrast Condition was dependent on whether there had been a reinforcement effect when the Snp was introduced into the schedule. Birds 92 and 99 showed an increase in responding in S+ when the Snp was removed from S- in the Contrast Condition. Response rates then returned to former levels when the Snp was returned to the S- component in the next condition. The increase in responding was clearest for Bird 92, which had lower response rates initially. The overall response rates of Birds 94 and 65 had not shown a reinforcement effect following the original introduction of the Snp in the second condition, and, showed no positive behavioral contrast effect during the Contrast Condition. Bird 94 showed an increase in response rates in S+ during the Contrast Condition. But response

rates continued to increase in the next condition, suggesting that the change was due to conditions other than the removal of the Snp from the altered component. Bird 65 actually showed a small decrease in response rates in S+, but the maintenance of this level of responding in the next condition suggested that this effect was also due to factors other than the removal of the Snp from the other component. For Bird 65, the effects observed seem clearly related to the continued exposure to the Snp. This was shown by the increase in responding in S- following removal of the Snp from that component in the Contrast Condition and the decrease in overall response rates in S- when the Snp was returned to that component in the next condition.

The differences in overall response rates between the two sets of birds suggests that the pattern of responding under the second-order schedule was correspondingly different. The patterns of responding observed on the cumulative records showed a consistent set of differences. Figures 1, 2, 3, and 4 show representative portions of cumulative records for Birds 92, 99, 65, and 94, respectively. The top panel of each figure shows a portion of a cumulative record for a session from the latter part of the first condition and just prior to the second condition, the introduction of the Snp. The bottom panel of each figure shows a portion of a cumulative record from a session from the second condition, and just prior to the Contrast Condition. The marks on the bottom event line of each record indicate the occurrence of an Snp cycle (although, of

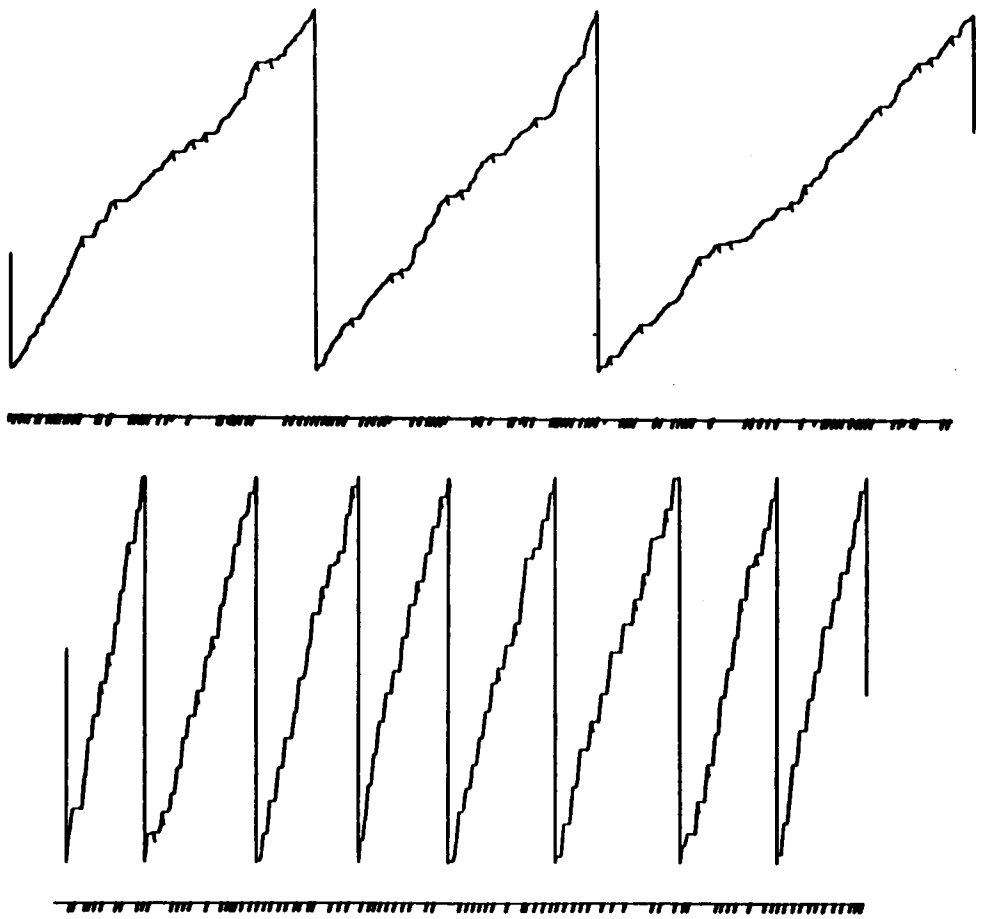

Figure 1. Cumulative records from Bird 92, Experiment I. The top panel shows performance prior to the introduction of the Snp. The bottom panel shows performance when the Snp was present.

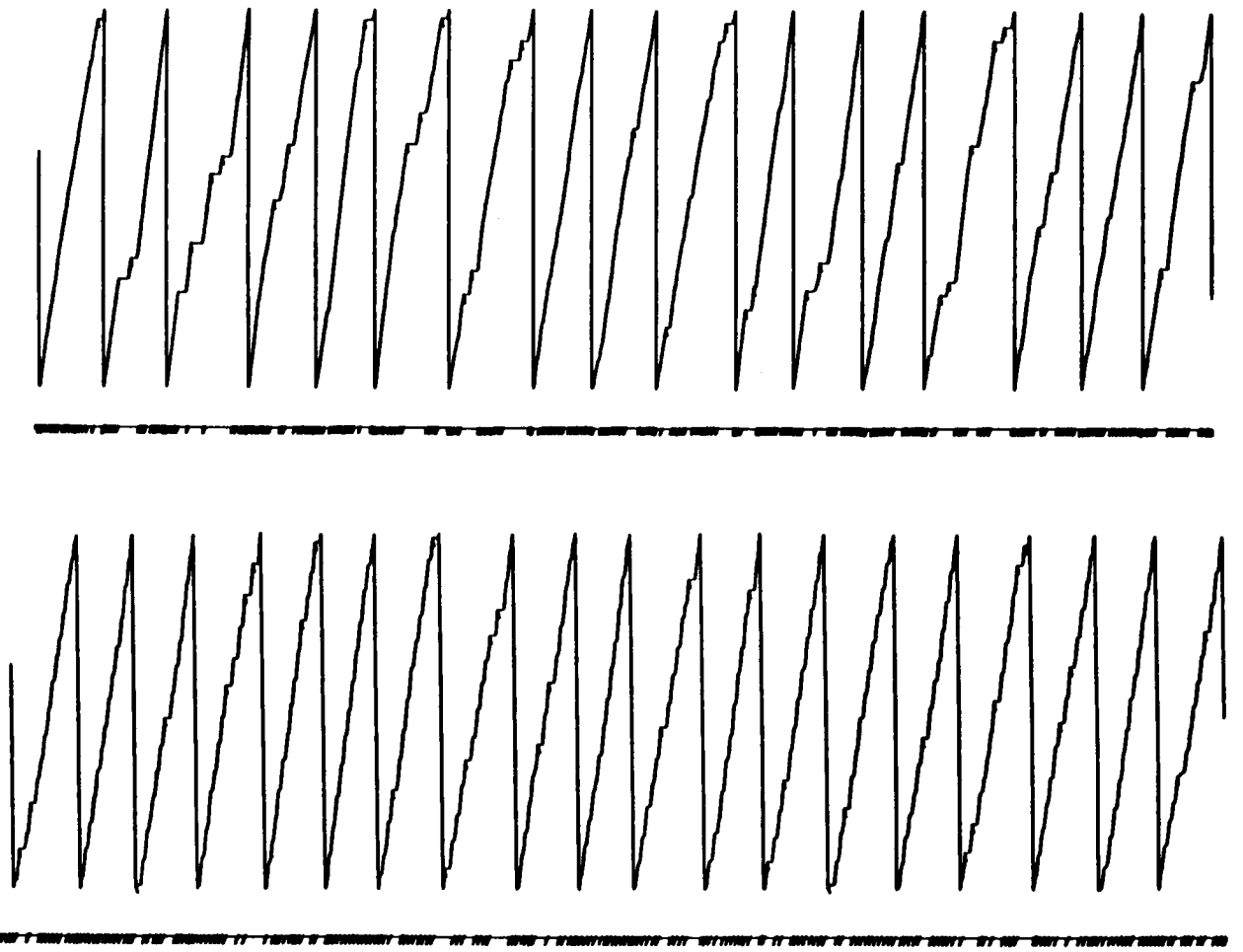

Figure 2. Cumulative records from Bird 99, Experiment I. The top panel shows performance prior to the introduction of the Snp. The bottom panel shows performance when the Snp was present.

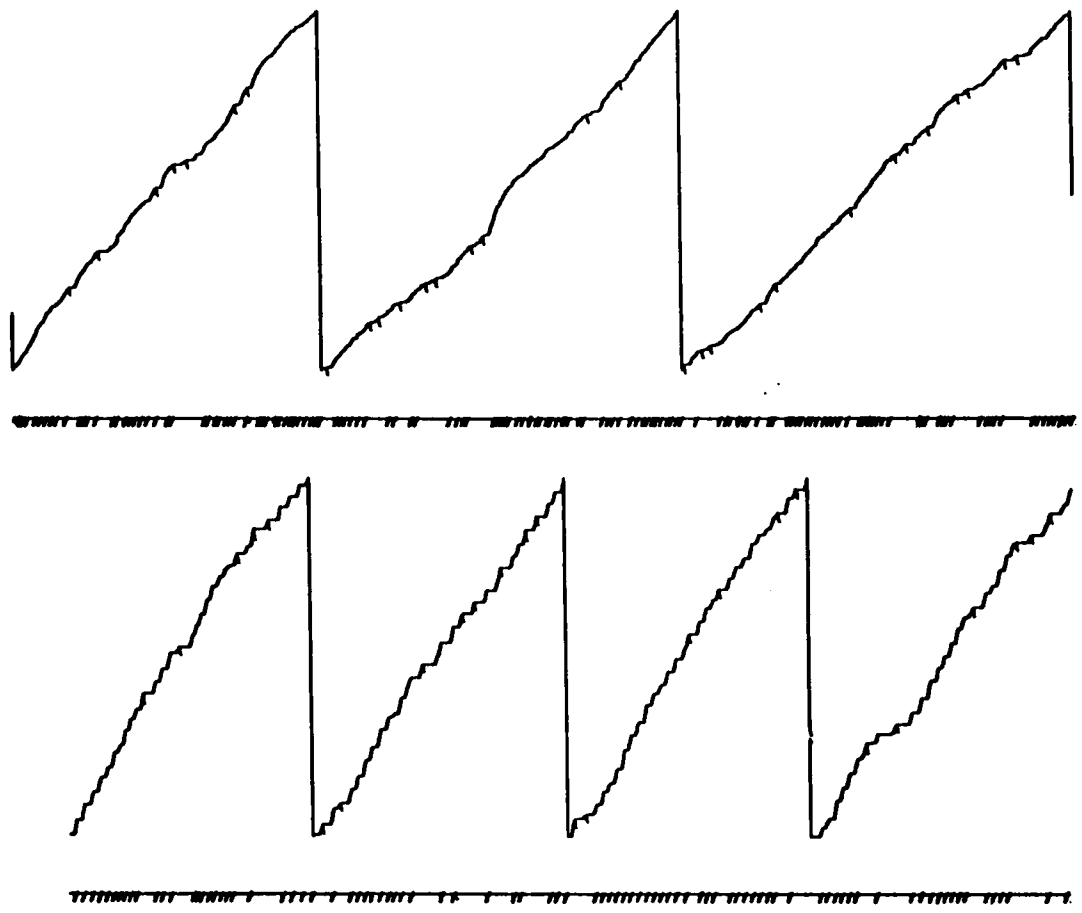

Figure 3. Cumulative records from Bird 65, Experiment I. The top panel shows performance prior to the introduction of the Snp. The bottom panel shows performance when the Snp was present.

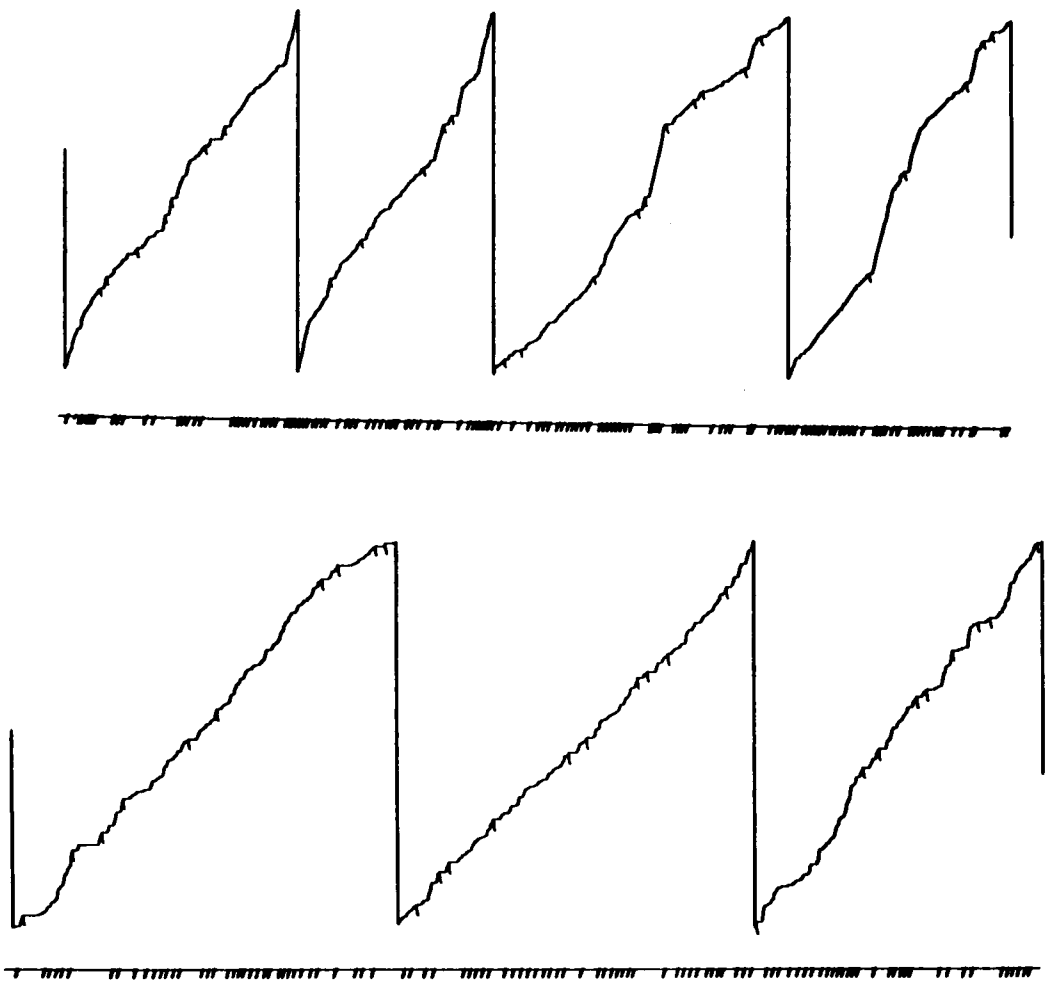

Figure 4. Cumulative records from Bird 94, Experiment I. The top panel shows performance prior to the introduction of the Snp. The bottom panel shows performance when the Snp was present.

course, there were no scheduled changes in the chamber in the first condition [top panels]); while food-presentation is indicated by downward marks on the cumulative response line. A comparison of the top and bottom records in each figure shows the changes in the pattern of responding following the introduction of the Snp. A comparison of the bottom panels across the figures shows the differences in the pattern of responding between the four birds.

Figure 1 shows portions from cumulative records for Bird 92. A comparison of the upper and lower records in the figure shows a clear change in the pattern of responding following the introduction of the Snp. Following the introduction of the Snp, the FR pattern of responding, break and run, under the control of the Snp is readily apparent. This is shown by the sharp transition from pausing to responding, and the relatively constant rate of responding, once begun. Figure 2 shows portions from the cumulative records for Bird 99. The overall change in the rate of responding following the introduction of the Snp into the second-order schedules was not as large as in the case of Bird 92, due to the relatively high response rates in the initial condition. However, the induction of pausing and the sharp transition to responding was clearly apparent. For both birds, the pattern of responding was very similar to that obtained by Shull (1970) in his parametric experiment.

The records for Bird 65 in Figure 3 and Bird 94 in Figure 4 are different in an important aspect from those of the previous birds. Comparison of the top and bottom panels of Figure 3 shows that

responding came under the control of the Snp. But, unlike the previous birds, the transition from pausing to pecking was much smoother, with the rate of responding often showing positive acceleration once responding had begun. The cumulative records for Bird 94 (Figure 4) illustrates another difference in performance from Birds 92 and 99. The differences between the top and bottom panels were not as large as in the three previous figures. However, in this figure, periods of "granularity" are apparent in the bottom record; granularity refers to local variations in responding. Observation during the sessions showed that responding was under control of the Snp, but that during these periods only a very few responses occurred before the FI 5-sec interval requirement was met. Both smooth acceleration of responding and cyclic variations in the amount of responses per interval are characteristic of responding under FI schedules (Dews, 1970, 1978; Ferster & Skinner, 1957).

These differences in the pattern of responding were found to be consistent for the birds across the course of conditions. The differences suggest that the same schedule produced two systematically different types of performance. Birds 92 and 99 responded as if under a FR schedule, and, Birds 65 and 94 responded as if under an FI schedule.

A comparison of cumulative records for all birds prior to the introduction of the Snp was made to see if there was anything obvious which would account for the differences between Birds 92 and 99 versus Birds 65 and 94. There were no obvious differences in

local response rates just prior to food-reinforcement between the pairs of birds, with the exception of the generally higher rate consistently shown by Bird 99. Nor were there obvious differences between the pairs of birds in the acceleration of responding following the post-reinforcement pause.

The pattern of differences was also consistent on a session by session basis. Figure 5 shows the session by session account of responding for Birds 92 and 65, the two birds that showed the clearest differences in averaged performance (i.e., in Table 1, p. 43) across this experiment. This figure shows overall response rates for each component during each session. It begins with the last 5 days of training in the initial condition, in which the Snp was not available, and shows the complete sequence of sessions thereafter (omitting an occasional session in which there was an equipment malfunction). In Figure 5, and throughout the text, the component indicated by the filled-circles was the S+ (i.e., the unaltered component during the Contrast Condition). The particular line-orientation which signaled this component is indicated in the right-hand portion of the figure.

Bird 92's performance, when the Snp was introduced into the schedule, was like that found by Neuringer and Chung. Introduction of the Snp produced a strong reinforcement effect, overall response rates approximately tripled over the course of the condition. In the Contrast Condition, elimination of the Snp from S- (the altered component) produced positive behavioral contrast, an increase in

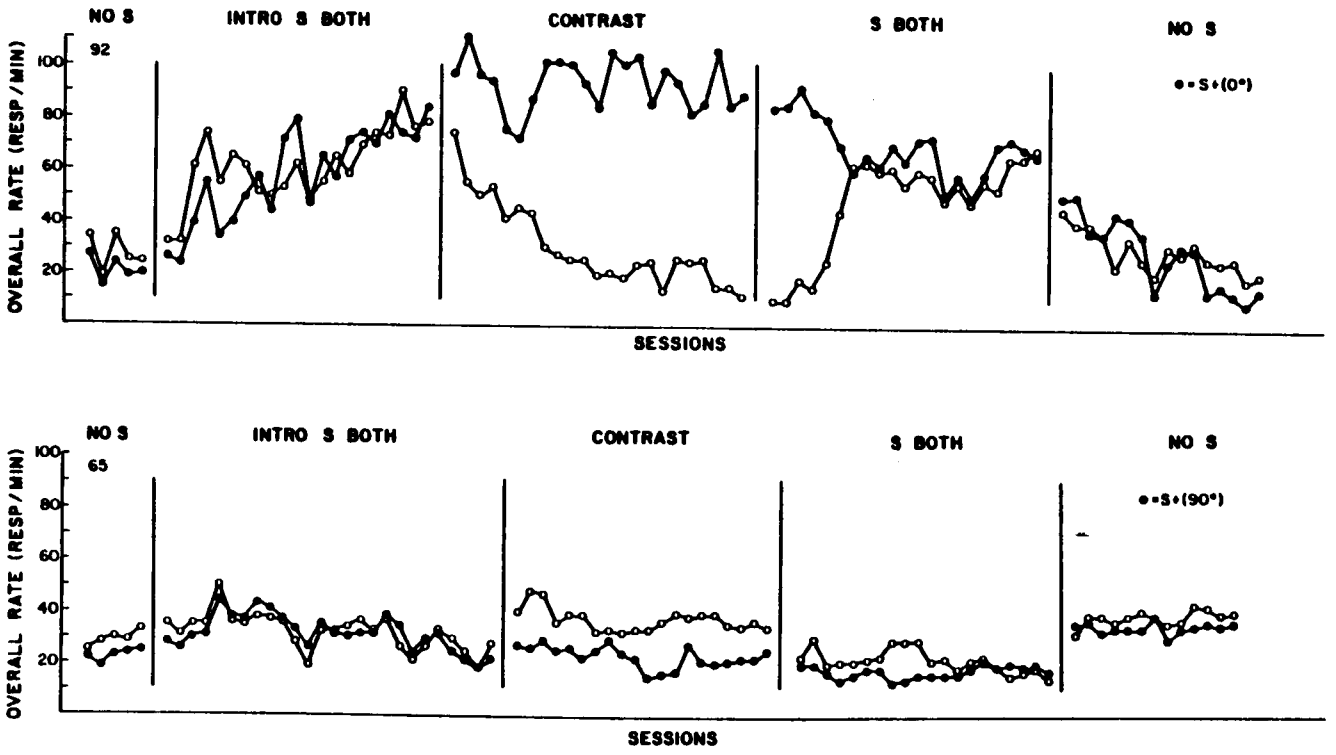

Figure 5. Results for Birds 92 and 65, Experiment I. Performance according to overall response rates.

response rates in S+ (the unaltered component). The return of the Snp to the altered component produced a return of response rates for both S+ and S- to their former levels. The recovery of the former response rates during S+ showed that the increase during the Contrast Condition was due to the removal of the Snp. Elimination of the Snp from both components in the final condition led to a decline in response rates to the levels observed prior to the introduction of the Snp. Hence, manipulation of the presence of the Snp produced effects in the same manner as is often produced by manipulation of food-reinforcement.

The response rates for Bird 65 show a very different pattern of changes. Introduction of the Snp produced a small and transient increase in overall response rates, followed by a gradual decrease over the course of the condition. This decrease was due in large part to the development of pausing under control of the Snp, as shown in the cumulative record in Figure 3 (p. 48). In the Contrast Condition, response rates during S- showed an immediate increase. This was due in large part to the elimination of post-Snp pauses, since the Snp no longer occurred in that component. Response rates during S+ showed virtually no change during this condition. Reinstatement of the Snp into the S- component produced a decline in overall response rates, due to the reestablishment of post-Snp pausing. Elimination of the Snp from both components in the final condition resulted in an immediate and sustained recovery of the initial response rates.

Figure 5 shows that the results summarized in Table 1 (p. 43) accurately reflected the pattern of changes on a session by session basis for Birds 92 and 65. The session by session results for Bird 99 were consistently like that of Bird 92, although the effects were never as large. The session by session results for Bird 94 were like that of Bird 65, with the exception that there was also a gradual increase in overall response rates over the later conditions.

Discussion

Four birds were exposed to a sequence of conditions designed to replicate the findings of Neuringer and Chung (1967) within a multiple schedule, and to determine whether the elimination of the Snp from one component of the multiple schedule would result in positive behavioral contrast in the unaltered component. Such a result would show a functional parallel between the effects of manipulating food and the Snp. This would show that the Snp was a positive reinforcer as a consequence of being encountered in a second-order schedule.

Following introduction of the Snp into the second-order schedules, two different patterns of responding developed. An examination of cumulative records showed that responding had come under control of the Snp for all subjects. One pattern of responding was best characterized as FR performance. This pattern showed a rapid transition from pausing to pecking, and a constant rate of

responding, once responding had begun (i.e., break and run). This pattern of responding was shown by Birds 92 and 99. A second pattern of responding was shown by Birds 65 and 94. This pattern of responding was best characterized as FI performance and differed from the other pattern in the following respects. There was a more gradual transition from pausing to pecking, with instances of positive acceleration of response rate (i.e., scalloping). There was cyclic variation also in the number of responses per interval, a second characteristic of FI responding.

There were no obvious local differences in the pattern of responding prior to the introduction of the Snp which accounted for the differences between the birds. But for any particular subject, the pattern of responding was consistent across the sequence of conditions. Although the emergence of an FI pattern of responding under (tand FR 1 FI 5-sec) has not been reported before, it is not that surprising a finding since it is essentially an interval schedule.

The differences between Birds 92 and 99 versus Birds 65 and 94 were reflected also in overall response rates. Birds 92 and 99 showed both a reinforcement effect, when the Snp was introduced, and positive behavioral contrast. The effect included both an increase in response rates in the unaltered component during the Contrast Condition, and recovery of the former levels of performance in the unaltered component following reinstatement of the Snp into the S- component. On the other hand, the overall response rates of Birds

65 and 94 did not show a reinforcement effect when the Snp was introduced. Instead, there was a transient increase and gradual decline over the course of the condition. Nor was there a positive behavioral contrast effect observed when the Snp was eliminated. Little effect was observed on overall rates in S+, while response rates during S- showed an increase due to the elimination of post-Snp pauses following the removal of the Snp.

Contrast effects may or may not be evidenced in overall response rates under FI schedules. FI scalloping is maintained under food-contrast situations (Reynolds & Catania, 1961) and such a pattern often prevents the occurrence of differences in rates of responding (Staddon, 1969). Positive contrast effects are evidenced by decreases in pause duration, whether an FR or an FI schedule is in effect. There appeared to be instances of pause reduction in the cumulative records during the Contrast Condition. However the intervals used here were quite short, and quantitative data were not readily available. The next experiment was therefore carried out to obtain quantitative data on changes in pause times across the sequence of conditions. Data on positive contrast would thus be available whichever pattern of responding emerged.

CHAPTER III

EXPERIMENT II

In the previous experiment not all subjects showed the FR pattern of responding previously reported to develop under (tand FR 1 FI X-sec) by Shull (1970). Instead, patterns of responding developed that characterize FI performance. Only overall response rate data were available in the first experiment, which hampered interpretation of the effects. Overall response rates are often unreliable as indicators of changes in responding under FI schedules (Richelle & Lejeune, 1980) and the problem was accentuated here given the short duration of the interval used. FI performance is characterized by a gradual acceleration of responding. The 5-sec interval does not allow enough time to show much differentiation in terms of overall response rates, since the calculation of overall response rates also incorporates pause times.

In this experiment two new subjects were exposed to the sequence of conditions used in Experiment I. However, the recording apparatus was modified so that quantitative data were obtained on changes in the local pattern of responding. The measures of responding now included average running rate and cumulative pause time per session. Average running rate refers to the number of responses occurring during the response-initiated interval divided by the time in the interval, averaged over each session. Cumulative pause time refers to the sum of the time over the course of a

session from the offset of each Snp cycle to the first response which initiated the next FI 5-sec interval. This permitted a dissociation of the contributions of pausing and responding to the overall response rate measure.

These additional measures increased the chances of observing positive contrast effects if they occur, even though overall response rates may not be strongly affected. If an FI pattern of responding develops and positive contrast effects do occur, they should be seen as a reduction in pause times (Staddon, 1969) or as an increase in the number of responses per interval (Reynolds & Catania, 1961). If an FR pattern of responding develops, positive contrast effects should primarily be seen as reductions in pause times (Crossman, 1968; Reynolds, 1961b; Shuster, 1959).

Method

Subjects

Two adult pigeons, a White Carneaux (Bird 74) and a Silver King (Bird 68), were maintained at approximately 80% of their free-feeding weights over the course of the experiment. Both subjects had previous experimental histories of varying kinds. Neither had previous experimental experience with either FR, FI, or second-order schedules.

Apparatus

The apparatus was the same as that used in Experiment I, with the addition of time-recording devices to the programming and recording equipment.

Procedure

The same basic procedure and sequence of conditions were followed as in Experiment I. The pause and pecking phases of responding were computed in the following manner. The response which initiated the FI 5-sec interval also started a running-time meter which was stopped by the first response to occur following the passage of the interval. Average running rate was computed by dividing the number of responses during that component by the cumulated running time for that component for each session. Cumulative pause time was computed by subtracting the cumulated running time, food-cycle time, and Snp-cycle time from the programmed session time for that component (1800-sec). Transitions between components stopped the running meter if it was operating and, as before, reset the response requirements of (tand FR 1 FI 5-sec). The same recording techniques were used, whether or not the Snp was presented, to permit comparisons between all conditions.

Results

Figures 6 and 7 show the results of the experiment for Birds 68 and 74, respectively. Each figure begins with the last 10 sessions of responding in the initial baseline condition, in which no Snp was presented, and shows the complete sequence of conditions and sessions thereafter, omitting an occasional session during which there was an equipment malfunction. Each figure shows the session by session account of the three measures of responding concurrently; the top row shows overall response rates, the middle row shows average running rates, and the bottom row shows cumulative pause times per session. Hence, one may look at a change in overall response rates and determine whether the change was due to effects on running rates and/or pause times by examining the appropriate data points immediately underneath. As in Experiment I, the component which was treated as S+ in the Contrast Condition (i.e., the unaltered component) is indicated by filled circles. The particular line-orientation used to signal the S+ component is indicated in the top right-hand portion of the figure.

Figure 6 shows the results for Bird 68. Introduction of the Snp in the second condition produced a series of changes in overall response rates that were similar to those observed with Bird 65 in the previous experiment. There was a transient increase in overall response rates that was followed by a steady gentle decline to levels lower than the final sessions of the initial condition.

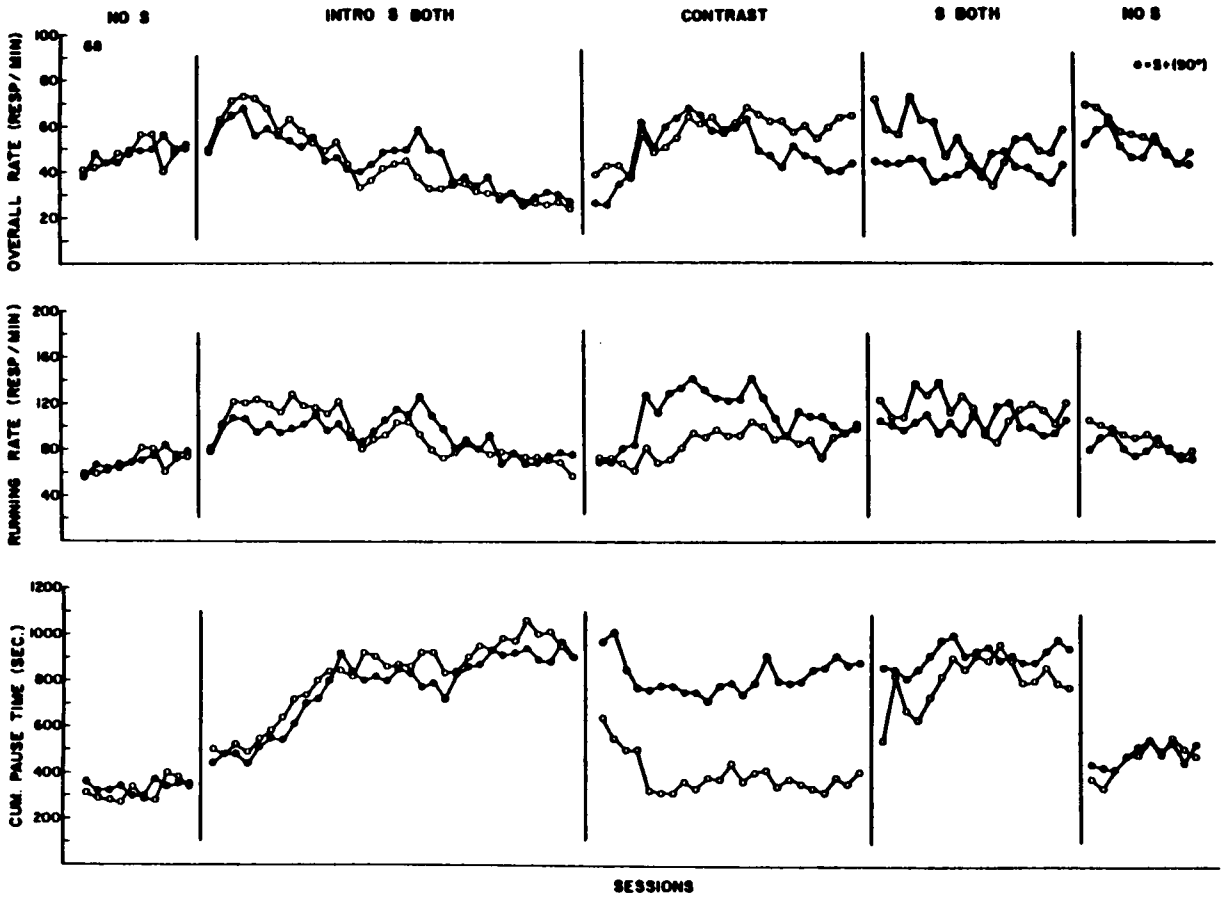

Figure 6. Results for Bird 68, Experiment II. Performance is shown concurrently for the three response measures: overall response rates, running rates, and cumulative pause times (top to bottom).

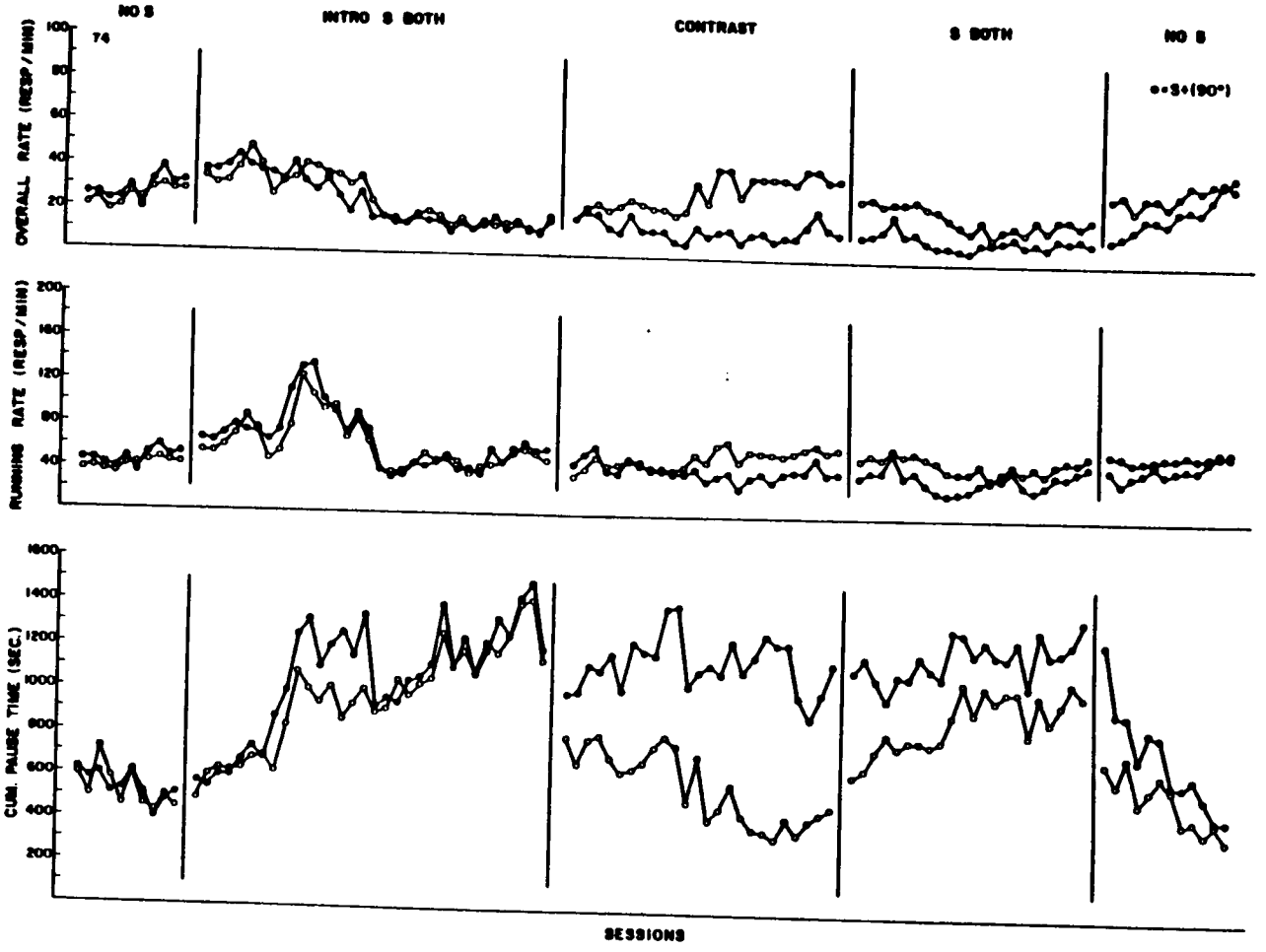

Figure 7. Results for Bird 74, Experiment II. Performance is shown concurrently for the three response measures: overall response rates, running rates, and cumulative pause times (top to bottom).

An appreciation of the dynamic changes in the pattern of responding which resulted from the introduction of the Snp comes from an examination of the lower portions of the figure. It shows that running rates and pause times were not simply alternative measures of the same change; that is, it was not the case, following the introduction of the Snp, that the change in performance at the level of the unit-schedule simply consisted of inducing pauses in the stream of responding. This was clearest in the initial sessions following the introduction of the Snp. Both running rates and pause times increased. This showed that the subject pecked faster, when pecking, and paused longer, when pausing. The gradual decline in overall response rates over the course of the condition was due to a continued increase in pause times and a decline in running rates.

Cumulative records, over the course of this condition, showed that the pattern of responding was best characterized as FI performance. Both scalloping and variation in the number of responses per interval were clearly evident. Scalloping, the gradual acceleration of responding, was reflected in Figure 6 as the decline in running rates over the course of the second condition.

In the Contrast Condition, positive behavioral contrast was observed in overall response rates in S+. Changes in both running rates and pause times contributed to the effect, with running rates increasing and pause times decreasing. Overall response rates in S- (the altered component) were either equal to or higher than in S+. The lower panels show that this was due to the elimination of

pausing following removal of the Snp, since running rates in S- were lower than in S+.

In the next condition, the reintroduction of the Snp into the S- component produced an increase in both running rates and pause times for that component. The increase in pause times produced the predominant effect on overall response rates, as overall rates continued to decline over the course of the condition. The effect on responding in S+ in this condition was more modest. Overall response rates and running rates showed little change from the final sessions of the Contrast Condition. Pause times, on the other hand, showed a recovery of the levels observed prior to the Contrast Condition. Removal of the Snp from both components in the final condition resulted in the recovery of the pattern of responding that was observed in the initial condition.

An examination of cumulative records from the conditions immediately prior to and following the Contrast Condition suggested that the pattern of responding had changed for Bird 68. Figure 8 shows representative portions of cumulative records from these two conditions. The top panel of the figure is from a session just prior to the Contrast Condition. The bottom panel is from a session following the Contrast Condition, and, just prior to the final condition of the experiment. There were important changes in the pattern of responding. Prior to the Contrast Condition, FI performance was seen. The transitions from pausing to pecking were gradual, with frequent occurrences of positively-accelerated

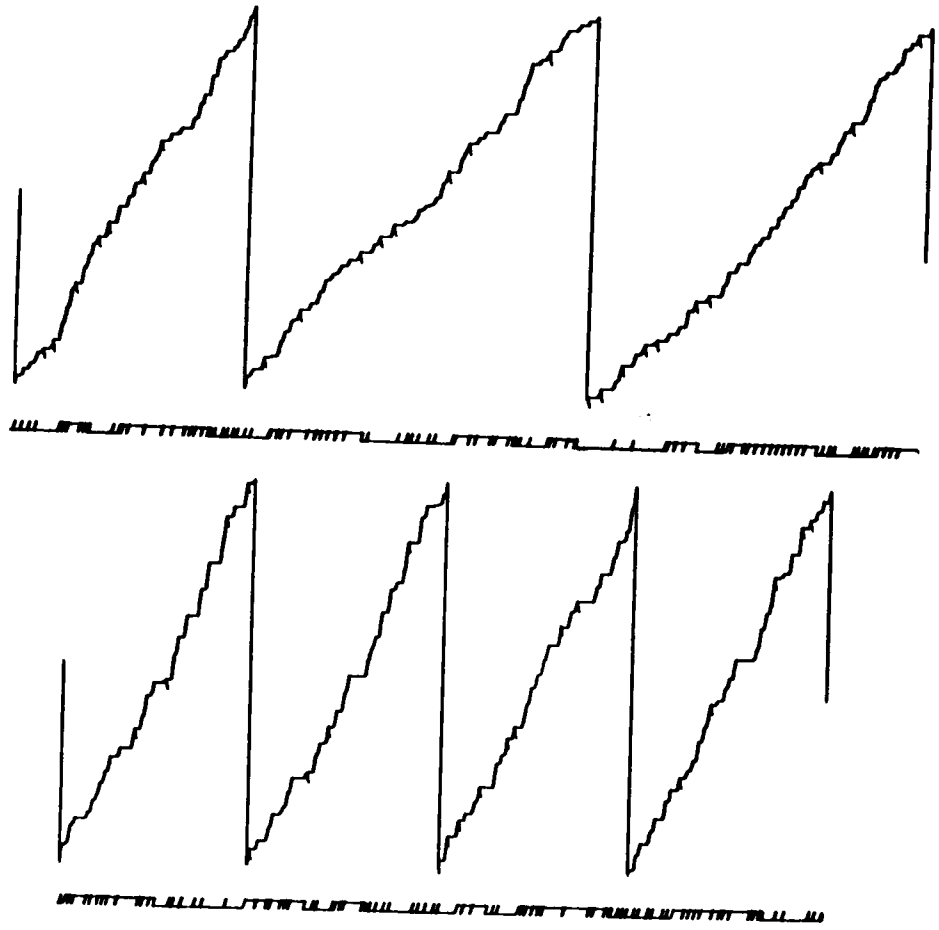

Figure 8. Cumulative records from Bird 68, Experiment II. The top panel shows performance prior to the Contrast Condition. The bottom panel shows performance following the Contrast Condition.

responding. Following the Contrast Condition, transitions were more sharply defined and responding, once begun, often occurred at a constant rate. In other words, the pattern of responding appeared to have changed from an FI to an FR pattern during the Contrast Condition.

Figure 6 (p. 62) shows that this change in the pattern of responding was reflected in the changes observed in running rates during these conditions. Running rates showed a large increase in S+ during the Contrast Condition but did not decline to their former levels in the next condition. This suggests that the change in the pattern of responding was a consequence of the Contrast Condition and was a "metastable" effect, that is, an effect induced by a change in conditions that is not reversed when conditions are reversed (Staddon, 1965).

Figure 7 (p. 63) shows the results of the experiment for Bird 74. Introduction of the Snp in the second condition produced a series of changes that were similar to those observed with Bird 68. Overall response rates showed a transient increase and then declined to below the levels observed in the initial condition. Part of the effect on overall rates was due to a similar change in running rates. Running rates also showed a transient increase and then declined to levels that were approximately equal to those observed in the first condition. Cumulative pause times, however, continued to increase over the course of the second condition until, by the last 5 sessions, approximately 75% of the session was accounted for

by pause times. An examination of cumulative records showed that the pattern of responding was best characterized as FI, with gradual acceleration of responding following post-Snp pauses. Figure 9 shows a portion of a cumulative record from Bird 74 during this condition.

In the Contrast Condition, overall response rates and running rates during S+ showed little change from the previous condition. Positive behavioral contrast occurred primarily as a reduction in cumulative pause times, although the data were erratic. Like Bird 68, overall response rates during S- increased over the course of the condition. The lower panels of the figure show that this was due to the joint contribution of decreased pause times following the elimination of the Snp from that component, and, to a much lesser extent, an increase in running rates as the pattern of responding returned to what was observed in the first condition of the experiment.

Reinstatement of the Snp into S- in the next condition resulted in a recovery of the FI pattern of responding in that component. Overall response rates declined, as the time consumed by pausing increased. Running rates were relatively unaffected. Practically no changes were observed in either overall response rates or in running rates in S+ during this condition. But cumulative pause times showed an increase to the levels observed just prior to the Contrast Condition. The recovery of the previous levels of pause times showed that the decline observed during the Contrast Condition did represent positive behavioral contrast.

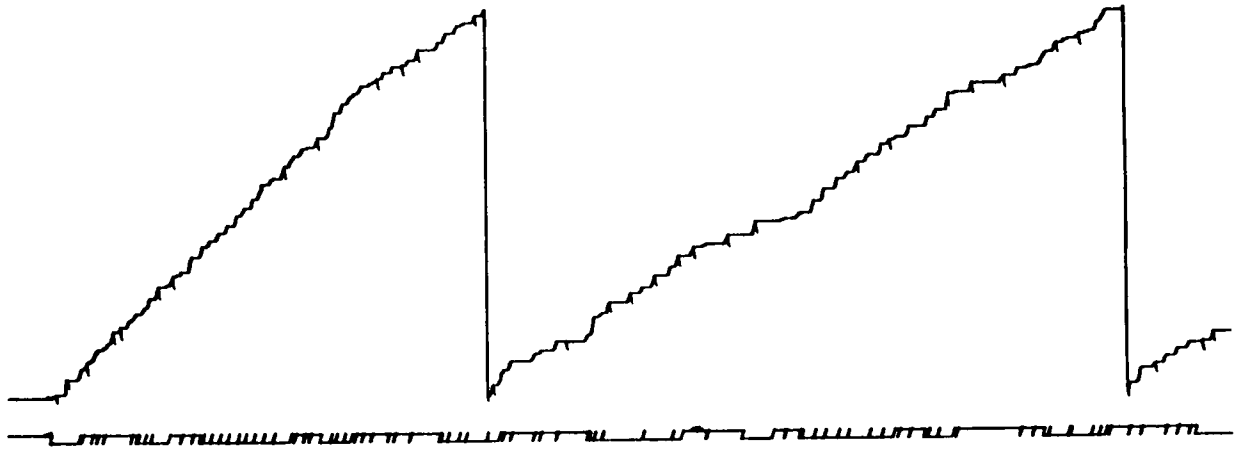

Figure 9. Cumulative record from Bird 74, Experiment II. Performance when the Snp was present.

Elimination of the Snp from both components in the final condition of the experiment resulted in a recovery of the initial pattern of responding. Overall response rates increased, due primarily to the elimination of pausing induced by the Snp. Running rates in S+ showed a gradual decrease, while running rates in S- showed little change.

Discussion

The additional measurement of pause times and running rates showed more clearly the pattern of changes induced by manipulating the presence of the Snp in the second-order schedule. Introduction of the Snp resulted in a reinforcement effect. Cumulative records showed the development of an FI pattern of responding for both birds. The effect of this pattern of performance on the new measures was seen as a large increase in pause times and a transient increase in running rates. The combination of the changes in pausing and pecking resulted in a decline in overall response rates, as pausing consumed the major portion of the session.

Positive behavioral contrast was observed in S+ during the Contrast Condition. For both birds, this was reflected in a reduction in cumulative pause times. This finding parallels Staddon's (1969) results when manipulating food-reinforcement rates in multiple FI FI schedules. Reinstating the Snp into the altered component in the next condition resulted in a recovery of the levels of pause times observed prior to the Contrast Condition; which

showed that the pause time reduction was a consequence of the Contrast Condition. In addition, Bird 68 showed an increase in running rates during the Contrast Condition that did not dissipate during the next condition. Cumulative records for Bird 68 showed that the pattern of responding had changed to an FR pattern during the Contrast Condition and, perhaps, as a consequence of the condition. The cumulative records for Bird 74 showed an FI pattern of responding, when the Snp was present, throughout the course of the experiment.

Unlike the report of Shull (1970), the patterns of responding on cumulative records here were best characterized as FI prior to the Contrast Condition for both birds. There are a number of measures designed to characterize quantitatively the pattern of responding under fixed-interval schedules (see Richelle & Lejeune, 1980, for a general review of the methodological issues in the measurement of the temporal pattern of responding). For example, Dews' (1978) "acceleration index" is designed to distinguish between FI and FR responding by differentiating whether responding, once begun, continues to accelerate throughout the rest of the interval (i.e., FI) or is fairly constant in rate, once begun (i.e., FR; but see Mazur & Hyslop, 1982, for more recent work on the constancy of response rates under FR). Unfortunately, such measures depend on subdividing the interval into several portions to compare response rates among the portions and, thus, are impractical with a 5-sec interval.

If the pattern of responding was FI, this would explain the transient increase in running rates. Running rates were computed by having the first post-Snp/food response start a running time meter, which was then stopped by the first response following the completion of the 5-sec interval. As scalloping began to develop a greater proportion of the response-initiated interval would be taken up by the more gradual acceleration of responding under FI (relative to FR). This would be reflected in running rates as a decline.

Bird 68 showed a change in the pattern of responding from FI to FR during the Contrast Condition. This change persisted through the next condition. It would appear that the response rate increase in S+, that was produced by the removal of Snp from the other component, became entrained by the schedule such that the increase was metastable (i.e., did not reverse when the original conditions were reinstated). This possibility is strengthened by the results of Experiment I which showed that either pattern of responding was maintained by (tand FR 1 FI 5-sec). On the other hand, it may simply be that the results reflect a progressive change in the pattern due to continued exposure to the situation. Whichever interpretation is the better, the results of Experiments I and II suggested that (tand FR 1 FI 5-sec) was an "unstable" schedule arrangement in terms of the pattern of responding that could be expected to occur.

Arnett (1972) also reported a change in response rates in the terminal link of the concurrent-chain that contained (tand FR 1 FI 5-sec:Snp). She found that "local" response rates declined in

that terminal-link over the course of the experiment and suggested that the reinforcement effect "adapts out." She reported no other measures of responding. The results of the two experiments here suggest an alternative possibility, which is a shift in the pattern of responding under the schedule. In these experiments, either overall response rates or running rates, taken alone, were not always good indicators of the pattern of performance. The pattern of responding that was observed on the cumulative records was best reflected in the combination of measures used here.

Although manipulating the presence of the Snp did induce positive contrast, this was not necessarily because the Snp occurred in a second-order reinforcement schedule. For example, it could be that the disruption in responding caused by simply removing the Snp from the situation was responsible for the contrast effect. A comparison is still necessary with conditions in which the Snp is manipulated in a similar manner, while not appearing in a second-order schedule relationship.

However, the above experiments suggested that the unit schedule, (tand FR 1 FI 5-sec), was an unstable arrangement. The particular pattern of responding that emerged depended on, as yet, unspecified conditions and such performances were often metastable. Since the general design of the experimental sequence requires stable and recoverable patterns of responding across conditions, such effects present practical problems of interpretation. Neuringer and Chung (1967) also used (FR 11) as a

unit in a second-order schedule and obtained a reinforcement effect. In this case, ratio performance is explicitly scheduled. The decision was made to switch to this unit schedule to see if the pattern of changes was more appropriate for the purposes of these experiments.

CHAPTER IV

EXPERIMENT III

The two previous experiments showed that manipulating the presence of a brief stimulus in a multiple second-order schedule produced both reinforcement and positive behavioral contrast effects in a manner similar to effects produced by the manipulation of food. The two previous experiments also showed that disparate patterns of responding (either FR or FI) could be equally well maintained under VI 1-min (tand FR 1 FI 5-sec:Snp). Further, in Experiment II, the pattern of responding by Bird 68 changed from FI to FR during the Contrast Condition and this new performance was maintained even when the prior condition was reinstated. This metastable effect, in combination with the finding that sometimes an FI and sometimes an FR response pattern would emerge, suggested that the unit schedule (tand FR 1 FI 5-sec) was an unstable schedule arrangement for purposes of the experiments here. This is because the general design of the experimental sequence requires stable and recoverable patterns of responding.

Neuringer and Chung (1967) also used (FR 11) as the unit in a second-order schedule. The decision was made to switch to this second-order schedule to see if more stable patterns of responding would develop. A second purpose of this experiment was to see whether manipulating the presence of the Snp would produce reinforcement and positive behavioral contrast effects under a

different multiple second-order schedule. If such effects do occur, this would extend the generality of the previous findings by showing that the effects were not dependent on the use of a particular second-order schedule.

The same sequence of conditions was used as in the previous experiments. The performance measures included overall response rate, running rate, cumulative pause time, and cumulative records, as in Experiment II. The major change consisted of the use of VI 1-min (FR 11) as the second-order reinforcement schedule. In this case FR performance was explicitly scheduled. If the characterization of performance as FI in the previous experiments was correct, then FR performance, explicitly scheduled here, should produce different effects on the response measures. In particular, the increase in running rates should be larger and less transient than was observed with FI performance. Positive contrast effects should occur primarily as a reduction in pause times, but will also be reflected to some extent by an increase in overall response rates, given the relative constancy of ratio responding.

Method

Subjects

Three adult pigeons (Birds 93, 95, and 89) were maintained at approximately 80% of their free-feeding weights over the course of the experiment. All subjects had previous experimental histories of

varying kinds. None had previous experimental experience with either FR, FI or second-order schedules.

Apparatus

The apparatus was the same as used in the previous experiments.

Procedure

The procedure was the same as in the previous experiments except in the following aspects. Following handshaping, the initial condition consisted of 20 sessions of the multiple schedule in which responding during a component was reinforced according to VI 1-min (FR 11). Under the second-order schedule VI 1-min (FR 11), (FR 11) is treated as a unitary response which is reinforced by food according to VI 1-min. In practice, the FR counter began at zero at the beginning of each component. The first 10 responses were recorded but had no scheduled consequences in the experimental chamber. The eleventh response resulted in one of two mutually exclusive events. If the VI 1-min tape had programmed food-reinforcement, the response produced 3-sec access to mixed grain. If the VI 1-min tape had not programmed food-reinforcement, no scheduled consequences occurred in the chamber for the first 20 sessions. But, as in the previous experiments, the Snp cycle did occur in its effect on the programming and recording equipment. During an Snp or food cycle, the response counters were disabled and the FR counter was both disabled and reset to zero. The cumulative

recorder continued to record all responses on the key throughout the session.

Following the initial condition, the Snp was introduced into the schedule, and the second-order schedule became VI 1-min (FR 11:Snp). As in the previous experiments, the Snp consisted of a 1-sec period during which a red houselight was illuminated and the response key was darkened. As before, the response key continued to be illuminated during food cycles but was darkened during the 1-sec transition between components. Completion of the FR 11 requirement resulted in food if the VI 1-min tape had programmed food-reinforcement; otherwise completion of the FR 11 requirement resulted in the Snp. This condition lasted approximately 30 sessions and was followed by the Contrast Condition. Under the Contrast Condition, the Snp was removed from one component of the multiple schedule for approximately 22 sessions. It was returned in the next condition, which lasted approximately 22 sessions also. The Snp was removed from both components of the multiple schedule in the final condition (approximately 13 sessions).

Overall response rates equaled the number of responses in a component in a session divided by the programmed session time for that component (1800-sec). Average running rates were computed in the following manner. The first response under FR 11 started a running-time meter, which was stopped by the completion of the FR 11 requirement (or the end of that component). Average running rate equaled the number of responses in that component during a session

divided by the cumulated running-time for that component during a session. Cumulative pause time per session was computed, as before, by subtracting cumulated running-time, Snp cycle time, and food cycle time from the programmed session time for that component.

Results

Figures 10, 11, and 12 show the results of the experiment for Birds 93, 95, and 89, respectively. As in the previous experiment, each figure begins with the last 10 days of training under the initial condition and shows the complete sequence of sessions and conditions thereafter, omitting the occasional session during which there was an equipment malfunction. S+ (filled circles) indicates the component which was not altered during the Contrast Condition, and the particular line-orientation which signaled that component is indicated in the upper right-hand portion of the figure. Each figure shows the session by session account of the three measures of responding concurrently; the top row shows overall response rates, the middle row shows average running rates, and the bottom row shows cumulative pause times per session. Hence, one may look at a change in overall response rates and determine whether the change was due to effects on running rates and/or pause times by examining the appropriate data points immediately underneath.

Figure 10 shows the results of the experiment for Bird 93. The introduction of the Snp produced a reinforcement effect on overall response rates. An examination of the lower portions of the figure

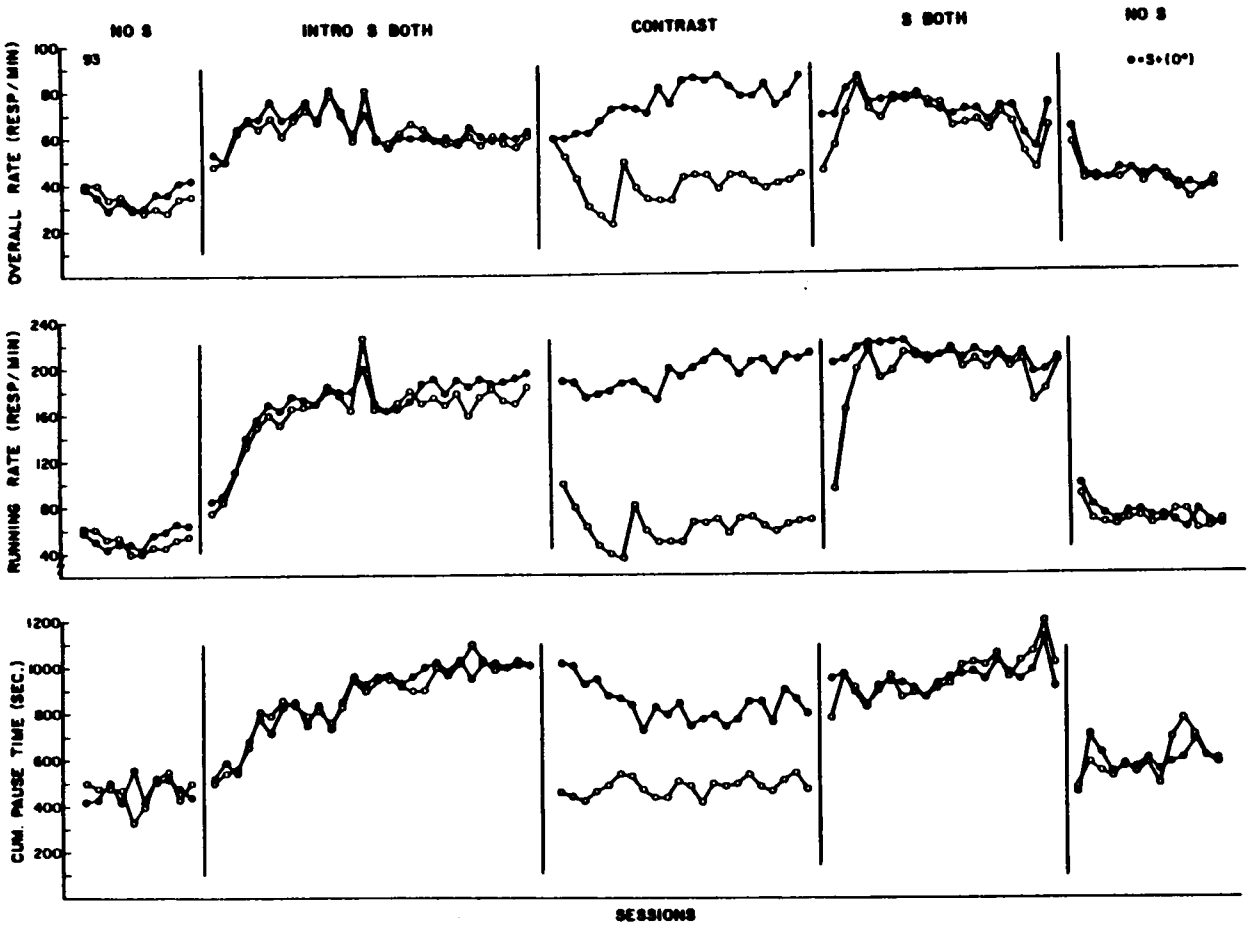

Figure 10. Results for Bird 93, Experiment III. Performance is shown concurrently for the three response measures: overall response rates, running rates, and cumulative pause times (top to bottom).

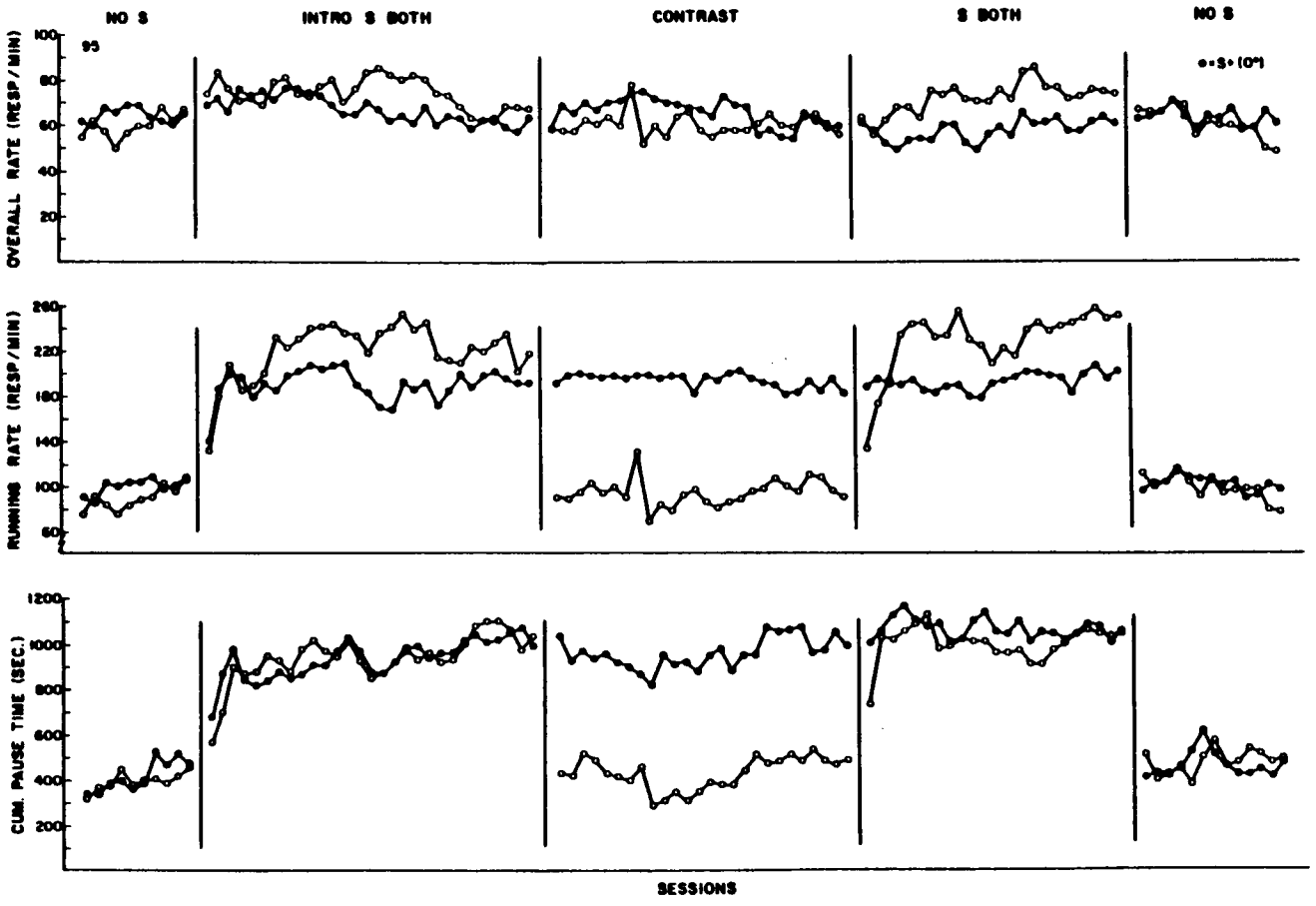

Figure 11. Results for Bird 95, Experiment III. Performance is shown concurrently for the three response measures: overall response rates, running rates, and cumulative pause times (top to bottom).

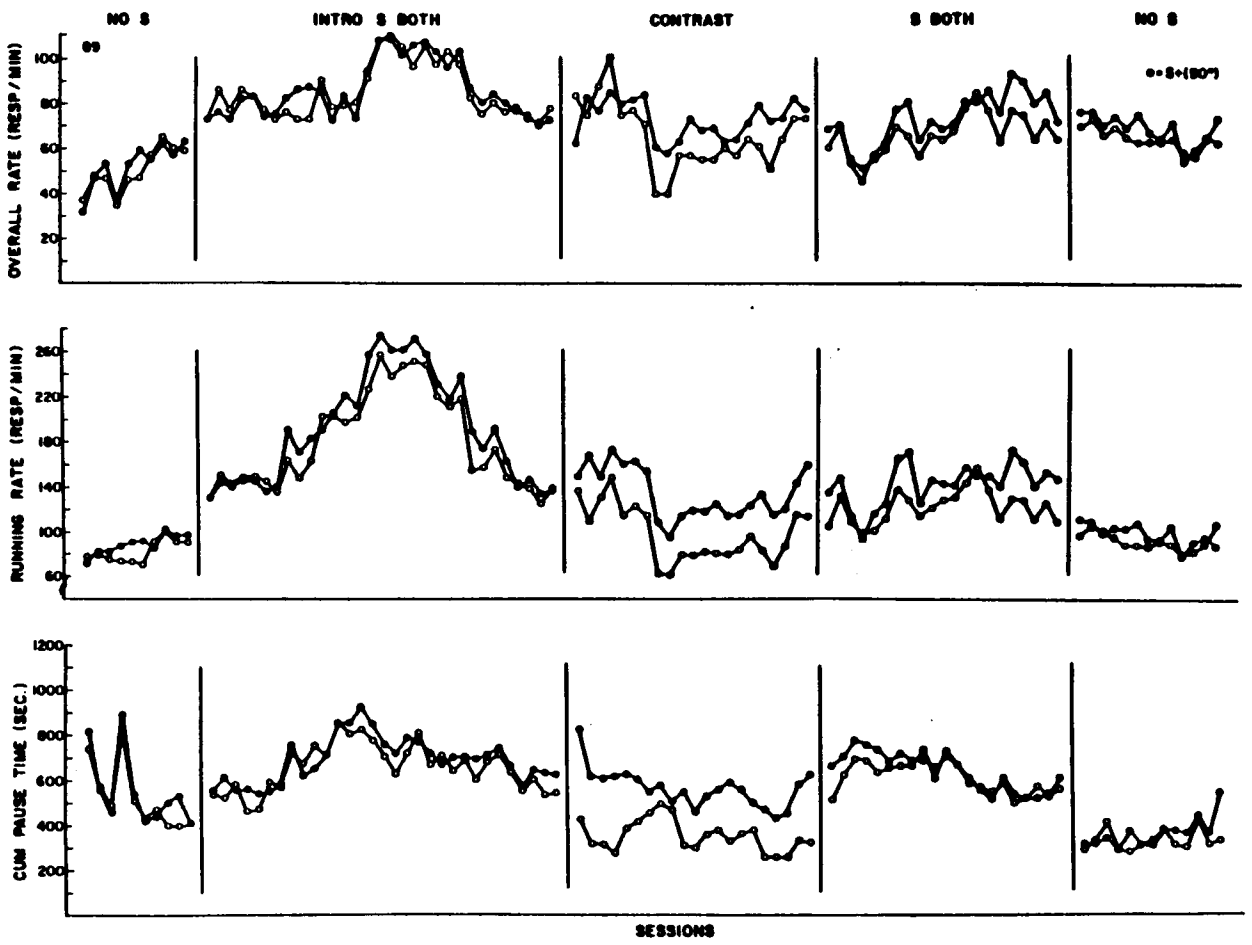

Figure 12. Results for Bird 89, Experiment III. Performance is shown concurrently for the three response measures: overall response rates, running rates, and cumulative pause times (top to bottom).

shows that there was a simultaneous increase in both pause times and running rates. Pause times doubled and running rates quadrupled over the course of the condition.

Figure 13 shows representative portions from cumulative records obtained from the latter sessions of the first two conditions with Bird 93. The top panel of the figure shows a section from a cumulative record prior to the introduction of the Snp, and the bottom panel shows a section from a cumulative record following the introduction of the Snp into the schedule. It can be seen that the pattern of responding was clearly changed by the introduction of the Snp and was best characterized as an FR pattern. There were both sharp transitions between pausing and responding, and a relatively constant rate of responding, once begun.

In the Contrast Condition, positive behavioral contrast was evident in overall response rates in S+. The lower portions of Figure 10 show that the effect was primarily due to a reduction in pause times, although running rates in S+ continued to show a gradual increase over the course of the Contrast Condition. The elimination of the Snp from the S- resulted in a return to the pattern of responding observed in the initial condition for that component.

Reinstatement of the Snp into the S- component in the next condition produced a recovery of the FR pattern of responding in that component. Overall rates of responding in S+ in this condition declined, but did not return completely to the levels observed just

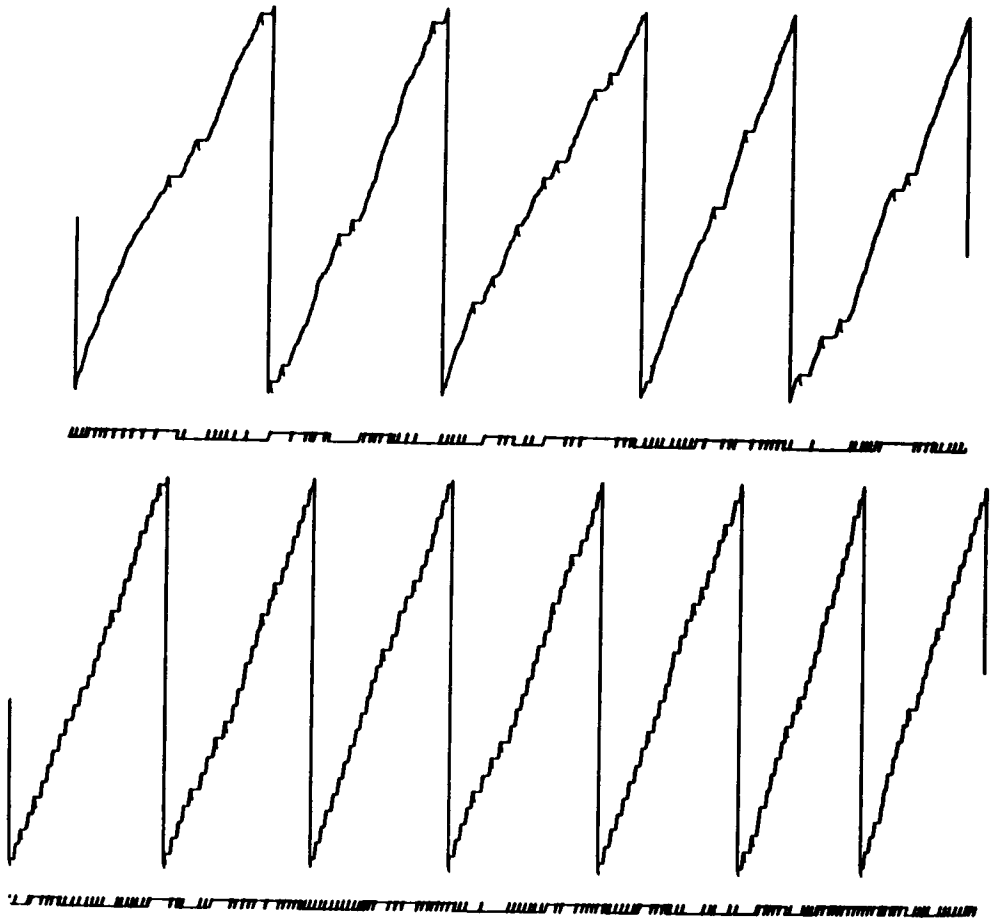

Figure 13. Cumulative records from Bird 93, Experiment III. The top panel shows performance prior to the introduction of the Snp. The bottom panel shows performance when the Snp was present.

prior to the Contrast Condition. The lower portions of the figure show that there was recovery of the former levels of pause times, but that running rates continued to be maintained at the levels found at the end of the Contrast Condition. In the final condition, elimination of the Snp from both components produced a decline in overall response rates, as the pattern of responding returned to what was observed in the initial condition.

Figure 11 shows the results for Bird 95. Introduction of the Snp into the second-order schedules in both components did not produce a large effect on overall response rates. The lower portions of the figure show that this was due to the action of the joint increase in running rates and pause times, as both more than doubled over the course of the condition. Cumulative records showed the development of an FR pattern of responding similar to that shown for Bird 93.

In the Contrast Condition, overall response rates in S+ showed an increase over previous levels of responding. The positive behavioral contrast in this case was clearly due <u>solely</u> to the reduction in pause times, as running rates remained remarkably constant over the course of the condition. The removal of the Snp from the S- component resulted in a return to the pattern of responding in this component that was observed in the initial condition.

The reinstatement of the Snp into the S- in the next condition resulted in a recovery of the FR pattern of responding in that

component, as running rates and pause times increased to the levels observed in the second condition. Overall response rates in S+ showed a small decline for 15 sessions and eventual recovery of the rates observed just prior to the Contrast Condition. The lower portions of the figure show that this was due to the increase in pause times. In the final condition, elimination of the Snp from both components produced a return to the pattern of responding that occurred in the initial condition.

Figure 12 shows the results of the experiment for Bird 89. In general, the results were more erratic than was observed with the previous birds. Following the introduction of the Snp, overall response rates showed an increase and then a decline to the values of the first condition. The lower portions of Figure 12 show that the changes in overall response rates reflected the large changes in running rates during this condition. Running rates showed a large increase until at their peak values they represented responding that was occurring, on the average, at more than 4.5 responses per second! Following this peak, running rates showed a quick decline and approached the values observed in the initial condition.

The following qualitative observations were made on the changes in the pattern of responding shown by the bird over the course of this condition. Initially, cumulative records showed that an FR pattern of responding began to emerge, as with the previous birds. As the increase in running rates neared their peak values, responses were executed in "bursts" that frequently ran well into, and

sometimes through, the Snp cycle. No other bird in these experiments ever showed responding during the Snp under a second-order schedule. In the latter stages of this condition, the pattern of responding often occurred in the following manner. Following the production of the Snp, a pause ensued. The pause was terminated by a rapid burst of responses at a rate similar to what was observed when running rates were at their peak values. Commonly, the burst consisted of 7-9 responses, a very short pause, and, then, a second burst of 3-4 responses which produced the Snp.

The development of this pattern of responding had several ill effects on the response measures. The pause in the middle of completing the FR requirement contributed to a decrease in running rate values, as this increased the time to complete the requirement. Such pauses were variable in duration, and, thus, produced variability in the values. Cumulative pause time values were reduced because of the frequent occurrence of a response burst extending through the Snp cycle. Because pause time values were based on time until the first post-Snp/food response, response bursts that extended through the Snp cycle produced for the recording apparatus the condition that responding on the next ratio had begun. This produced the egregious condition that the bird was pausing following the occurrence of the prior Snp while the recording apparatus was reacting as if the bird had begun the next ratio.

In the Contrast Condition, the removal of the Snp from S- produced a decline in running rates and pause times for that

component. This showed that responding, although erratic, was still under control of the Snp. Overall response rates in S+ showed a transient increase, which was followed by a decline below the final values of the previous condition, and then a recovery. The lower portions of the figure show that the initial increase in overall response rates was due to a transient increase in running rates. Cumulative pause times in S+ showed a decline over the course of the condition.

Following reinstatement of the Snp into S- in the next condition, pause times in S+ showed a sustained increase, while running rates in S+ showed a transient decrease and recovery. The recovery of pause time values suggests that positive behavioral contrast had occurred in the previous condition. The elimination of Snp from both components in the final condition resulted in a return to the pattern of responding observed in the initial condition.

Reduction of post-Snp/food pause times was the major effect observed in S+ during the Contrast Condition. Table 2 shows this change at the level of a single (average) FR 11 unit. The data in the table were computed in the following manner. For each session included in the table, average pause time per FR unit per session equaled cumulative pause time for a component divided by the sum of the number of Snp and food cycles for that component. Each number in the table represents the mean average of six consecutive sessions of the S+ component alone. The data under "S Both" (1 and 2) represents the last six sessions of the conditions just prior to, and

immediately following the Contrast Condition. The data under "Contrast" represents the average from the middle six sessions of the Contrast Condition.

TABLE 2

Average Pause Time Per FR 11 Unit (Sec)

Bird	S Both (1)	Contrast	S Both (2)
93	6.4	3.4	6.1
95	6.5	5.1	6.5
89	3.2	2.4	2.9

The table shows more clearly the strength of the effects seen in the figures, even though the data under the "Contrast" column do not necessarily show the maximum amount of reduction in pause times for that condition. Both the reduction in pause time per FR 11 unit and the subsequent increase (recovery) in the next condition are clear for Birds 93 and 95. The differences between conditions for Bird 89 were less distinct, but the changes were in the appropriate direction.

In summary, all three subjects initially showed the emergence of an FR pattern of responding following the introduction of the Snp into the second-order schedules. FR performance was evidenced by the

sustained increase in running rates over the course of the experiment by Birds 93 and 95. The appropriate break-and-run pattern was apparent on cumulative records. This pattern was consistent over the course of the experiment for Birds 93 and 95. Bird 89's manner of responding eventually "stabilized" into a pattern in which responding, once begun, occurred in a series of bursts. This produced large variations in the measures of running rates and pause times.

Clear positive behavioral contrast effects were observed in S+ during the Contrast Condition for Birds 93 and 95. The major source of the effect was due to a reduction in pause times. The appropriate recovery of pause times in S+ occurred when the Snp was returned to the S- in the next condition. The contrast effect was very evident at the level of average pause time per FR 11 unit. The results for Bird 89 were less distinct, although the changes during the Contrast Condition and the following condition were in the appropriate directions.

Discussion

Manipulating the presence of the Snp in the multiple second-order schedule in this experiment produced effects in a manner normally associated with food-reinforcement for Birds 93 and 95. Introduction of the Snp into both components of the multiple schedule resulted in a reinforcement effect, and removing the Snp from one component of the multiple schedule resulted in positive

behavioral contrast in the unaltered component. Positive behavioral contrast occurred primarily as a reduction in pause times, the manner in which positive contrast effects were reported to occur with different reinforcement frequencies in multiple FR FR schedules (Reynolds, 1961b; Shuster, 1959).

The results of this experiment extend the generality of the positive behavioral contrast effects reported in the previous experiments. In this experiment, positive behavioral contrast effects resulted from the manipulation of the presence of the Snp in a different second-order schedule, VI 1-min (FR 11). This showed that the production of positive behavioral contrast was not dependent on the use of a particular response unit requirement.

Although all three subjects showed an FR pattern of responding when the Snp was originally introduced, Bird 89 showed a further change in the pattern of responding over the course of the condition such that responding, once begun, tended to occur in multiple bursts. This pattern of responding emerged after response rates had increased to such an extent that responding often extended into the Snp cycle, an effect not observed with any other birds under a second-order schedule in these experiments. Bird 89 was also the only subject not to show clearly a positive behavioral contrast effect. This may have been due to the effects on the response measures of the pattern of responding. But it may also represent a genuine difference in the occurrence or magnitude of positive behavioral contrast due to the elimination of an important

similarity between food and the Snp. For the other birds, both the Snp and food terminated responding for some time period. This was not the case for Bird 89. In either case, the use of an Snp-event which more efficiently terminates responding, such as total darkening of the chamber (Neuringer & Chung, 1967) or mild electric-shock (Stubbs & Silverman, 1972), should have resulted in the clearer occurrence of positive behavioral contrast for this bird.

Although positive behavioral contrast resulted from the manipulation of the presence of the Snp, this does not necessarily show that the effect was due to the occurrence of the Snp in a second-order schedule. For example, the contrast effects may have resulted from the disruptive effects of removing the Snp, independent of the second-order schedule. If this is true then removing the response-produced Snp from one component of a multiple schedule should produce positive behavioral contrast effects even when food and the Snp are not produced under a second-order schedule relationship.

Neuringer and Chung (1967) reported that the Snp did not produce a reinforcement effect on overall response rates nor did it affect the pattern of responding if food and the Snp were produced according to the following schedule: conjoint VI 1-min FR 11:Snp. Under this schedule, food is produced according to VI 1-min and the Snp is produced according to FR 11. The reinforcement schedule requirements for food and the Snp operate simultaneously and independently. If the above effects were dependent on the Snp

occurring in a second-order schedule, then manipulations of the presence of the Snp in a multiple conjoint schedule should not produce either reinforcement or positive behavioral contrast effects, even though the Snp is still produced according to FR 11. This was investigated in the next experiment.

CHAPTER V

EXPERIMENT IV

The previous experiments demonstrated that manipulating the presence of the Snp in a multiple second-order schedule produced both reinforcement and positive behavioral contrast effects in a manner typically associated with the manipulation of food-reinforcement. The assumption was made that the appearance of these effects was dependent on the Snp occurring within the context of a second-order schedule. The purpose of this experiment was to test that assumption.

This was tested by presenting food and the Snp under a conjoint schedule, conjoint VI 1-min FR 11:Snp. Under a conjoint schedule (Catania, 1968), the reinforcement schedules are in operation simultaneously and independently. In this experiment the VI 1-min schedule programmed food-reinforcement and the FR 11 schedule programmed presentation of the Snp. Hence, the conjoint schedule in this experiment was similar to the second-order schedule in the previous experiment in that overall food-reinforcement rate was the same (i.e., VI 1-min) and the response requirement for the Snp was the same (i.e., FR 11) as before. However, the situation differed from the previous experiment in that food and the Snp were now produced according to different response requirements; the food was made available according to VI 1-min (FR 1) instead of VI 1-min (FR 11). Neuringer and Chung (1967) reported that when food and the

Snp were available under a conjoint schedule, the presence of the Snp made little difference. It did not result in either an FR pattern of responding or an increase in overall response rates.

In this experiment, the subjects were exposed to the same sequence of conditions as in the previous experiments. Following baseline training on a multiple conjoint schedule in which the Snp was not presented, the Snp was introduced into both components to see if a reinforcement effect would occur. Following exposure to this condition, the Snp was removed from one component of the multiple schedule to see if positive behavioral contrast would occur in the unaltered component. The Snp was then returned to the altered component to verify that the effects that took place during the Contrast Condition were due to the removal of the Snp. If the previous reinforcement and contrast effects were dependent on the Snp occurring within a second-order schedule, then neither a reinforcement effect nor behavioral contrast should occur in this experiment.

Method

Subjects

The same birds, 93, 95, and 89, from the previous experiment served as subjects in this experiment.

Apparatus

The same apparatus was used as in the previous experiments.

Procedure

The same basic procedure was used as in the previous experiment, with the exception of the change of the reinforcement schedule in the multiple schedule components to conjoint VI 1-min FR 11. Under this schedule, food was made available according to VI 1-min and each response also contributed towards satisfying the FR 11 requirement. For approximately 17 sessions completion of FR 11 resulted in no scheduled consequences in the experimental chamber; but, as before, the programming and recording apparatus operated in the same manner whether the Snp was actually presented or not. During either a food or an Snp cycle, all counters were disabled and only the completion of the FR 11 requirement (or a transition to a new component) reset the FR counter.

Following this condition, the schedule in the components was changed to conjoint VI 1-min FR 11:Snp. Under this schedule food was produced according to VI 1-min and every 11 responses also produced the Snp, which consisted of a 1-sec period during which the red houselight was illuminated and the response key was darkened. In order to preserve the nonpaired status of the stimulus, no single response could produce both food and the Snp. In those few cases where both food and the Snp were programmed to occur following the next response, the food cycle assumed priority and the next response, after food delivery, produced the Snp. This happened quite

infrequently, approximately 3-4 times out of 60 programmed food-reinforcements per session.

The response measurement techniques had to be modified only slightly to incorporate the new schedule. Average running rates were computed in the following manner. The first response under FR 11 started the running-time meter. The meter was stopped by either the completion of the ratio requirement, the production of food, or the end of the component. If food-reinforcement had stopped the running-time meter and the ratio requirement had not been completed, then the next response restarted the running-time meter until the ratio requirement had been completed. Average running rate equaled the number of responses in that component during a session divided by the cumulated running-time for that component during a session. Cumulative pause time per session was computed as before; cumulated running-time, Snp cycle time, and food cycle time in a session for a component were subtracted from the programmed session time for that component. Since either the occurrence of food or the Snp could independently stop the running-time meter and cumulative pause time was computed subtractively, this procedure would, if anything, slightly increase the pause time values here relative to the pause time values under the second-order schedule in Experiment III.

Results

Figures 14, 15, and 16 show the results of the experiment for Birds 93, 95, and 89, respectively. Each figure begins with the last

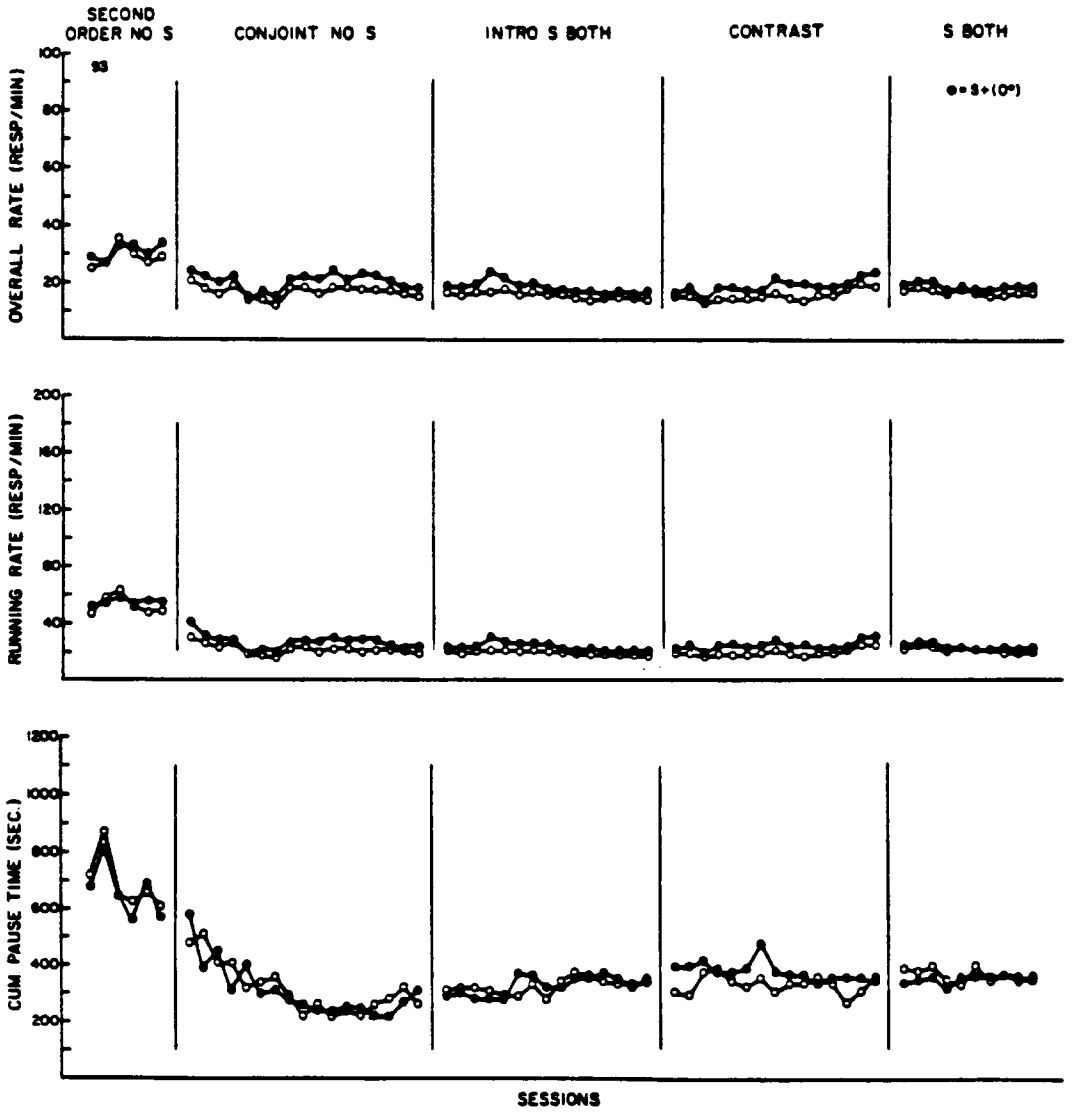

Figure 14. Results for Bird 93, Experiment IV. Performance is shown concurrently for the three response measures: overall response rates, running rates, and cumulative pause times (top to bottom).

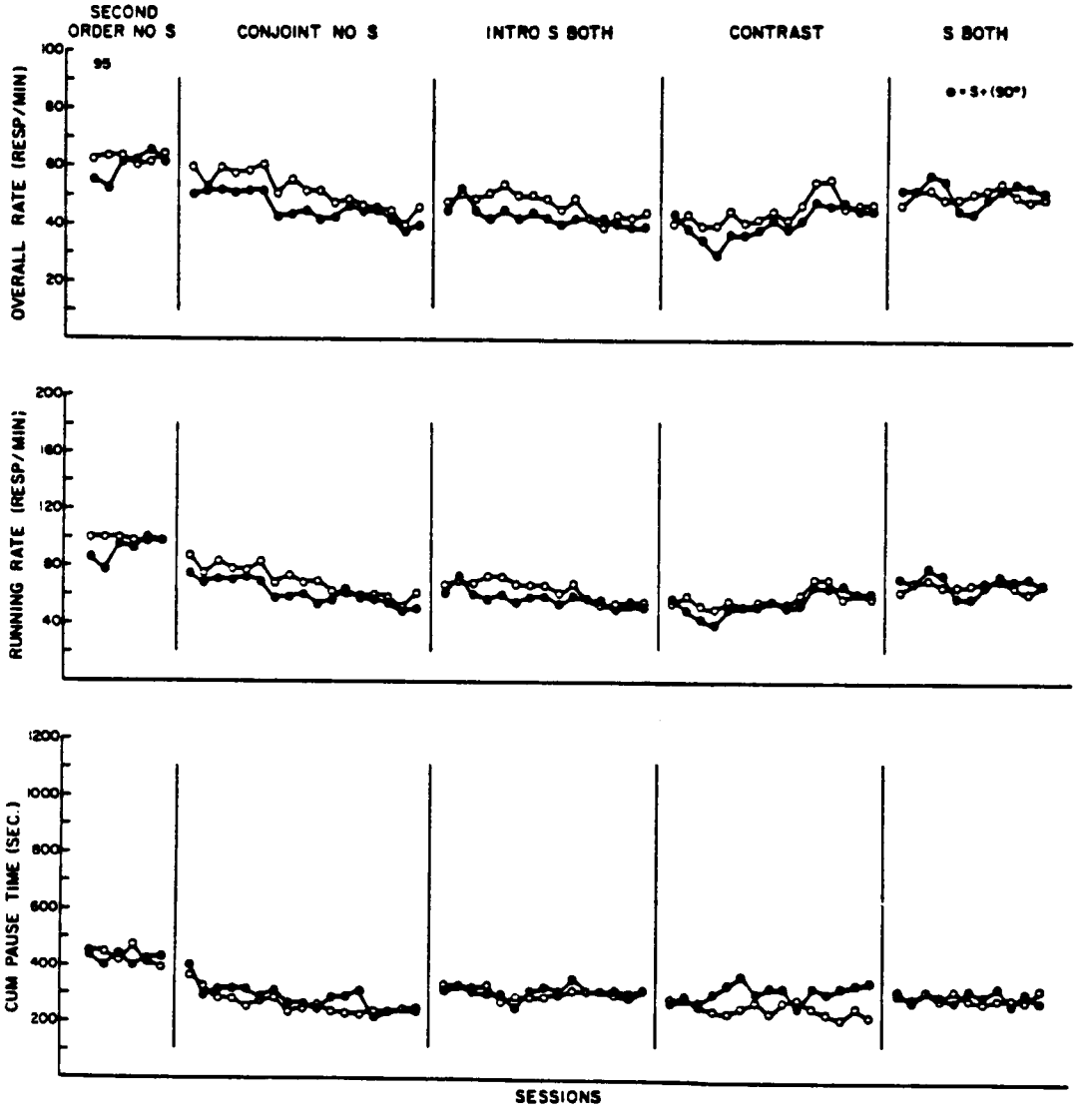

Figure 15. Results for Bird 95, Experiment IV. Performance is shown concurrently for the three response measures: overall response rates, running rates, and cumulative pause times (top to bottom).

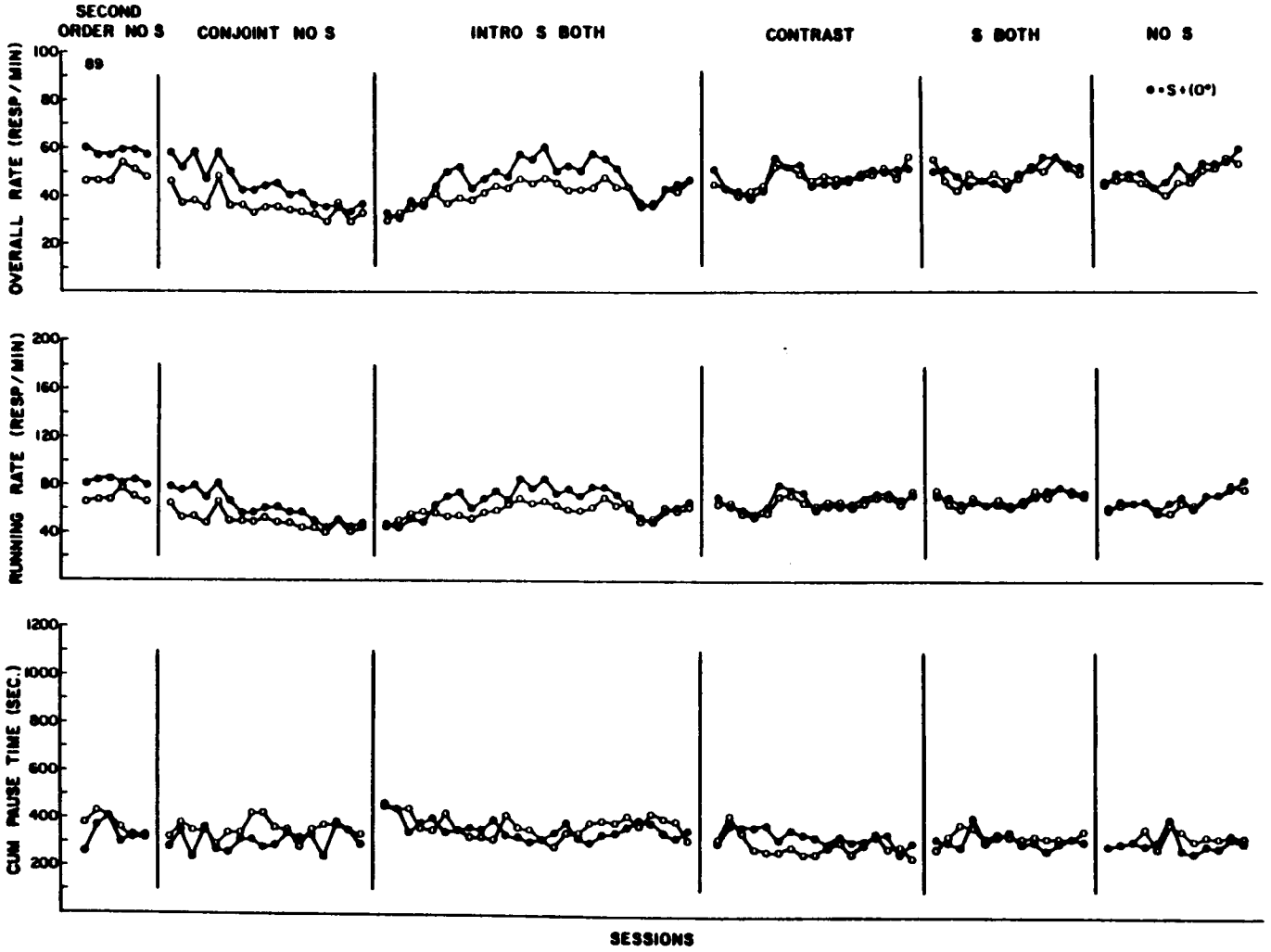

Figure 16. Results for Bird 89, Experiment IV. Performance is shown concurrently for the three response measures: overall response rates, running rates, and cumulative pause times (top to bottom).

six days of responding under the multiple second-order schedule (during which the Snp was not presented) from the final condition of the previous experiment, and shows the complete sequence of conditions and sessions thereafter. As before, S+ (filled circles) indicates the component which remained unaltered during the Contrast Condition. As before, each figure shows the session by session account of the three measures of responding; the top row shows overall response rates, the middle row shows average running rates, and the bottom row shows cumulative pause times per session.

Figure 14 shows the results for Bird 93. There was a gradual reduction in pause times following the transition from the second-order to the conjoint schedule. This showed that the change in reinforcement contingencies produced a change in the pattern of responding which could not be accounted for solely by the change in recording methods. A change due solely to the new recording method would be seen as an abrupt transition concomitant with the new method and little effect afterwards. In addition, the change was in a direction opposite to what would have occurred if the effect were due solely to the slight difference in recording methods from Experiment III. Examination of cumulative records suggested that this effect was due, in part, to a decrease in the duration of the post-reinforcement pause.

Otherwise, the results of the experiment can be quickly summarized. There was virtually no effect of introducing or removing the Snp on either overall response rates or running rates over the

course of the experiment. The miniscule effects on pause times as a function of the presence of the Snp can be wholly accounted for by the slight disruption in responding caused by the darkening of the response key during the Snp cycle.

Figure 15 shows the results for Bird 95, which were quite similar to those for Bird 93. The transition from the second-order to the conjoint schedule produced a gradual decline in both pause times and running rates, showing that there was a change in the pattern of responding under the different food-reinforcement contingencies which could not be accounted for by the change in the manner of recording. Introduction of the Snp into both components produced a very small and transient effect on running rates, while pause times showed a small and immediate increase. During the Contrast Condition, a very small reverse effect from positive behavioral contrast was observed in S+. Running rates showed a transient decline and pause times a small increase. This effect was orderly. Reinstatement of the Snp in the next condition produced a very small increase in running rates and decline in pause times for the S+. The changes in pause times across the experiment can mainly be accounted for by the slight disruption of responding due to the darkening of the response key when a Snp occurred.

Figure 16 shows the results for Bird 89. The transition from the second-order to the conjoint schedule resulted in a decline in running rates, while pause times remained relatively unaffected. Introduction of the Snp into both components produced an increase in

overall response rates. The lower portion of the figure shows that this was due to an increase in running rates, while pause times remained relatively unaffected. There was virtually no change in responding in S+, either in the Contrast Condition or when the Snp was returned to the altered component during the next condition. The only change observed in S- during these two conditions was the very slight reduction in pause times during the Contrast Condition when the Snp was no longer presented during the component. This change can be wholly accounted for by the effect of the response key no longer darkening during the Snp cycle.

Since there had been an increase in response rates following the introduction of the Snp, Bird 89 was exposed to an additional condition. The Snp was removed from both components of the multiple schedule to see if response rates would show a corresponding decline. No such change was observed, showing that the Snp was not producing an increase in response rates, at least by the end of the experiment.

The lack of large changes in either running rates or pause times over the course of the experiment suggested that the presence of the Snp produced little change in the pattern of responding. The lack of effect was apparent from the cumulative records. Figure 17 shows representative portions from two cumulative records for Bird 93. The top panel is from a cumulative record for a session just prior to the introduction of the Snp. The bottom panel is from a cumulative record following the introduction of the Snp, and just

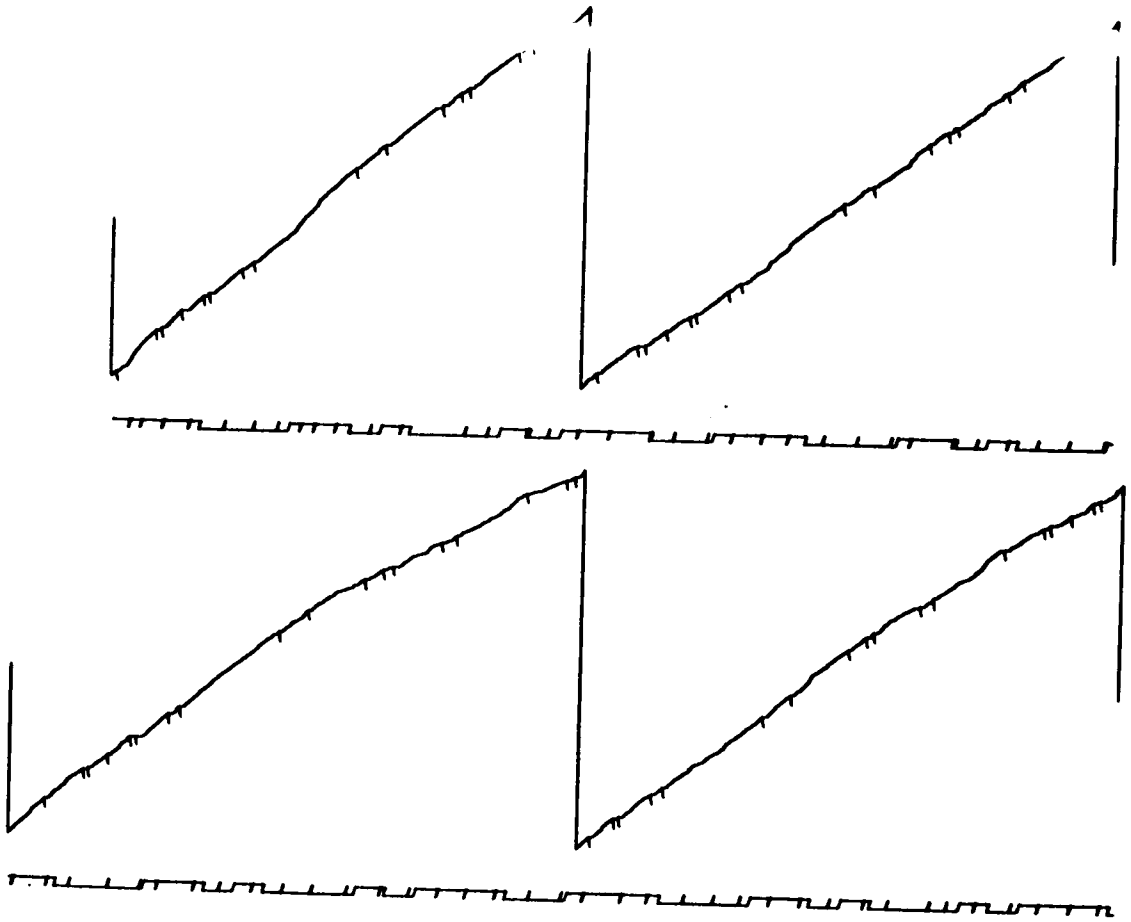

Figure 17. Cumulative records from Bird 93, Experiment IV. The top panel shows performance prior to the introduction of the Snp. The bottom panel shows performance when the Snp was present.

prior to the Contrast Condition. The patterns of responding on the two records are virtually indistinguishable, even though the top panel is from a session during which the Snp was absent and the bottom panel is from a session during which the Snp was present.

Table 3 shows the change in average pause time following Snp/food for the S+ in the Contrast Condition, as compared with the immediately preceding and following conditions. The data in Table 3 were computed in the same manner as in Table 2 (p. 89). Each value represents the mean average of six consecutive sessions, with the data under "S Both" (1 and 2) taken from the last six sessions of the conditions immediately preceding and following the Contrast Condition, and the data under "Contrast" taken from the middle six sessions of the Contrast Condition. It can be seen that there was little change observed at this level either; Birds 93 and 95 showed a very small increase and Bird 89 showed a very small decrease during the Contrast Condition.

TABLE 3

Average Pause Time Per Snp/Food Event (Sec)

Bird	S Both (1)	Contrast	S Both (2)
93	5.4	5.8	5.7
95	2.2	2.6	1.9
89	2.8	1.9	1.9

In summary, the results showed that there was a change in the pattern of responding following the transition from the second-order to the conjoint reinforcement schedule. This showed that the birds were sensitive to the change in the response requirements for food. Introduction of the Snp into both components produced little change in the pattern of responding, even though the Snp was produced according to FR 11 as in Experiment III and the overall food-reinforcement rate was the same as that in Experiment III. Cumulative records from sessions with and without the Snp present were virtually indistinguishable. Nor were positive behavioral contrast effects observed in S+ during the Contrast Condition for any of the subjects. The only systematic change observed for all subjects was a very small increase in pause times in components in which the Snp was present, which can be accounted for by the slight disruption in responding produced by the darkening of the response key during the Snp cycle.

Discussion

The results of the experiment were very clear. There was a change in performance following the switch from the second-order to the conjoint reinforcement schedule. This showed that the birds were sensitive to the change in contingencies of food-reinforcement. However, there was virtually no effect of the Snp on the pattern of responding, even though the same Snp was produced according to the same FR 11 requirement in the context of the same rate of food-

reinforcement. This showed that the Snp was a very different event, depending on whether it occurred under a second-order or conjoint schedule. This replicated the findings by Neuringer and Chung (1967) and Stubbs (1971) in their comparisons of the two types of schedules.

The important result here was that elimination of the Snp from one component of the multiple schedule did not produce any sign of positive behavioral contrast in the unaltered component. There was almost no discernable change in either average running rate or cumulative pause times in the S+. This showed that the occurrence of positive behavioral contrast in Experiment III was dependent on the Snp occurring under a second-order schedule, as other aspects of the presence or absence of the Snp were the same in both experiments.

It is interesting to note in historical context the perspective from which the last two experiments were viewed. As presented here, this experiment constituted a control experiment relative to the previous experiment. It served to show whether aspects of the presence of the Snp, other than its occurrence under a second-order schedule, could account for the production of either quasi-reinforcement or positive behavioral contrast effects. The predicted result was that the Snp would not produce either reinforcement or positive behavioral contrast effects under a conjoint schedule.

Now consider Experiments III and IV in the context of the traditional experimental approach to the topic of conditioned reinforcement (cf., Macintosh, 1974; Nevin, 1973). Traditionally,

there are two phases of the conditioned reinforcement experiment, training and testing. During the training phase some "neutral event" (i.e., an event which is assumed or empirically demonstrated not to be presently acting as a reinforcer under the prevailing conditions of the experimental situation) is spatio-temporally paired with another event which is (or, is presumed to be) a reinforcer under the prevailing conditions of the experimental situation. After the training phase, the subject is exposed to a test situation. The test consists of determining whether the event (the putative conditioned reinforcer) will act as a reinforcer under some <u>different</u> set of conditions. This follows the strategy of identifying reinforcers by their transituational effects, as suggested by Meehl (1950).

Experiments III and IV would also fit into this research strategy. The Snp, presented under the second-order schedule, would constitute the training phase. The Snp, presented under the conjoint schedule, would constitute the test phase. In other words, the rationale for the sequence of the two experiments would be viewed in the following manner. If the Snp became a conditioned reinforcer as a consequence of occurring under a second-order schedule, then the Snp should act as a (conditioned) reinforcer under the conjoint schedule. Note that the predicted effect from this view is the <u>opposite</u> from above; the response-contingent Snp should effect the pattern of responding.

This difference in perspective illustrates the change in the concept of reinforcement discussed in the Introduction (i.e., the

work of Premack, 1965, and Morse and Kelleher, 1977). The more traditional approach (e.g., Meehl, 1950) emphasizes the properties of the events (whether immanent or acquired) which transfer among situations; whereas the more recent work emphasizes the properties of the situations themselves. Thus, in the experiments here, the focus is on whether the event produces certain effects (i.e., positive behavioral contrast) in a particular situation (i.e., a multiple second-order schedule), and the effect was not expected to occur in another situation (i.e., a multiple conjoint schedule) even though the same events were used in both situations. This, of course, is not to say that the transfer of effects is never to be expected, but that the basis for such transfer resides in an analysis of the relations among the situations.

The results of the experiments up to this point show a clear difference between the effects of manipulating the presence of the Snp in second-order and conjoint reinforcement schedules. Manipulating the presence of the Snp under second-order schedules produced positive behavioral contrast effects in a manner normally associated with manipulating food rate. This did not occur with the Snp under the conjoint schedule. However, there has been no previous behavioral contrast study using similar second-order schedules. Although it would seem unlikely, it is possible that manipulating food-reinforcement rate would not produce the same pattern of results. This possibility was tested in the next experiment.

CHAPTER VI

EXPERIMENT V

The previous experiments were based on the argument that if the Snp was a positive reinforcer, as a consequence of occurring under a second-order schedule, then manipulations of the presence of the Snp in a multiple schedule should produce effects normally associated with manipulation of the rates of food-reinforcement. The most consistent contrast effects in these experiments were reductions in pause times in the unaltered component. These results paralleled what has been reported for responding in components differing in food-reinforcement rate in multiple FR FR (Reynolds, 1961b; Shuster, 1959) and multiple FI FI (Staddon, 1969) schedules.

But there are many procedural differences between the experiments here and the experiments cited. This is not at all surprising since the primary interest of those experiments was the properties of contrast effects, per se. The general argument would be strengthened by showing that manipulating food-reinforcement rate in the procedure used here produces effects in a manner similar to when the presence of the Snp was being manipulated. This was the purpose of this experiment.

Responding was first established under the multiple schedule used in Experiment III. The second-order reinforcement schedule was VI 1-min (FR 11:Snp), and the same Snp was used as in the previous experiments. Following this condition, both food and the Snp were

removed from one component in the Contrast Condition; and, in the final condition, food and the Snp were reinstated into the altered component. If the changes in responding during the Contrast Condition parallel the results obtained in Experiment III, then positive behavioral contrast should occur primarily as a reduction in pause times, with the consequent effects on overall response rates.

During the Contrast Condition, both food and the Snp were eliminated from the altered component. This was done for the following reasons. The experiment was not concerned with whether the Snp alone would maintain responding nor was it concerned with an attempt to compare the relative influence of food versus the Snp. The purpose of the experiment was to examine the changes in the pattern of responding under the most straightforward type of contrast procedure, changing the reinforcement rate in one component to extinction. Since the argument is that both food and the Snp contribute to the value of the component, both events were removed from the altered component during the Contrast Condition.

Method

Subjects

Birds 93, 95, and 68 served as subjects.

Apparatus

The apparatus was the same as in the previous experiments.

Procedure

For Birds 93 and 95, this experiment represented a continuation from the previous experiment. The reinforcement schedule during a component was changed from conjoint VI 1-min FR 11:Snp to the second-order schedule, VI 1-min (FR 11:Snp). Following approximately 17 sessions of responding under the multiple second-order schedule, both food and the Snp were eliminated from one component of the multiple schedule. Bird 68, following Experiment II, was exposed to a series of baseline conditions similar to the sequence for Birds 93 and 95 in Experiment III. This involved training under VI 1-min (FR11) for approximately 15 sessions prior to the introduction of the Snp. Immediately prior to the Contrast Condition in this experiment, Bird 68 had been responding under the multiple VI 1-min (FR 11:Snp) VI 1-min (FR 11:Snp) schedule for 16 sessions.

All details of the programming and recording procedures were the same as in Experiment III.

Results

Figures 18, 19, and 20 show the results of the experiment for Birds 93, 95, and 68, respectively. The figures were plotted in the same manner as in the previous experiments. Each figure shows the session by session account of the three measures of responding; the top row shows overall response rates, the middle row shows average running rates, and the bottom row shows cumulative pause times per

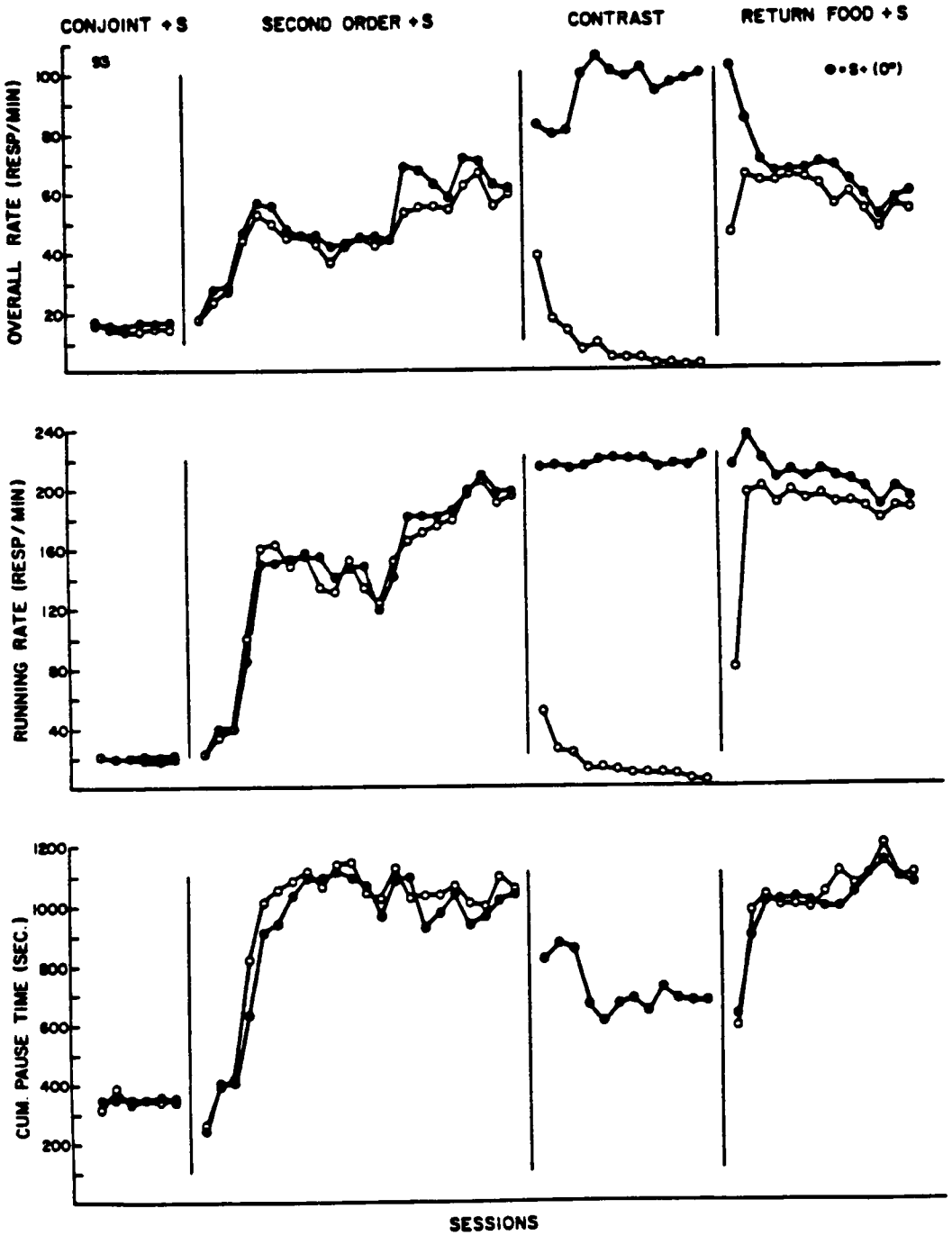

Figure 18. Results for Bird 93, Experiment V. Performance is shown concurrently for the three response measures: overall response rates, running rates, and cumulative pause times (top to bottom).

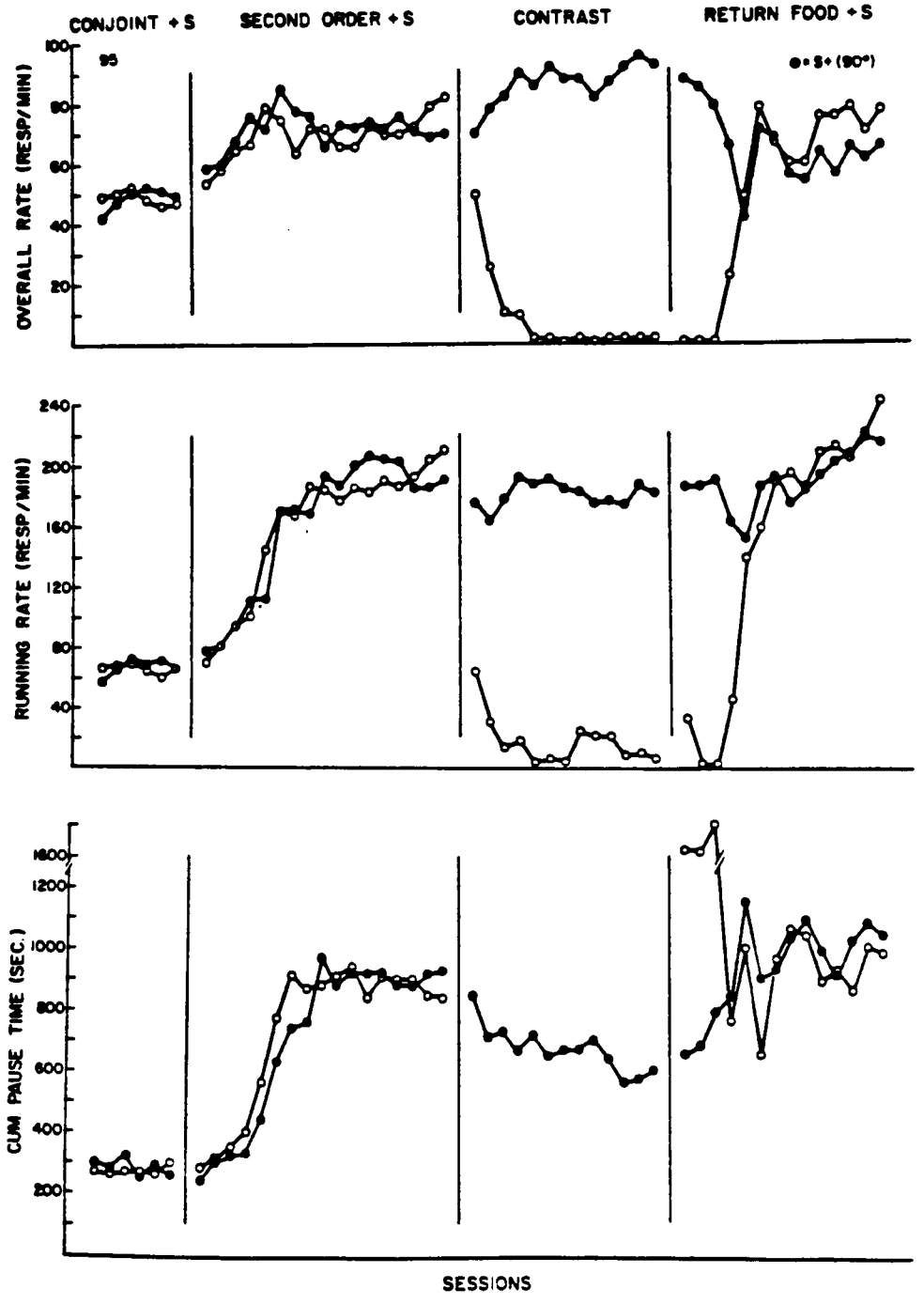

Figure 19. Results for Bird 95, Experiment V. Performance is shown concurrently for the three response measures: overall response rates, running rates, and cumulative pause times (top to bottom).

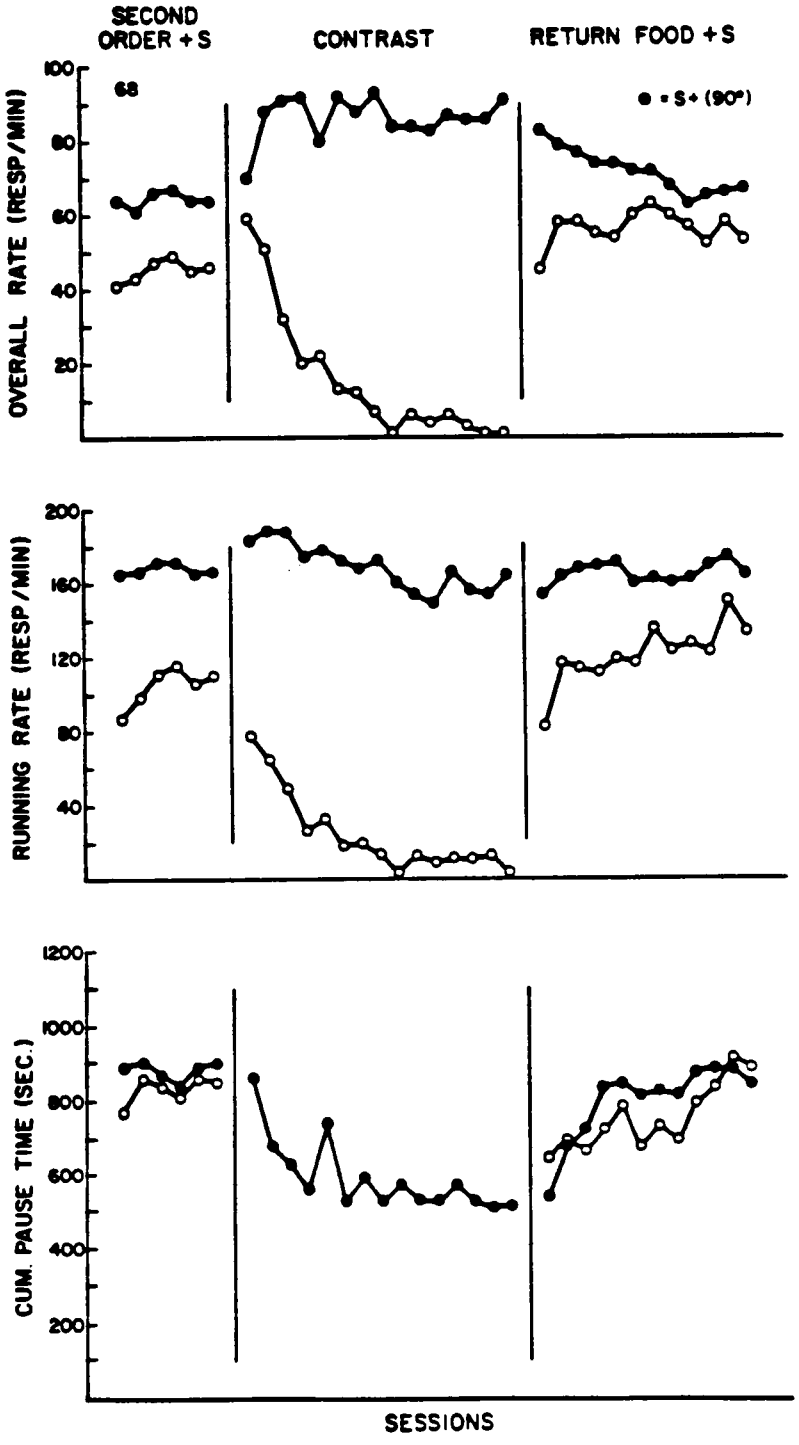

Figure 20. Results for Bird 68, Experiment V. Performance is shown concurrently for the three response measures: overall response rates, running rates, and cumulative pause times (top to bottom).

session. Cumulative pause times were not plotted for the altered component during EXT, since these data were not very informative and would have required expanding the scale to accommodate the occasional large values. The component which served as S+ during the Contrast Condition is indicated by the filled circles and the particular line orientation which signaled that component is indicated in the upper right hand portion of the figure. For Birds 93 and 95, each figure begins with the last six sessions of responding under the multiple conjoint VI 1-min FR 11:Snp schedule from the previous experiment; while the figure for Bird 68 begins with the last six sessions of responding under the multiple VI 1-min (FR 11:Snp) schedule.

Figure 18 shows the results for Bird 93. The transition from the multiple conjoint schedule to the multiple second-order schedule produced a swift and clear change in performance, as running rates more than quadrupled and pause times more than doubled. Cumulative records showed the quick return of an FR pattern of responding. In the Contrast Condition, overall response rates showed the typical pattern of changes observed with positive behavioral contrast. There was an increase in overall response rates in S+ as responding during S- declined. The lower portions of the figure show that the increase in overall response rates in S+ was due primarily to the decrease in pause times, although running rates in S+ showed a small but sustained increase over the course of the Contrast Condition. Reinstatement of the food and the Snp into S- in the final condition

produced a recovery of the FR pattern of responding in S-. Overall response rates in S+ declined to their former levels. The lower portions of the figure show that the increase in pause times was responsible primarily for the decline in overall response rates in S+ during this condition, although running rates also showed a small decline.

Figure 19 shows the results for Bird 95. As with Bird 93, the transition from the multiple conjoint schedule to the multiple second-order schedule produced a swift and clear change in the pattern of responding. Both running rates and pause times more than tripled over the course of the condition. Cumulative records showed the quick return of an FR pattern of responding. In the Contrast Condition, overall response rates in S+ increased as responding during S- declined (i.e., positive behavioral contrast). The lower portions of the figure show that the contrast effect on overall response rates in S+ was due to the decrease in pause times, as running rates in S+ actually showed a small decline over the course of the Contrast Condition. The reinstatement of food and the Snp into the S- produced a recovery in S-, and S+, of the performance observed in the initial multiple second-order condition. The lower portions of the figure show that the decline in the overall response rates in S+ was due to the increase in pause times, as running rates in S+ showed an increase over the course of the final condition.

Figure 20 shows the results for Bird 68. This figure begins with the last six sessions of responding under the multiple second-

order schedule, since Bird 68 had not been exposed to the multiple conjoint schedule. The differences in running rates between the components prior to the Contrast Condition were due to slight differences in the pattern of responding during the components. Cumulative records showed that the transitions from pausing to responding were more graded in the component indicated by unfilled circles; this appeared related to the bird's prior history of responding under the interval schedule, (tand FR 1 FI 5-sec) in Experiment II. In the Contrast Condition, overall response rates in S+ increased as responding during S- declined (positive behavioral contrast). The lower portions of the figure show that the increase in overall response rates in S+ was due primarily to the decrease in pause times, although running rates in S+ showed a small and transient increase. Reinstatement of food and the Snp into S- in the final condition resulted in a recovery of the levels of responding in S+ that were present just prior to the Contrast Condition. The lower portions of the figure show that the recovery was due to the increase in pause times, as running rates remain relatively unaffected by the condition change.

Table 4 shows the change in pause times at the level of a single (average) FR 11 unit during the Contrast Condition. The data were computed in the same manner as for Table 2 (p. 89) in Experiment III. Each value represents the mean average of six consecutive sessions of responding in S+. The data under "S + food both" (1 and 2) were comprised of the last six sessions of

the conditions immediately prior to and following the Contrast Condition. The data under "Contrast" were comprised of the middle six sessions of the Contrast Condition. The table shows that pause time reduction during the Contrast Condition was very clear at the level of a single (average) FR 11 unit in S+. The observed reductions, not unexpectedly, were larger proportionately than in Experiment III.

TABLE 4

Average Pause Time Per FR 11 Unit (Sec)

Bird	S + food both (1)	Contrast	S + food both (2)
93	5.9	2.5	7.2
95	4.8	3.0	6.6
68	5.3	2.5	5.0

In summary, the transition from the multiple conjoint schedule to the multiple second-order schedule, for Birds 93 and 95, produced a quick return to an FR pattern of responding. This indicated the birds sensitivity to the differences between the two schedules. All subjects showed positive behavioral contrast in overall response rates in S+ during the Contrast Condition, and there was a subsequent recovery of the former levels of performance in S+ when

food and the Snp were returned to the altered component. When the changes in overall response rates in S+ were partitioned into changes in pause times and running rates, it was found that the contrast effects and subsequent recoveries were due primarily to changes in pause times. Pause times in S+ decreased during the Contrast Condition and increased to their former levels when food and the Snp was returned to the S- in the final condition. The changes in running rates in S+ during the Contrast Condition were small and inconsistent across subjects.

Discussion

The results of the experiment showed that elimination of both food and the Snp from one component of a multiple second-order schedule produced positive behavioral contrast in the unaltered component. More importantly, reductions in pause times were primarily responsible for the increases in overall response rates in S+ during the Contrast Condition, whereas changes in running rates in S+ were both small and inconsistent across birds in the Contrast Condition. These results paralleled the effects that were observed with S+ during the Contrast Condition in Experiment III when the Snp, but not food, was eliminated from one component of the multiple schedule. This parallel, in the pattern of effects in the Contrast Condition between Experiments III and V, strengthens the interpretation in the previous experiments that the changes in responding in S+, due to the removal of Snp during the Contrast

Condition, did represent positive behavioral contrast.

It could be asked why food alone was not eliminated, to examine the "pure" effect of food in producing contrast in this situation. The point of the experiment was not an attempt to determine the relative or absolute strengths of food versus the Snp. The point of the experiment was to see if pause times were affected, primarily, under the straightforward manipulation of changing the reinforcement rate in one component to EXT.

It is certainly true that the elimination of both food and the Snp during the Contrast Condition does not allow the determination of the sole effect of food in producing contrast effects in this experiment. However, eliminating only food from the altered component to accomplish this would be based on a very questionable assumption; the effects produced by removing the food, while leaving the Snp in the altered component, would be due only to the effect of food.

This assumption is clearly untenable. Two general points of the experiments make this clear. First, the whole sequence of experiments relies on the demonstrated <u>interactions</u> between components. Second, the control of responding by the Snp is dependent on the relationship between its manner of production and the production of food. Clearly, removing food from a component while leaving the Snp will affect the status of the Snp. Just as clearly, there is every reason to suspect that the status of the Snp in the unaltered component also will be affected. Hence, the performance in the unaltered component would reflect <u>both</u> the

changed status of the Snp, and, that food is now available only during the S+ component.

The finding that the contrast effects were primarily the result of decreases in pause times support the earlier characterizations of such effects in multiple FR FR schedules, and extends the observation of such effects to multiple second-order schedules. Such findings confirm again that the pause under FI or FR schedules of reinforcement is not simply a period of inactivity but is a dynamic part of the pattern of responding. The present findings support also the interpretation of results reported by Richards and Blackman (1981). They found that introducing a time-out following food-reinforcement in an FR schedule produced a decrease in pause durations. They suggested that the time-out served as an extinction component (hence, the schedule became multiple FR EXT) and that the reduced pause times represented the occurrence of positive behavioral contrast. The findings here support their interpretation in that, when positive behavioral contrast did occur in these experiments, the effect occurred primarily as a reduction in pause times.

One final aspect of the data must be stressed, the <u>rapid</u> change in the pattern of responding for Birds 93 and 95 following the transition from the conjoint schedule to the second-order schedule. The transition from the conjoint to the second-order schedule was unsignaled in that the same Snp was produced according to the same response requirement in the context of the same overall temporal

distribution of food in both schedules. A continuation of the performance that developed under the conjoint schedule throughout the second-order schedule condition would have resulted in the same rate of food. However, the change in schedule relationship between the Snp and food produced a rapid change in performance; although the speed was obviously influenced by the birds prior experience with the second-order schedule.

The above suggests that an important stimulus dimension exists, which may be termed relations of encounter. By this term it is meant that the subjects were sensitive to the relations of similarity and difference between the manners in which the various events were produced. Hence, for Birds 93 and 95, the Snp became a very different event in terms of the pattern of responding it controlled (and the ability to induce contrast effects) depending upon whether it was produced in a manner identical to food (i.e., the second-order schedule) or not (i.e., the conjoint schedule). What was important here was the discrimination of the transition from the conjoint to the second-order schedule relationship between food and the Snp. That the change in the pattern of responding took place within a few sessions suggests both the sensitivity to and importance of this dimension for the subjects. These considerations became important in view of the results in the next experiment.

CHAPTER VII

EXPERIMENT VI

The original design for Experiment V involved both subjects from Experiment II, Birds 68 and 74. Following Experiment II, which used (tand FR 1 FI 5-sec), the response requirement was changed to (FR 11) to begin a sequence of conditions as was used in Experiment III. When the brief stimulus was introduced into the second-order schedule, according to VI 1-min (FR 11:Snp), the pattern of responding that emerged initially was more similar to that under an FI schedule rather than FR schedule. This seemed obviously related to the birds prior training experience under VI 1-min (tand FR 1 FI 5-sec:Snp). In the case of Bird 74, the effect was very strong; pauses of very long duration quickly developed, as occurred with this bird in Experiment II. Since Bird 74 continued to respond under VI 1-min (FR 11:Snp) as if still under VI 1-min (tand FR 1 FI 5-sec:Snp), a different experimental sequence was begun to discover what features of the situation were responsible for the effect.

The first two conditions of this experiment were the original training under the multiple VI 1-min (FR 11) reinforcement schedule and the introduction of the Snp according to VI 1-min (FR 11:Snp), as in Experiment III. Following these conditions, the reinforcement schedule was changed to conjoint VI 1-min FR 11:Snp, the reinforcement schedule used in Experiment IV. The same Snp was still

available according to FR 11 under the conjoint schedule as under the second-order schedule but food-reinforcement was now available according to the VI 1-min requirements alone.

The change to the conjoint schedule served two purposes. First, the same Snp had been used in Experiment II as here. It could have been that the (response-produced) Snp itself had acquired response-rate controlling properties independent of its occurrence under the second-order reinforcement schedule. If this were so then making the Snp available according to FR 11, but independent of the food schedule, should continue for a time to produce the same pattern of responding as under the second-order schedule. Second, the results of Experiment IV showed that the pattern of responding under the conjoint relationship was controlled only by the food schedule. Response rates were uninfluenced by the presence of the Snp in that experiment. If similar performance developed here, then continued experience with the Snp under the conjoint schedule could serve to counter the effects of the prior history with the Snp under the second-order schedule of Experiment II.

Following exposure to training under the multiple conjoint schedule, the reinforcement schedule was changed back to VI 1-min (FR 11:Snp). This was done to see if an FR pattern of responding would emerge following training under the conjoint schedule. Following this condition, the reinforcement schedule was again made conjoint VI 1-min FR 11:Snp for several sessions and, then, the Snp

was eliminated from the conjoint schedule to determine the effects of the Snp on responding under this reinforcement schedule.

Method

Subjects

Bird 74 served as the subject.

Apparatus

The apparatus was the same as in the previous experiments.

Procedure

The same basic procedure was used as in the previous experiments. Following Experiment II, the reinforcement schedule during the components was changed to VI 1-min (FR 11) and, after 20 sessions under this condition, the Snp was introduced according to VI 1-min (FR 11:Snp). The Snp consisted of the 1-sec period during which the response key was darkened and a red houselight was illuminated, as in the previous experiments. Following 12 sessions during which the multiple VI 1-min (FR 11:Snp) was in force, the reinforcement schedule was changed to multiple conjoint VI 1-min FR 11:Snp. Under the conjoint reinforcement schedule, the Snp was still produced according to FR 11 but food-reinforcement now occurred according to only VI 1-min. The multiple conjoint schedule was in force for 22 sessions and was followed by the return to

multiple VI 1-min (FR 11:Snp) for 12 sessions. The final two conditions consisted of the return to multiple conjoint VI 1-min FR 11:Snp for 10 sessions, and the removal of the Snp from both components of the multiple schedule for 12 sessions in the last condition.

The programming and recording equipment operated in the same manner whether the Snp occurred in the experimental chamber or not, as in the previous experiments. Under the second-order reinforcement schedule conditions, the equipment operated as in Experiment III, and, under the conjoint reinforcement schedule conditions, the equipment operated as in Experiment IV. As was noted in Experiment IV, the method of computing pause times could serve to slightly enhance pause time values under the conjoint relative to the second-order reinforcement schedule.

Results

Figure 21 shows the results of the experiment. It begins with the last 10 sessions of responding under the multiple second-order reinforcement schedule, before the Snp was introduced, and shows the complete sequence of sessions and conditions thereafter. The figure shows the session by session account of the three measures of responding; the top row shows overall response rates, the middle row shows average running rates, and the bottom row shows cumulative pause times per session.

The introduction of the Snp into the second-order reinforcement

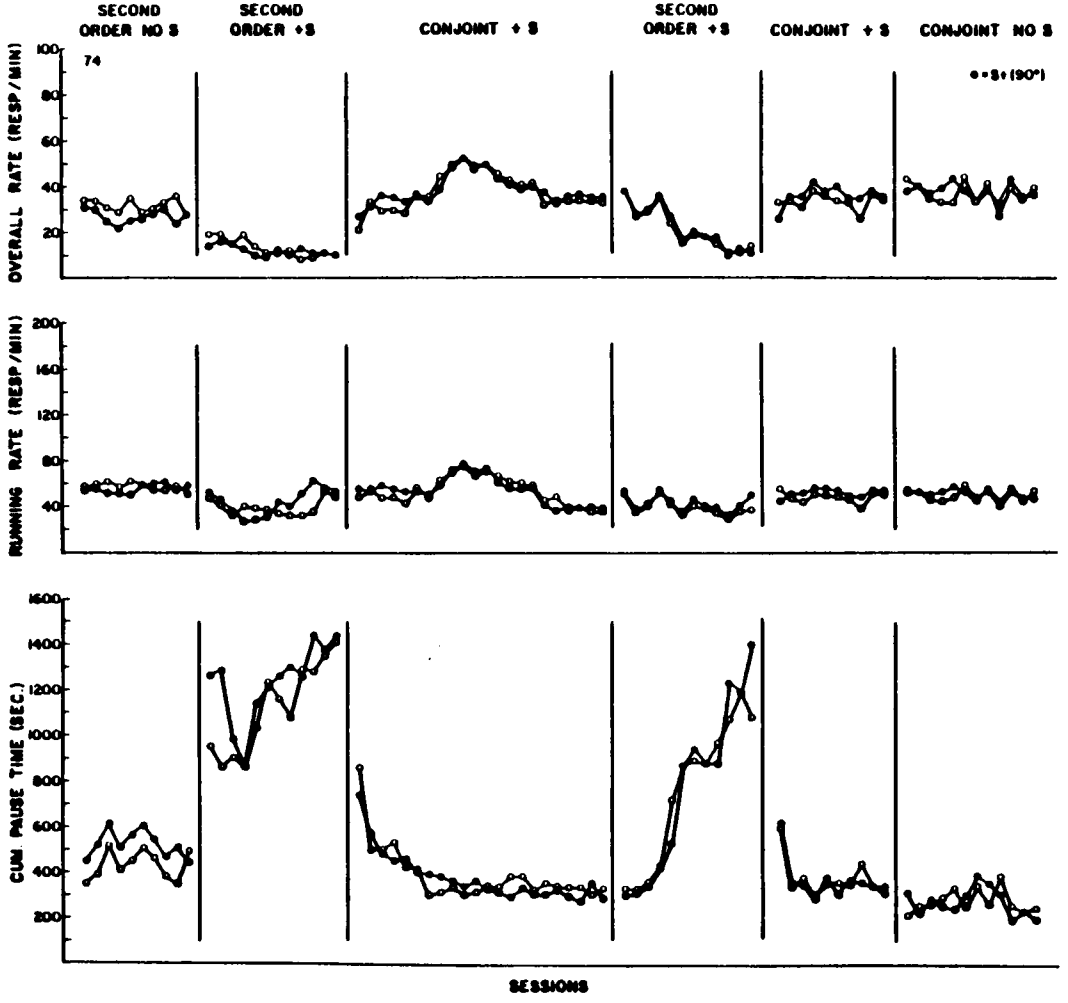

Figure 21. Results for Bird 74, Experiment VI. Performance is shown concurrently for the three response measures: overall response rates, running rates, and cumulative pause times (top to bottom).

schedule in the second condition produced the following changes. There was a decline in overall response rates. Cumulative pause times showed an immediate and large increase such that, by the end of the condition, approximately 80% of the programmed session time was accounted for by pause time values! The pause time values were even higher than was observed in Experiment II for this bird. However, running rates did not show an increase under VI 1-min (FR 11:Snp), as was observed for the other subjects under the same schedule in Experiments III and V; instead, running rates showed a transient decline and recovery. This was more consistent with the changes in running rates under an FI pattern of responding, as were shown in Experiment II. If an FI pattern was emerging, such a pattern of changes in running rates would not be unexpected. The gradual transition from pausing to responding, in combination with the required 11 responses to complete the ratio, would serve to lengthen the time to complete the FR 11 requirements and, hence, lower the value of the average running rates.

Figure 22 shows the cumulative record for the last session from this condition. The up/down position of the event marker on the bottom line of the record indicated which particular multiple schedule component (0^{o} or 90^{o}) was currently presented, whereas the brief displacements of the event marker indicated the occurrence of the Snp cycle. Responding was indicated by the upward movements of the pen in the top line, and food-reinforcement was indicated by a brief downstroke on the response line.

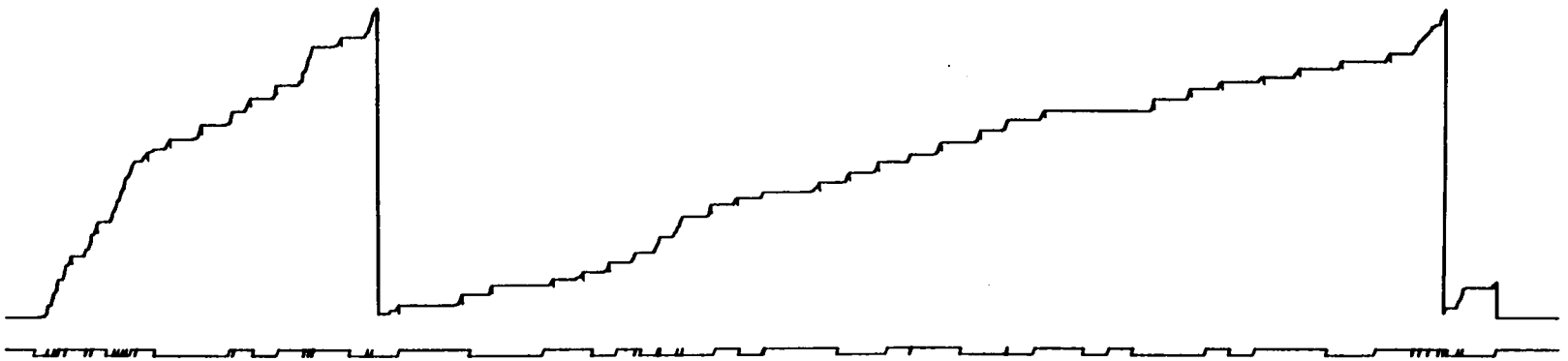

Figure 22. Cumulative record (second-order schedule) for Bird 74, Experiment VI. Performance for the last session of the second condition.

This cumulative record was typical of the performance by Bird 74 in this condition in several characteristics. First, the transitions from pausing to responding typically showed a gradual acceleration. This was more similar to the FI performance observed in Experiment II, compared to the FR performance seen in Experiments III and V. Second, the overall rate of responding tended to decrease over the course of the session. This was due to the increases in pause duration following Snp/food-reinforcement as responding, once begun, tended to occur at the same rate throughout the session. Third, because of the duration of the typical pause, completion of each FR 11 requirement tended to result in food-reinforcement; yet pause durations continued to increase over the course of the session. The length of time spent pausing produced a large reduction in obtained food-reinforcements in this condition relative to the prior condition. In the cumulative record for this session it can be seen that food-reinforcement occurred 30 times, compared to the typical obtained food-reinforcement rate of over 50 per session under the second-order schedule prior to the introduction of the Snp. Fourth, the durations of pause times following the Snp were more erratic than those following food-reinforcement, with often more than one Snp being produced before a pause ensued of duration typical of that following food-reinforcement.

The results of this condition suggested that the bird was responding as if still under the FI schedule of Experiment II. The results of the initial condition in this experiment showed that the

effect was not due to the response requirements of the second-order schedule alone. Since the same Snp was used in Experiment II and here, then the effect could be due to response-rate controlling properties of the Snp that had been developed during Experiment II. The effect, whatever its basis, was strong enough to overcome the consequent loss in food per session.

The third condition consisted of the change of the reinforcement schedule to conjoint VI 1-min FR 11:Snp, as was used in Experiment IV. Under this schedule the same Snp was still produced according to FR 11 as in the preceding condition, but food-reinforcement was now available according to VI 1-min alone. If the pattern of responding under the previous second-order schedule, VI 1-min (FR 11:Snp), was due primarily to the response-rate controlling properties of the (response-produced) Snp alone, then FR 11:Snp should also function to control responding under the conjoint schedule for some time.

Figure 23 shows the cumulative record for the <u>first</u> session of responding under the conjoint reinforcement schedule for Bird 74. It is read in the same manner as the cumulative record in Figure 22. Two aspects of the cumulative record are noteworthy. First, the record shows that there was an <u>immediate</u> disappearance of strong control by the Snp, even though it was still produced according to FR 11 in the same manner as before. This showed that the history effects observed in the second condition could not be considered to be due to properties of the Snp <u>alone</u>. Since the effect was not due

Figure 23. Cumulative record (conjoint schedule) for Bird 74, Experiment VI. Performance for the first session of the third condition.

to the second-order schedule alone and was not due to the use of the same response-produced Snp alone, this suggested that the history effect was due to the combination of the Snp and the second-order schedule. Second, the cumulative record shows that a frequent occurrence during the session was food-reinforcement followed by a pause long enough in duration such that the next response also produced food-reinforcement. Such a pattern of food-reinforcement could never occur under VI 1-min (FR 11:Snp), because 11 responses were always necessary to produce the next event. This difference suggests a likely basis for the bird's discrimination of the change in the contingencies of food-reinforcement.

Training under multiple conjoint VI 1-min FR 11:Snp was continued for 22 sessions. Figure 21 (p. 128) shows that the major change from the second-order reinforcement schedule was the large and immediate reduction in pause times, and the consequent effect on overall response rates. Cumulative records throughout the condition showed the steady responding typically found under VI reinforcement schedules with little apparent effect of the presence of the FR 11:Snp contingency in the schedule. Training was continued under the conjoint reinforcement schedule to see if the steady pattern of responding in the presence of the FR 11:Snp contingency would provide the necessary conditions to counter the effect observed in the prior condition. The efficacy of this "countertraining" was tested by reinstating the second-order schedule in the fourth condition. If the training was successful, then there should have

been the emergence of FR performance, as occurred with Experiments III and V, where the reinforcement schedule was also VI 1-min (FR 11:Snp).

Figure 21 (fourth panels, p. 128) shows the results of the return to the VI 1-min (FR 11:Snp) reinforcement schedule. The figure shows that the training under the conjoint VI 1-min FR 11:Snp reinforcement schedule did not serve to block the reemergence of the same pattern of responding that was observed in the second condition. As before, running rates remained relatively unaffected while pause times showed a large increase over the course of the condition. Cumulative records for the latter part of the condition were similar to that of Figure 22 (p. 130) showing both FI performance and extremely long pauses. It should be pointed out, again, that one consequence of this pattern of responding was a large reduction in the obtained rate of food-reinforcement per session, although this was not a necessary consequence of the response contingencies of the second-order reinforcement schedule. For example, if Bird 74 had continued to respond in a similar pattern under VI 1-min (FR 11:Snp) as it had just been doing in the immediately preceding condition, then the obtained rate of food per session would have remained the same for the two conditions. However, the return of performance like that obtained in the second condition resulted again in a halving of the obtained food rate.

Although there was no obvious effect of the Snp on responding under the conjoint reinforcement schedule, there was not an

appropriate baseline condition with which to compare. It could have been that there was some more subtle effect of the Snp alone which was not apparent from the cumulative records. Therefore, the reinforcement schedule was changed back to conjoint VI 1-min FR 11:Snp for 10 sessions and, in the final condition, the Snp was removed from the conjoint reinforcement schedule to see what had been the effect of the Snp under this schedule.

Figure 21 (fifth panels, p. 128) shows that the return to conjoint VI 1-min FR 11:Snp produced an immediate decline in pause times, while running rates were relatively unaffected. Cumulative records showed the quick emergence of the steady pattern of responding typically observed under VI reinforcement schedules, with no apparent influence of the FR 11:Snp contingency on performance. Elimination of the Snp from the reinforcement schedule in the final condition (Figure 21, extreme right panels) produced little effect on responding. Following the transition to the final condition, no change was observed in running rates and pause times showed only a minor decline. The small decrease in pause time values can be wholly accounted for by the lack of disruption of responding due to the fact that the response key no longer darkened during the Snp cycle. Cumulative records from the last two conditions were indistinguishable.

In summary, Bird 74 was exposed in the first condition to a multiple schedule during which responding was reinforced according to VI 1-min (FR 11). The introduction of a brief stimulus in the

second condition according to VI 1-min (FR 11:Snp) produced a change in the pattern of responding unlike that observed in Experiments III and V for other subjects under the same schedule. The pattern of responding consisted of post-Snp/food pauses of long duration, followed by a gradual pattern of acceleration until the next event was produced. The pattern of responding was similar to the one shown previously by the bird under VI 1-min (tand FR 1 FI 5-sec:Snp) in Experiment II. Since the effect on responding of the prior reinforcement history was strong enough to overcome the consequence of a large reduction in obtained rate of food-reinforcement per session, a series of conditions examined the basis for the effect.

The performance in the initial condition established that the effect on responding was not due solely to the response contingencies of the second-order schedule. In the third condition, the reinforcement schedule was changed to conjoint VI 1-min FR 11:Snp, under which the Snp was still produced according to FR 11, but food was now available according to VI 1-min alone. Control of responding by FR 11:Snp disappeared immediately, showing that the effects under VI 1-min (FR 11:Snp) were not due solely to the use of the same response-produced Snp in both experiments. Since the effect was not due to the second-order schedule <u>alone</u> and was not due to the use of the same response-produced Snp <u>alone</u>, this suggested that the history effect was due to the combination of the Snp under the second-order schedule. Extensive training under conjoint VI 1-min FR 11:Snp did not serve to block the reemergence

of the pattern of responding when the reinforcement schedule was again made VI 1-min (FR 11:Snp), even though the consequence of such performance was an approximate halving of the obtained food-reinforcements per session. A final comparison of responding under the conjoint reinforcement schedule, with and without the Snp, showed that the Snp exerted practically no effect on responding under this reinforcement schedule.

Discussion

The original intention for transferring Bird 74 to the VI 1-min (FR 11) reinforcement schedule was to take advantage of the more stable pattern of responding that had been observed to develop under this reinforcement schedule in Experiments III and V, relative to what was observed in experiments I and II. However, following the introduction of the Snp according to VI 1-min (FR 11:Snp), a strong effect of the prior reinforcement history was evident for Bird 74. The pattern of responding shown here by Bird 74 was more similar to its previous performance in Experiment II than to the pattern of responding shown under VI 1-min (FR 11:Snp) by the other subjects in Experiment III and V. Since the effect was strong enough to overcome the consequent reduction in obtained food-reinforcement per session, the experiment was changed to investigate the basis of the effect. The effect of the prior history of responding under VI 1-min (tand FR 1 FI 5-sec:Snp) on responding under VI 1-min (FR 11:Snp) was treated as an instance of <u>generalization</u>; that is, the pattern of

responding that developed under VI 1-min (FR 11:Snp) was evidence of the commonality of that situation with VI 1-min (tand FR 1 FI 5-sec:Snp) for Bird 74. A series of conditions was then planned to determine along which "dimension(s)" generalization had occurred.

Since the initial condition had shown that the effect was not due to the contingencies of the second-order reinforcement schedule alone, the transfer to the conjoint reinforcement schedule was begun to see if the effect could be cast into the traditional distinction of stimulus versus response generalization. For example, if the pattern of responding under the conjoint reinforcement schedule had been strongly influenced by FR 11:Snp, then another condition could have been introduced. Presenting the Snp non-contingently on responding could have been used to determine whether the control by the Snp was more strongly related to the use of the same Snp (i.e., stimulus generalization) or that the Snp was response-produced (i.e., response generalization) in both experiments. However such a test was not needed since any apparent control of responding by the FR 11:Snp contingency had disappeared by the end of the first session under the conjoint reinforcement schedule. Nor could any important effect of the Snp be detected under the conjoint schedule when an appropriate baseline comparison was performed in the last two conditions. Of further importance was the finding that 22 sessions of training in the presence of FR 11:Snp under the conjoint reinforcement schedule did not serve to counter the

reemergence of the long-duration pauses when the second-order schedule relation was reinstated.

These results made clear that the effects could not be neatly cast into a simple instance of stimulus or response generalization. For example, assume that the effects of the Snp in the second condition were due solely to the common use of the red houselight in this and the preceding experiment. In this case, the red houselight should have continued to control responding in a similar fashion under the conjoint schedule for some time. Next, the continued training under the conjoint schedule should have made VI performance the relevant rate-controlling property of the Snp. However, this is not what happened. Instead, the control of performance by the Snp disappeared almost immediately when the conjoint schedule was instated, and reappeared very quickly when the second-order schedule was reinstated. What this pattern of results do suggest was that the commonality between this experiment and Experiment II for Bird 74 lay in the occurrence of the Snp under a second-order schedule in both experiments. That is to say, the dimension along which generalization occurred was the second-order schedule relationship of food and the Snp.

In the previous experiments, the emphasis was on the Snp as a positive reinforcer under a second-order schedule. The functional status of the Snp was found to be very different depending not just on how it was produced but on how the Snp was produced in relation to how food was produced (c.f., Experiments III, IV, and V). It was

the similarity in the manner of production of the two events that resulted in the Snp becoming a reinforcer. In this experiment, a strong effect of prior reinforcement history was found. Like the reinforcement effect, it was found to depend upon the reoccurrence of a second-order schedule relationship, not on the particular events used nor on the particular response requirements to produce the event. This was the dimension along which generalization occurred; and, the effect was strong enough to overcome the loss in obtained food.

CHAPTER VIII

GENERAL DISCUSSION

Summary of the Experiments

The quasi-reinforcement effect of Neuringer and Chung (1967) specifies that a nonpaired stimulus (Snp) produced in the same manner as a current reinforcer will also show a reinforcement effect. The procedure used by Neuringer and Chung is one type of a class of schedules termed second-order schedules. The distinguishing feature of second-order schedules is that the effective response (e.g., for food) is itself defined by a schedule requirement (e.g., FR 11). A commonly held view is that the quasi-reinforcement effect, like many other second-order schedule effects, is not due to the event being a reinforcer, but is a side effect of other processes. One popular interpretation of effects such as quasi-reinforcement originated with Stubbs (1971). He argued that the appearance of a reinforcement effect was a by-product of the discriminative (signal) properties of the event. The Snp signals the non-occurrence of food and is therefore an extinction stimulus. For this reason, it produces a pause in responding. Responding eventually resumes due to the food schedule. Hence, the FI or FR performance observed under such a second-order schedule is not due to the Snp as a reinforcer of preceding responses but to the inhibitory effects of the Snp on responding immediately thereafter.

The general purpose of Stubbs' explanation was to account for the lack of difference between conditions in which the stimulus was explicitly paired and explicitly nonpaired with food. Close spatio-temporal pairing of some stimulus with food has been the traditional mechanism of so-called secondary or conditioned reinforcement. The defense of this view in operant research is ironic since the original purpose of the secondary reinforcement mechanism was to allow Hull (1943) to account for long sequences of behavior despite the restricted temporal efficacy of primary reinforcement.

There is no longer a necessity for casting effects into the Hullian type of framework. Such theories of reinforcement stressed inherent properties of the event to produce reinforcement effects and close spatio-temporal contiguity to such events as the basis for connection of stimuli and responses. Both views have proved to be insufficient. Contiguity has been replaced by correlation (Baum, 1973; Herrnstein, 1970; Rescorla, 1967). Properties of the event have been replaced by properties of the situation (Premack, 1965; Timberlake & Allison, 1974) and ongoing behavior (Morse & Kelleher, 1977). Such changes stress the analysis of situations which produce reinforcement effects.

The specific purpose of the experiments reported here was to differentiate between the two different interpretations of the quasi-reinforcement effect, Snp as reinforcer versus Snp as extinction stimulus. The first view considers the Snp a positive event while the second view considers the Snp an aversive event.

The general procedure was to examine whether the manipulation of the presence of the Snp would induce positive behavioral contrast, a functional property of positive reinforcers. Of equal importance was whether the the occurrence of positive contrast was dependent upon the second-order schedule relation between the Snp and food, since Neuringer and Chung claimed this was the critical condition for the reinforcement effect. This was tested by examining performance under another schedule, a conjoint schedule, which provided the same events under very similar requirements, but lacking the second-order relation.

Experiments I and II tested for the occurrence of positive behavioral contrast when the unit schedule was (tand FR 1 FI 5-sec). In Experiment I, it was found that the use of only an overall response rate measure was inadequate. Cumulative records showed that responding came under the control of the Snp for all subjects; but two different response patterns developed. The cumulative records for two birds showed FR performance. For these two birds, there was both a reinforcement effect and a positive behavioral contrast effect on overall response rates. The cumulative records for the other two birds showed FI performance. For these two birds, there was neither a reinforcement effect nor a positive behavioral contrast effect on overall response rates. The lack of effect on overall response rates was not surprising given that FI performance developed. There is a tenuous relationship between overall response rates and the development of FI performance (Richelle & Lejeune,

1980). What was not anticipated was the development of FI performance under this particular schedule for that had not been reported before.

Experiment II was a replication of Experiment I with a change in the recording apparatus such that both pause times and running rates could be determined in addition to overall response rates. Since positive behavioral contrast effects under both FI and FR schedules occur as a reduction of pause duration, it would not matter which response pattern emerged. Both birds in Experiment II showed FI performance when the Snp was introduced. Positive behavioral contrast for both birds occurred as a reduction in pause times. In addition, one bird showed an increase in running rates and a change to an FR break-and-run pattern during the Contrast Condition. This change in performance did not reverse when the Snp was reintroduced into the altered component.

The results of Experiments I and II showed that manipulation of the presence of the Snp did induce positive behavioral contrast. The general design of these experiments, however, required stable and recoverable performance. The mixture of FI and FR performance in the two experiments suggested that (tand FR 1 FI 5-sec) was an unstable schedule unit for the purposes of the experiments here. Experiment III examined whether the use of (FR 11) as the response unit would result in behavioral contrast and, also, provide more stable performance for the specific purposes here. The results showed that positive behavioral contrast occurred for all subjects.

This showed that the contrast effects were not dependent on the use of (tand FR 1 FI 5-sec) as the response unit. Performance was also more stable under this schedule for two of the three birds.

Experiment IV tested whether the reinforcement and contrast effects observed in the previous experiments were dependent upon the second-order schedule relationship of the Snp and food. This was tested by presenting food and the Snp under a conjoint schedule. Under a conjoint schedule, the reinforcement schedules are in operation simultaneously and independently. In this experiment, the food and Snp schedules were the same as used in Experiment III. From the previous work by Neuringer and Chung and by Stubbs it was expected that there would be no reinforcement effect. The additional prediction here was that positive behavioral contrast would <u>not</u> be seen. The results showed that there were neither reinforcement nor contrast effects. This showed that the occurrence of positive behavioral contrast in Experiment III (and, by implication, Experiments I and II) was dependent on the second-order relationship, since all other aspects were held constant. In fact, there was so little difference in performance as a function of the presence of the Snp under the conjoint schedule relationship that it would not be inaccurate to describe the Snp as functionally "invisible" to the birds.

The above experiments found that contrast effects occurred primarily as reductions in pause times. This was consistent with what had been previously reported for FR and FI procedures. However,

the schedules and measures used here were different enough from other experiments that it was considered appropriate to ensure that a contrast effect induced by food would show the same pattern of results with the present procedure as occurred with manipulation of the Snp. This was the purpose of Experiment V. In this experiment both food and the Snp were removed during the Contrast Condition. The results were consistent with the previous experiments. Positive behavioral contrast occurred primarily as a reduction in pause times. This result strengthened the interpretation that the effects observed in the previous experiments did represent positive behavioral contrast.

Experiment VI was a departure from the planned series of experiments. One subject, that was to participate in Experiment V, showed an extremely strong effect of its prior training experiences in Experiment II. Since the effect was strong enough to overcome the consequent loss in food, it was considered worthwhile to investigate the effect systematically. Experiment VI was designed to determine the basis of the similarity between the two experiments for the bird. This involved a series of conditions which compared performance under second-order and conjoint schedules, with and without the presence of the Snp. The results showed that the basis of the similarity was the combination of the occurrence of the Snp under the second-order schedule. Further, it was found that training under a conjoint schedule with the Snp would not counter the effect of the Snp under the second-order schedule. This demonstrated that

the Snp under a second-order schedule was a very different event from the "same" Snp under a conjoint schedule, as had been implied by the results of Experiments III and IV.

The results of these experiments permit two positive conclusions. First, the Snp was a reinforcer, as it produced positive behavioral contrast in the same manner as other positive reinforcers. Second, the necessary and sufficient conditions for the Snp to become a reinforcer was the second-order schedule relationship between it and food.

Two Common Questions

The description of the present results typically leads to two general types of questions. The first concerns terming the Snp a reinforcer. The essence of the question is that the Snp acts <u>like</u> a reinforcer, but it just doesn't seem like a <u>real</u> reinforcer. What makes this a <u>real</u> reinforcer? The second question concerns <u>why</u> such an effect should ever occur in the first place. The essence of the second question focuses on whether the effects represent something restricted to the narrow area of second-order reinforcement schedules or whether the results capture some condition of general interest. Both questions are worthy of discussion.

A technically correct answer to the first question is that reinforcers are defined empirically. Some event is a reinforcer when it brings under control the responding upon which the event is contingent. However, such an answer is certain to prove

unsatisfactory to many. One reason for this dissatisfaction is because the question is based on a common, but incorrect, view of reinforcement.

When most ask such a question they are thinking of a particular event, food. Food is assumed to be the standard by which we judge the properties of reinforcers. Does the Snp have the same properties as food? When the question is rephrased in this manner, it permits a more direct answer.

First, it has to be realized that there is an assumption that the properties of food-reinforcement represents the appropriate standard. This is usually due to an emphasis on its immediate contribution to biological fitness. A basic question is whether the properties of food-reinforcement are even representative of all events which can be categorized by their immediate contribution to fitness? The answer is that it is <u>not</u> reasonable to do so. Hogan and Roper (1978) surveyed the classes of effects shown by various reinforcers. One conclusion that they reached was that if food was made the standard then many events of equal importance to fitness would not be classified as reinforcers because they do not show the same properties as food.

The Snp certainly does not show all the properties on responding that grain does. For example, the Snp did not produce a contrast effect under the conjoint schedule. It seems a safe prediction that if mixed grain was available according to both FR 11 and VI 1-min concurrently, then behavioral contrast would have been

produced when the FR 11 grain was eliminated. The Snp is not grain. Only if one's definition of reinforcement is tied completely to mixed-grain, does the difference between the two permit one to be called a reinforcer and not the other.

Second, the question of the validity of terming the Snp a reinforcer is also related to a misinterpretation of the fact that the effect is dependent upon certain conditions. The concern can be expressed in the following manner. The Snp is sometimes a reinforcer (i.e., under the second-order schedule) and sometimes not (i.e., under a conjoint schedule). It seems to be a very transient effect, unlike a real reinforcer. The problem, again, is assessing the effect against a misunderstanding of the effects of the typical reinforcer, food.

Food-reinforcement effects only occur under certain conditions, but this dependence is not emphasized enough. All response classes are not equally susceptible to food-reinforcement, as was pointed out by Thorndike and others since then (e.g., Shettleworth, 1975). A response class that does show food-reinforcement will not be reinforced by food all the time; the most obvious example is the change in the efficacy of food-reinforcement as a function of food deprivation. Nor will a reinforcement effect necessarily be maintained if requirements are changed too rapidly (e.g., "ratio strain"), alternatives change or become available (e.g., "choice" procedure effects), or new events are introduced (e.g., "suppression" effects of free food or shock).

All reinforcement effects are tied to certain conditions. In the Introduction it was stressed that the significance of Premack's work was to make clear that progress was to be made by making the analysis of conditions which produce reinforcement effects a central rather than a peripheral factor. The requirement for progress is not that effects do not change, but that differences are orderly. That is what was observed here. The Snp did or did not produce a reinforcement effect, depending upon the particular schedule used. If there was a reinforcement effect, then a behavioral contrast effect was also seen. If there was no reinforcement effect, then no behavioral contrast was seen. Different schedules produced effects, but the different effects occurred in an orderly fashion.

A final question is that of <u>why</u> did the Snp became a reinforcer? This is the second general type of question. What conditions were captured or represented in both second-order and conjoint schedules such that a reinforcement effect was produced in one but not the other? Were these conditions which relate solely to specific, narrow details of reinforcement schedules or are they of more general significance?

The different effects of the Snp under the two schedules were generally referred to as a difference in the <u>functional</u> status of the Snp. The specific aim of the work here was to show that the Snp was a "good" event under the second-order but not the conjoint schedule. But if we step back from that specific question, we are confronted by the fact of the difference in functional status. The

phrase, functional status, refers to the fact that the Snp had a different meaning under the two schedules. Thus, in a very broad sense, the differences between the two schedules must represent some basis for how events come to have meaning. The final question becomes: what do the effects here show about how events come to have particular meanings?

The Approach of Gibson

The results here are most relevant to the approach of J. J. Gibson (1966, 1979). The incorporation of a Gibsonian perspective at this point does not represent an act of apostasy. Gibson was a behaviorist in the best sense of the term. This has come to be realized recently by others (e.g., Costall, 1984). A short description of his views shows why this perspective is relevant to the results here and of general significance.

Gibson's theoretical position is quite different from most current approaches to perception. He characterized this difference as one between "direct" versus "indirect" perception. Other approaches are examples of theories of mediated or "indirect" perception. They assume that stimulus information is impoverished or incomplete; and hence must be enriched by internal constructive processes to result in a "percept." One common example of the indirect approach is seen in the presentation of the "problem" of depth perception. The problem, so the argument goes, is that the three-dimensional world ends up on the retina as a two-dimensional

image. Since the third-dimension is "lost" at the level of the retina, the task is to discover how the experience of depth is "recovered" at later stages of visual processing. Gibson, in contrast, argued that the information in the "optic array," the sea of light in which we live, contains all that is necessary for responding to differences in depth and that we respond "directly" to such information. Two aspects of this statement require further description: what is meant by information in the optic array? and, what is meant by responding directly?

One of Gibson's key arguments was that psychology never developed an appreciation for the orderly changes in the stimulus array which are available to the organism. It was this inadequate understanding of what is available that was responsible in large part for the continued adherence to views of mediated perception. An example is the misinterpretation of the meaning of psycho-physical "slippages" such as color constancy, in which judged color of an illuminant does not correspond monotonically to the physicist's metric of wavelength. Psycho-physical slippages such as these were taken to mean that some other process must intervene (e.g., Helmholtz's "unconscious inference"). Therefore, perception meant a process comprised of the effect of intervening processes on the stimulus input.

Gibson argued that this represents an inappropriate borrowing of metrics from physics. Physics developed metrics such as frequency, wavelength, and amplitude to order phenomena for their

own purposes. There is no reason to expect that those metrics will apply in the same manner to the problems of psychology. Failures of psycho-physical correspondence represent the inappropriate use of the measures of another field, and do not imply the need for additional "processing."

One of the central tasks for Gibson was the development of an "ecological physics." Such a physics involves a naturalistic description at the level of the behaving organism. This involves, for example, the description of orderly static relationships (structural invariants) and orderly dynamic relationships (transformational invariants) to which we respond. One way to conceive of some invariants is as a "melody" which survives transposition to a new key. But the concept is much broader than this since transformations delineate change as well as permanence. Such relations are available to and used by organisms. The most well-known example from Gibson is his classification of the meanings of different patterns of optical flow.

Another more recent example is the work of Pittenger and Shaw (i.e., Pittenger & Shaw, 1975a, 1975b; Pittenger, Shaw, & Mark, 1979; Shaw & Pittenger, 1977). They showed that people consistently rank order according to "age" various stimulus sets (e.g., pictures of people, cartoon drawings). The ranking was in correspondence with a transformational relationship termed "cardiod strain." Cardiod strain is a topological relationship which describes the effect of strain on a visco-elastic body, such as the head, due to factors

such as gravity and fluid pressure (cf., Thompson, 1917). One important feature of such relationships, like cardiod strain, from the viewpoint of these workers is that such metrics are naturalistic. They are describable by physics, at least in principle, and therefore do not support mentalism or psychophysical dualism.

The second aspect of Gibson's opposition to the traditional approach to perception is his statement that such variables are responded to directly. The best way to understand the meaning of this term is from a currently popular analogy, the polar planimeter (Runeson, 1977). The polar planimeter is a device used in drafting to determine area. We were taught in school that to determine area we needed to know first the length and width of some figure, and, then, derive area according to the formula, A = L x W. In other words, area is a "higher-order" property that is based on the lower-order properties of length and width. What makes the polar planimeter an interesting device is that it does not work in this manner. It will accurately measure area, but does not do so by first determining length. In fact, the device is quite inaccurate when used to measure length. This is said to be a device that responds directly to area.

This illustrates the meaning of direct. Through evolution, our perceptual systems have become attuned to certain kinds of information. These types of information are responded to without recourse to additional or intervening processes. We respond directly

to this information, just as the polar planimeter responds directly to area without initially computing length. The general point is that a constructivist bias has led us to use analogies that impose certain relationships between higher-order and lower-order properties; for example, the higher-order property of "triangle" is based on the lower-order properties of angles and connecting lines. Just because high-school geometry works in this fashion does not mean that we must do so in the same fashion.

The above points have sketched Gibson's view of the basis of perception. The perceptual apparatus of organisms have been shaped, through evolution, to be able to use complex orderly changes in the world with no need for elaboration by subsequent computational mechanisms. The next question is what is seen? This question is dealt with by Gibson's concept of affordance.

We see affordances, according to Gibson. Affordances are what the environment offers to the animal. What is seen are the acts permitted by objects, places, and events for that particular animal. A "chair" is that which affords sitting for a particular animal. The assertion that what we see is the meaning or value of objects is not new. It corresponds basically to emphases on phenomenal objects (e.g., Koffka, 1935). What distinguishes Gibson's approach is that such affordances are also perceived directly. There is no distinction between the behavioral chair and the physical chair. There is only one chair, and "sitting-upon" is an invariant property of that object which is available for a particular animal.

"An affordance is not bestowed upon an object by a need of an observer and his act of perceiving it. The object offers what it does because it is what it is." (Gibson, 1979, p. 139).

Gibson's overall point is the same as before. Here it is an argument against a second type of constructivist position. Just as the perception of depth is not elaborated from a two-dimensional retinal image, the perception of an affordance is not the process of perceiving a value-free physical object to which meaning is somehow added. Objects are not value-free, instead they are value-rich. They afford a variety of activities, to some of which we become attuned.

Application of Gibson's View

An apposition of the results here to a Gibsonian perspective is relevant and fruitful. One point that such a perspective emphasizes is the search for stimulus dimensions that constitute orderly relations of change that an animal uses. The present results pointed to such a variable which was termed relations of encounter. By this term, it was meant that not only were the pigeons sensitive to how some event was produced, but how it was produced in relation to how another event was produced.

This was illustrated most directly by the results in Experiment VI. The transitions between the conjoint and second-order schedules were unsignaled in that the same Snp was produced according to FR 11 in both cases and the programmed temporal distribution of food was the same in both cases. The only difference between the schedules

was that under the second-order schedule both food and the Snp was produced according to FR 11 whereas under the conjoint schedule only the Snp required completion of 11 responses. A continuation of the performance, that had developed under the conjoint schedule, throughout the second-order condition would have resulted in the same food rate under both schedules. In fact, if food-rate was the sole controlling relation then overall response rates should have been higher under the second-order schedule because of the FR 11 food contingency. This was the opposite of what was observed.

Instead the effect of the Snp on performance was drastically different under the two schedule relations. Moreover, the change in performance was quite fast. As those familiar with discrimination learning experiments will have noted, the changes in performance between conditions in Experiment VI occurred at a rate comparable to what would be observed with the repeated reversals of an S+/S- relationship of "obvious" stimuli such as red and green keylights. These two factors, the speed and strength of the effect, suggest that this stimulus dimension, relations of encounter, is an important one.

It is worth pointing out, again, that discrimination between the two types of schedule relations did not require mystical powers on the part of the pigeon. One local basis for differentiation was pointed out. The bird often encountered two occurrences of food separated by less than eleven responses under the conjoint schedule. Previous work by Shimp (Hawkes & Shimp, 1975; Shimp, 1981, 1982,

1983) suggests that pigeons would be able to use such a difference.

An explanation for the different patterns of results under the different schedules can be derived from the concept of affordance. Affordance is a theory of meaning which states that the meaning (or value or functional status) of some event is constituted of the acts permitted by it. The second-order schedules used here arrange conditions such that the same pattern of behavior produced one of two events, food or the Snp. We can redescribe this experimental arrangement by saying that the conditions of the second-order schedule constrain the sets of actions available such that the Snp and food are constituted of (produced by) similar acts and, thus, have similar meanings.

The use of a term like constrain needs careful definition. It refers to the most likely manner of encounter. The response requirements of the second-order schedule did not force the pigeon to show FR or FI performance. The results in the initial baseline conditions in these experiments showed that the birds did not show FR or FI performance when only the response requirements were in effect. Baseline performance was quite different from when the Snp was available. What the second-order schedule arranged was the likelihood that the Snp and food were produced following the same pattern of behavior. This is what is meant by constrain. Again, this did not force FR or FI performance. A continuation of the response pattern from the prior condition is perfectly adequate in maintaining food rate. It is because the second-order relationship

is there, that performance changes accordingly. Performance changes because both events exist in a similar relationship of production. This resulted in their having similar meanings such that manipulation of the presence of the Snp produced behavioral contrast in a manner analogous to the manipulation of food.

A similar interpretation explains the different effects under the conjoint schedule. The conditions of the conjoint schedule were such that the two events followed <u>different</u> patterns of responding. The Snp was produced according to a rule based on the number of preceding responses (i.e., FR 11); the availability of food was more dependent on the passage of time. The meanings (effects) of the two events were thus different because the response patterns (acts) which produced (constituted) them were different. For reasons which will subsequently be made clear, I will refer to the Snp and food as having <u>independent</u> meanings, because satisfying the schedule requirement for one had little impact on the production of the other.

The application of a Gibsonian perspective to the present results offers more than just a redescription. It suggests further lines of inquiry. One example would be a procedure to give two events "opposite meanings."

The present results showed that pigeons were sensitive to the relationship between events, with this relationship determining meaning. Two types of schedule relationships were used and two types of meaning were found in the experiments here. Under the quasi-

reinforcement second-order schedules, both events were produced according to the same rule and had similar meanings. Under the conjoint schedules, both events were produced according to independent rules, and the Snp had little influence. This suggests a third type of relationship should also exist. If two events are produced according to incompatible rules, then they should have incompatible meanings by virtue of that relationship.

Consider the following reinforcement schedule contingencies. Under an overall VI food schedule, the effective response (upon which food is contingent) is defined by a rule which specifies a sequence (i.e., a "run") of interresponse times below some criterion. Defining the effective response in this manner specifies that local response rate, for some period, must exceed a criterion to constitute an effective response. A second rule is also in operation. When interresponse times over the same sequence exceed some criterion (i.e., local response rate falls below that criterion) then the requirements for a second type of effective response have been met.

This schedule has the following properties of interest. Two classes of effective responses are specified. They are related, since the completion of one affects the completion of the other. Most importantly, this relationship is one of incompatibility since the occurrence of one prohibits the occurrence of the other. If the preceding analysis is correct, then, by virtue of this relationship, the two events which are produced will have incompatible meanings.

This schedule specifies a manner to produce a "quasi-punisher," to extend the terminology of Neuringer and Chung. Following exposure to a condition in which only food is given (according to the first type of response rule), the introduction of an Snp contingent on the second type of response rule should result in a decrease in the rate of that response class. Further, the Snp should show other "aversive" properties.

Whether the aversive properties of the Snp are best tested with the behavioral contrast paradigm used here is less certain for the following reasons. In the experiments reported here, both events were assumed to be "good." In the schedule under discussion, the presence of the Snp and food in each component represents a mixture of "bad" and good. This sets the conditions for contrast effects within components. Eliminating the bad-Snp from one component should make it a "better" component. This should make the other component "worse" and produce negative behavioral contrast, a reduction in overall response rates for that component. But response rates within that component are being maintained also by contrast effects between food and the Snp. The reduction in response rates may produce more of the bad-Snp which may serve to prevent further reduction in response rates in that component. Hence, the effect on response rates is unclear on an a priori basis because the situation pits contrast effects between components against contrast effects within components.

The above example gives a specific application of the Gibsonian

perspective, but the fruitful consequences on overall research strategy must be mentioned. One consequence is that the "things" which we study are based on orderly changes in time. This was obvious in Gibson's treatment of a "stimulus"; that is, the presumption that it was the dynamic changes in the optic array to which were attuned. It is important to realize that the perspective applies equally to the treatment of a "response."

Early in his career, Skinner (1931) proposed that a response (class) was defined functionally; that is, by orderly covariance with consequences. This set the stage for developing the analysis of a temporally-extended response. Over fifty years later, our units still revolve around the punctate and instantaneous keypeck and barpress, or session averages. The theoretical importance of the integrity of the FI scallop is given homage, but little specific work has been done on how to approach such response classes under less obvious circumstances. Even Skinner seems to have forgotten his earlier work, with his persistent invocations of chaining of discrete units (e.g., Epstein, Lanza, & Skinner, 1980; Skinner, 1953).

A second consequence is that such things presume the elimination of many traditional distinctions between perception and action, and the linear relationship which binds them. The popular notion is that stimuli are prior independent entities or energies that bring about some effect which succeeds them in time. The example of a mobile animal, negotiating a cluttered path, shows the

false economy of such distinctions. The distinction between stimulus and response cannot be tied to some specific part of the situation. The postural changes are both response and stimulus (e.g., kinesthesia), the optic array is both stimulus and response (e.g., movement parallax). The essence of the stimulus/response distinction is to impose a specific relationship, linear flow, on the analysis. But such a relation does not fit without considerable strain on, e.g., kinesthesia. Clearly, there is not muscle contraction, and <u>then</u> stretching of the receptors; both occur in conjunction.

Consequences like the above are important. We are still at the point of developing our basic categories and relations. This was the concern which motivated the work reported here. The phenomenon of reinforcement was treated as an effect which is still to be understood, and <u>not</u> as the solution to other questions. The quasi-reinforcement effect suggested one manner by which events come to produce reinforcement effects. The question of why the effect occurs suggested the relationship of this effect to the more general problem of the perception of "objects" or "events." What is good and general about the work of a Gibson or a Skinner are the suggestions on how to proceed. It is always the initial step that is most difficult since we must abandon at the outset our comfortable, but flawed, distinctions for an uncertain result. There is no merit in avoiding difficult problems. The restriction of analysis to what is customary in a field makes science an onerous ritual.

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