JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1998, **70,** 321–324 NUMBER 3 (NOVEMBER)

DO PARAKEETS EXHIBIT DERIVED STIMULUS CONTROL? SOME THOUGHTS ON EXPERIMENTAL CONTROL PROCEDURES

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Breaking new ground in the study of emergent stimulus control in nonverbal subjects may require innovation in procedures. A recent study of parakeets is exemplary. This study used intricate procedures for maintaining test-trial performance without differential reinforcement of the target emergent performance. Also, it used successive simple discrimination procedures, which are rare in such studies. Given the importance of these innovations and the outcomes that they produced, we suggest additional control procedures that would rule out the possibility of adventitious reinforcement of the test-trial performances.

Key words: adventitious reinforcement, stimulus equivalence, symmetry, parakeets

The investigation of derived stimulus control stands to advance greatly with the development of innovative methods for studying nonhuman and verbally limited human subjects. Two areas of procedural development seem especially important. First, with these populations, it may be particularly informative to study forms of derived stimulus control other than arbitrary matching to sample, which currently predominates in the literature. For example, a recent study suggests the potential of simple successive discrimination, in which two or more discriminative stimuli control topographically distinct responses, for the study of emergent stimulus control in birds (Manabe, Kawashima, & Staddon, 1995).

Second, unlike in studies of verbally sophisticated human subjects, in most animal studies that showed evidence of emergent stimulus control, test-trial responses were differentially reinforced (e.g., D'Amato, Salmon, Loukas, & Tomie, 1985; Schusterman & Kastak, 1993). Although it is too soon to know for sure, test-trial reinforcement might be crucial to the study of verbally limited subjects. This aspect of procedure, however, necessitates control conditions to rule out differential reinforcement as a determinant of test-trial accuracy.

Because these two procedures—reinforcement of test-trial responses and simple successive discrimination—have been used relatively infrequently, it seems timely to discuss special considerations of their use. An important study involving parakeets (Manabe et al., 1995), which combined these procedures, will serve as the focus of our discussion. The Manabe et al. study is an exciting contribution to the literature on derived stimulus control, because it suggests the possibility of highly accurate bidirectional transfer in birds. Previous studies with nonhuman animals have shown little (Zentall, Sherburne, & Steirn, 1992) or no (D'Amato et al., 1985; Rodewald, 1974; Sidman et al., 1982) evidence of bidirectional transfer.

A particularly innovative feature of Manabe et al.'s (1995) procedures is that they were designed to show transfer of stimulus control within a simple successive discrimination. To our knowledge, this is the only study to do so with birds. Taking advantage of the malleable vocal repertoire of the parakeet, Manabe et al. developed automated reinforcement procedures for establishing stimulus control of parakeets' vocal behavior—a major accomplishment in itself. In Experiment 1, the birds were trained to make a high-frequency call in the presence of a red stimulus and a low-fre-

Preparation was supported by National Institute of Child Health and Human Development Grants R29-HD27314, PO1-HD18955, and P30-HD02528 to the Schiefelbusch Institute for Life Span Studies, University of Kansas. We thank our colleagues on the Program Project Grant, Communication of People with Mental Retardation, along with Pat White, Donna Dutcher, and Jennifer O'Donnell for helpful comments and editorial assistance.

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quency call in the presence of a green stimulus. For convenience, we will discuss all procedures without describing stimulus counterbalancing. Experiments 2 and 3 were designed to demonstrate emergent stimulus control of the calls.

To address the problem of maintaining behavior on test trials, the stimulus to which control was transferred was the sample in a matching-to-sample procedure. Within the matching procedures, the calls served as observing responses. In the test trials, either call produced the comparison stimuli, and differential reinforcement procedures were in effect for pecking the correct comparison. These procedures ostensibly precluded differential reinforcement of particular sample–call relations, the emergent behavior of interest, while maintaining test-trial performance.

Our concern is that such procedures may not effectively rule out the possibility of generating the demonstrated performances through adventitious reinforcement. Because test-trial contingencies involved the reinforcement of specific comparison-selection responses, and because comparison selection was always preceded by a call, call-comparison units may have developed (i.e., chains; see Boren, 1969). To illustrate the complexity of the experimental control issues, we will describe Manabe et al.'s (1995) procedures in further detail. As a heuristic device, we will speculate that the outcome *was* due to adventitious reinforcement, despite incomplete evidence. Regardless of whether there is evidence of adventitious reinforcement in Manabe et al.'s study, however, the procedures allow a possible confounding effect that future studies should attempt to eliminate.

Controls for the possibility of adventitious reinforcement seem especially important for the procedures used in Experiment 3 (and for Subject 4 of Experiment 2, whose procedures were similar). Here, it seems possible that the *baseline* training established call-comparison units that were then reinforced in test trials. There is evidence that units analogous to these can be established (e.g., Urcuioli, 1985; Urcuioli & Honig, 1980). The top panel of Figure 1 illustrates the procedures. Red and green stimuli were samples in a matching-to-sample procedure. Making the correct call produced the comparison stimuli, which were two different forms. Responding to one abstract form, F3, was reinforced in the presence of red (and after the high call) and responding to the other form, F4, was reinforced in the presence of green (after the low call). The solid boxes outline the units that may have been selected by reinforcement in the training sessions: high call/F3 and low

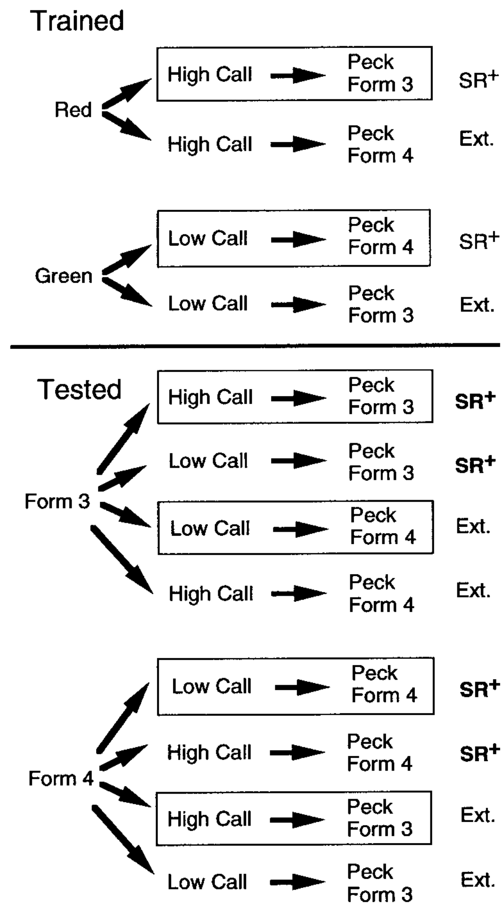

Fig. 1. The top panel shows the contingencies in effect during training trials. Solid lines surround the units that are presumably at strength after training, and no lines surround units that are not at strength. (During training, trials ended when the low call was emitted in the presence of red or the high call was emitted in the presence of green; this is not shown.) The bottom panel shows that, although any one of four units was possible on test trials, only two met the reinforcement contingencies. Of these, only one was already at strength, and thus more likely to be selected by the contingencies. (Given that any call could produce the comparison stimuli on test trials, calls that were in neither the high nor the low class may have also occurred. We have not attempted to illustrate this possibility, given that one of the target responses was emitted on the majority of trials.)

call/F4. During test sessions, these units were maintained on half of the trials (the baseline trials). The top panel also shows the terminal units that were extinguished during training. At the end of training, their probability was very low.

Test trials were designed to determine whether each form would occasion the call that had previously preceded it (i.e., would F3 now control the high call?). That is, a key prerequisite for the ''derived'' *F3/high-call* relation was said to be the trained *high-call/F3* relation. Test trials presented the forms as samples in an identity matching-to-sample format. Any vocalization could produce the comparison stimuli. Given the subjects' history, we speculate that they made either the high call or the low call on most trials (but at first the calls were not under the control of particular sample stimuli).

Because only two call-form units were reinforced during training, these units were disproportionately available for selection by the test-trial contingencies (i.e., differential reinforcement of correct comparison selection). The lower panel of Figure 1 shows the units that presumably could be selected on test trials, with the solid boxes indicating the units that training made most probable. It seems likely that subjects usually pecked F3 after emitting the high call. If so, when the selection of F3 was reinforced in the presence of the F3 sample, the high-call/F3 unit was reinforced adventitiously (see Boren, 1969; Skinner & Morse, 1972). Thus, the F3 sample may have come to occasion not only selection of the F3 comparison but the selection of the entire high-call/F3 unit. The same argument would hold for the low-call/F4 unit.

Although other units were possible candidates for selection, their actual availability was likely to be relatively low. At the end of Experiment 1, calls that did not meet the response definitions were virtually nonexistent. Moreover, the interspersed baseline trials, which required the terminal chain that was shown on test trials, could conceivably serve to prevent drift away from the expected outcome, because the emission of novel call-form combinations on baseline trials produced a timeout. Therefore, a molar contingency favoring the high-call/peck F3, low-call/peck F4 terminal links might also operate. This contingency, however, was not absolute. Initially, on approximately half of the test trials, subjects made the incorrect call. They also initially selected the incorrect comparison stimulus on approximately half of the test trials. Thus, some disruption might be expected due to nonreinforcement of the proposed chains. This may account for the noticeably imperfect correspondence between calling accuracy and selection accuracy in some sessions (e.g., Sessions 3 and 4 for Subject 6 and Sessions 7, 8, and 9 for Subject 5).

Unfortunately, we do not know which call the subjects made on error trials. Unlike in two-choice matching-to-sample procedures, accuracy measures of successive discrimination performance do not allow unequivocal inference of the subject's behavior on incorrect trials. Our educated guess is that errors were usually the alternative call. In reporting the results for Experiments 1 and 2, the paper notes that initial test responses were either high or low calls (Manabe et al., 1995, pp. 119–120, 122). Moreover, with human subjects, ''errors'' in successive discrimination are likely to be the response that is correct in the presence of the other stimulus (Saunders & Spradlin, 1990). This information is not given for Experiment 3, however, and our guess is a poor substitute for data on the proportion of high calls followed by F3 and low calls followed by F4 throughout testing. We suggest that studies using procedures that have multiple response options make a practice of reporting error-trial responses, because they are an important aspect of the data.

Although our primary goal has been to illustrate the need for control procedures, we will also suggest some specific possibilities. A partial solution would be to present novel stimuli as comparisons. Given that the sample–call relation is the derived relation of interest, it is not necessary to use the same comparisons on both training and test trials. This would break up the call-comparison chain, making adventitious reinforcement of a specific call much less likely.

It is important to note, however, that this procedure would not eliminate the need for replication within and across subjects. With lengthy exposure to test trials under differential reinforcement procedures, chaining could occur during tests even though specific call-selection units had not been established prior to testing. If so, this procedure would likely produce different outcomes across replications (either within or across subjects). Assuming that the trained call topographies were captured by the test-trial contingencies, four outcomes might be expected. A subject might make a different call to each sample either "correctly" or with the calls reversed. Alternatively, one or the other call might predominate, regardless of the sample. Note that this consideration affects the interpretation of the results for Subjects 5 and 6 in Experiment 2. Each showed one of the four patterns that could result, assuming that the two previously established calls were maintained superstitiously (with nondifferential reinforcement). Subject 5 made a different call in the presence of each sample, and Subject 6 made the same call in the presence of both samples. Given these outcomes, the positive result with Subject 5 is difficult to interpret without replication.

Another potential control procedure would be to test using simple successive discrimination procedures with nondifferential reinforcement. That is, in the presence of either form, any vocalization would be reinforced (and there would be no comparison stimuli). This procedure would lessen the possibility of adventitious reinforcement of the "derived" form–call relations. Nondifferential reinforcement has been used effectively in a study of derived stimulus control within a conditional position discrimination procedure (Wasserman, DeVolder, & Coppage, 1992).

Manabe et al.'s (1995) exciting findings are certain to inspire replication. The potential revolutionary importance of this work makes it imperative that future studies rule out alternative explanations. We have identified a potential mechanism for the performances observed, in hopes of contributing to the development of experimental procedures.

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Received October 3, 1995
Final acceptance June 30, 1998