JOURNAL OF APPLIED BEHAVIOR ANALYSIS 2001, **34,** 127–144 NUMBER 2 (SUMMER 2001)

CORRESPONDENCE AS CONDITIONAL STIMULUS CONTROL: INSIGHTS FROM EXPERIMENTS WITH PIGEONS

KENNON A. LATTAL AND KARLA J. DOEPKE

WEST VIRGINIA UNIVERSITY

Correspondence between saying and doing, typically studied in young children and individuals with developmental disabilities, was examined as an instance of conditional stimulus control. In Experiment 1, 3 pigeons were exposed to a two-component repeated-trials procedure. In the first—sample or say—component, two response keys transilluminated by different colored lights were presented and the pigeon pecked one of the keys. After 1 s of darkness in the chamber, the second—choice or do—component was presented, in which the two keys again were transilluminated, one by the color selected in the first component and the second by another color. Selecting the color that matched that selected in the say component resulted in access to food. Selecting the other color produced a blackout of the chamber. After an intertrial interval (ITI), the next say component was programmed, and the procedure was repeated. Correspondence remained at chance levels through several manipulations of ITI duration and sample response requirement. When a correction procedure was added such that only the originally selected sample stimulus was re-presented until a correct choice response occurred, reliable correspondence developed in 2 pigeons. This correspondence was eliminated by making reinforcement independent of correspondence and subsequently was reestablished when reinforcement again depended on correspondence. In Experiment 2, 3 other pigeons rapidly acquired correspondence under the final procedure used in Experiment 1. Increasing the time interval between the say and do components diminished correspondence. The results of the two experiments suggest how correspondence may be considered an instance of conditional stimulus control and that it is possible to construct a homologue of human say-do correspondence with pigeons.

DESCRIPTORS: say-do correspondence, conditional stimulus control, animal homologue, key peck, pigeons

---

Correspondence is a generic label that describes a relation between actions occurring at two different times. In one commonly studied variation of correspondence, described by some as report-do and by others as say-do correspondence, a human indicates by reporting, typically verbally by "saying," which of several alternative activities or items he or she is likely to select subsequently. This is followed by an opportunity to "do" by choosing from among different activities or stimuli. Selection of the alternative indicated in the first—report or say—component over the other choices is reinforced. Such a selection has been described as the development of a "correspondence between a report about future behavior and its corresponding non-verbal behavior" (Paniagua, 1990, p. 113). This type of correspondence has been of interest to applied behavior analysts because of its implications for behavioral processes of humans described by terms like *honesty, reliability,* and *truthfulness* (R. A. Baer, Williams, Osnes, & Stokes, 1984; Rogers-Warren & Baer, 1976). The possibilities of cross-fertilization between basic re-

---

We thank Matthew Lattal for help in collecting the data. The data in Experiment 1 were included in a thesis submitted by Karla Doepke to the Department of Psychology at West Virginia University in partial fulfillment of the requirements for the MA degree.

Reprints may be obtained from Kennon A. Lattal, Department of Psychology, West Virginia University, Morgantown, West Virginia 26506-6040 (E-mail: klattal@wvu.edu) or from Karla J. Doepke, Department of Psychology, Illinois State University, Normal, Illinois 61790.

search in the experimental analysis of behavior and applied behavior analysis provided the impetus for the present analysis of correspondence using animal subjects.[1]

Such cross-fertilization between applied behavior analysis and the conduct of basic research with animals has both strategic and tactical benefits. Strategically, extrapolating the findings of animal research to further understand human behavior is considered by many to constitute a significant part of the value of conducting behavioral research with animals (e.g., Miller, 1985). To the extent that basic research with animals has revealed general behavioral processes that also are relevant to humans, research with animals has contributed to the conceptual development of applied behavior analysis. In turn, applied behavior-analytic research and treatment have provided systematic replications and extensions that establish the generality of many behavioral phenomena first identified using animals. Tactically, animal investigations often offer the possibility of more precise control over potential controlling variables than do many more fluid applied settings. Such investigations also allow the study of a wider range of problems and variables because a different code of ethics governs experimentation with animals compared to humans (e.g., Domjan & Burkhard, 1986). Animal studies also may be useful in applied behavior analysis in that they make possible an analysis of the provenance of the behavior, something that is not always possible with humans because interventions often are implemented after the target behavior already has been established and maintained. Lastly, animal research may be useful because conducting animal research on processes of interest to applied behavior analysts requires that behavioral phenomena be reduced conceptually, and often experimentally, to their essential components (e.g., Catania, 1977; Mazur, 1986). This latter use provided the organizing framework for the present investigation of correspondence.

Both correspondence and conditional discrimination, or what is known more generally but less accurately as matching-to-sample, procedures involve a relation between actions at two different times. In correspondence, during a first condition the participant chooses or states what subsequently will be done in the next condition. Following a brief delay, the participant has the opportunity to engage in one of several options. If the choice in the first condition matches the behavior in the second condition, such a match is reinforced and correspondence is said to have occurred. In a conditional discrimination procedure, during a first condition or component a sample stimulus (e.g., a color) is presented and in the subsequent choice condition or component the participant selects between two colored stimuli, one of which was the previous sample stimulus. Selection of the latter is reinforced. In both correspondence and conditional discrimination procedures, effective responding is occasioned by the relation between two or more stimuli. Correspondence may differ functionally from such a conditional discrimination procedure only in that the particpant, rather than the experimenter, selects

[1] We use the term *animal* despite the recent questioning of its use by Dess and Chapman (1998) on the grounds that it maintains a distinction inconsistent with evolutionary theory. Contrasted to their position is the fact that rarely are humans referred to as "human animals," although the assumption that humans are animals is implicit when thus described in virtually all scientific writing. To parallel the use of the term *human,* we might refer to *nonhumans,* but this descriptor also includes plants and rocks. The term *nonhuman animal* is awkward and does not parallel the common description of humans noted above. Furthermore, as Baron, Perone, and Galizio (1991) have noted, the term *animal* has been institutionalized in universities where Animal Care and Use Committees oversee the use of a number of species in research and teaching, and in psychology where journals like *Animal Learning & Behavior* and the *Journal of Experimental Psychology: Animal Behavior Processes* publish studies almost exclusively involving animals other than humans.

the stimulus in the first (sample) component. This similarity prompted us to investigate with animals these similarities and their conceptual implications.

Our assumption was that the essential features of say-do correspondence may be found in conditional stimulus control, an elementary behavioral process that often is studied with animals (Carter & Werner, 1978; Cumming & Berryman, 1965). Proposing such a similarity requires examining the function of the say response rather than its form or topography. This function is to select the preferred object or activity that subsequently will be reported or engaged in by the participant. Here, we used a simple motoric operant response as a homologue of the human verbal report because in both cases the response functions to indicate selection of one stimulus object or activity over others. The initial task was to establish reliable correspondence. This in turn was followed by an examination of the roles of reinforcement of correspondence (in the latter part of Experiment 1) and delays between saying and doing (in Experiment 2) on the maintenance of such behavior.

EXPERIMENT 1

In the first experiment we investigated several procedural variations on a conditional discrimination procedure in an attempt to develop correspondence between sample selection and subsequent choice responding.

Method

Subjects

Each of 3 experimentally naive adult male White Carneau pigeons was maintained at 80% of its free-feeding weight. Each was housed individually and had free access to water and health grit throughout the experiment.

Apparatus

A standard operant conditioning chamber was used. The dimensions of the work area were 30 cm by 32 cm by 39.5 cm. The work panel contained two response keys located 8 cm to either side of the midline of the panel and 22 cm from the floor. The keys could be transilluminated by red, white, or green 28-VDC bulbs. Reinforcement was 3-s access to mixed grain from a food hopper made accessible through an aperture (5 cm square) with its lower edge 8.5 cm from the floor on the midline of the work panel. The aperture was illuminated by two 28-VDC clear bulbs during hopper availability. A 7.5-W 110-V white houselight, located behind a translucent plastic cover, 9 cm to the right of the midline of the work panel and 2 cm from the floor, was on throughout the session except during reinforcement and timeout. White noise was present throughout each session, and a continuously operating fan provided both additional masking of extraneous noise and ventilation of the chamber. In an adjacent room to the chamber, a PDP 8a® computer using SuperSKED® software (Snapper & Inglis, 1979) arranged the contingencies and recorded data.

Procedure

Each pigeon was magazine trained, and its pecking both of the response keys was hand shaped. The colors of the response keys during training were changed following each reinforcer so that all three of the colors used in the experiment were displayed on all of the keys. After this initial training, correspondence training was begun by implementing a modified conditional discrimination procedure. Some of the details of the procedure differed during the various phases of the experiment, as noted below, but the basic procedure was as follows. Each session was divided into a series of discrete trials separated by intertrial intervals (ITIs) during

Table 1
Sequence and Description of Conditions in Experiment 1

Condition	Reinforcement of correspondence?	Correction procedure	Say response requirement	Mean ITI duration (s)	Houselight in ITI?
A	Yes		FR 1	15	Yes
B	Yes	Do only	FR 1	60	Yes
C	Yes	Do only	FR 1	60	No
D	Yes	Do only	FR 5	60	No
E	Yes	Do only	FR 5	60	No
F	Yes	FR 5 for chosen say then go to do	FR 5	60	No
G	No	None	Nominally FR 5 (see text)	60	No
H	Yes	FR 15 for chosen say then go to do	FR 5	60	No

which the chamber was dark. Each trial was divided into a sample (hereafter, say) and a choice (hereafter, do) component. During the say component, the two response keys were illuminated with two of the three colors in the stimulus pool (red, green, or white). Both location (left or right key) and color were determined by a semirandom sequence that ensured equal presentations of all combinations of colors and locations. The pigeon selected one of the two colors by pecking the appropriate key, at which point both keys were darkened for 1.0 s. Following this, in the do component, the two response keys were illuminated with two of the three colors in the stimulus pool. One of the latter colors corresponded to the color selected in the previous say component. The other color and the location of the two colors were selected semirandomly as noted above. Thus, the locations of a color selected in the say component and subsequently in the do component could be left-left, right-right, left-right, or right-left on any trial. If in the do component the pigeon pecked the color corresponding to its say component selection, food was presented. In the language of correspondence, if the animal subsequently did what it earlier said, then such correspondence was reinforced. If the pigeon pecked the key with the noncorresponding color, a 3-s blackout of the chamber occurred. Following the ITI, the say component was reinstated, and the procedure was repeated. Daily sessions (6 days per week) ended with the completion of 50 trials, excluding correction trials (see below).

Beginning with one set of parameters, over the course of the experiment we manipulated several of those parameters in an attempt to establish say-do correspondence as we have defined it. These parameters are summarized in Table 1. A mastery criterion of at least 80% correspondence was set; if this criterion was not met after several sessions based on our assessment of the performance, the next condition was implemented.

The first four conditions (A through D) involved three manipulations. First, the intertrial-interval (ITI) duration was fixed at 15 s in the first condition and at 60 s thereafter. This manipulation was based on the finding of Nelson and Wasserman (1978) and others (see Mackay, 1991) showing that conditional discrimination performance improves with longer ITIs. Second, the response requirement in the say component was fixed-ratio (FR) 1 in Conditions A, B, and C and FR 5 in Condition D and subsequent conditions. When a response is required to the sample (say) stimulus, accuracy is greater than if no such requirement is in effect. Sacks, Kamil, and Mack (1972), for example, reported that pigeons were more likely to meet criterion conditional discrimination performance of 85% correct responses with higher numbers of responses required during the sample component to move to the choice component. Third, the houselight illumination during the ITI was manipulated. The houselight was on in Conditions A and B and off during the other conditions. The rationale for this manipulation was the finding that imposing the stimuli present during the conditional discrimination procedure during the ITI produces proactive interference (Jarvik, Goldfarb, & Carley, 1969). None of these manipulations systematically improved correspondence.

Each of these first four conditions also utilized a correction procedure that operated when the color selected in the do component did not correspond to the color selected in the immediately preceding say component. Such correction trials help to prevent stimulus or side biases (Mackay, 1991). Correction trials occurred immediately following a 5-s blackout for an incorrect choice response. The correction trial consisted of repeating, in only the do component, the two sample stimuli from the preceding do trial in which the incorrect response was made. A single response (Conditions A through C) or five responses (FR 5; Conditions D and E, for the reasons stated above; cf. Sacks et al., 1972) to one of the now-re-presented sample stimuli turned off the keylights and reinforcement or blackout occurred depending on whether or not the pecked key color corresponded to the previously selected sample color. The program advanced to a new, as opposed to a repeated, say component only after a correct choice response was made.

During Condition E, the correction procedure was changed to further underscore the relation between a selected stimulus and the correlated choice response. Following each incorrect choice response and subsequent 5-s blackout, only the color initially chosen in the preceding say component was presented on a single key. Five responses on this key turned off the keylight for 1 s. Both keys then were transilluminated, one corresponding to the color of the key just pecked in the say component and the other a randomly chosen color from the other two colors. Five responses to the key with the color corresponding to that in the just-completed say component produced food access. Pecking the key with the noncorresponding color produced a 5-s time-out followed by another return to the say component with only the color initially chosen presented on one of the keys. In Condition F, an FR 15 on the sample key was required to advance to the do component during a correction trial in an attempt to further increase exposure to the sample and to its relation with the subsequent do component stimuli. As before, the program advanced to a new say component with both keys transilluminated only after a correct choice response. Also in Condition F, for Pigeon 3634 the number of possible position sequences within a given correction trial was limited to left-right or right-left. This was done in an attempt to eliminate the left-left or right-right sequence bias of this pigeon that interfered with accurate correspondence.

During Condition G (Pigeons 445 and 702 only), the correspondence contingency was removed to examine the effect of that contingency on maintaining say-do correspondence. Five responses to one of the keys in the say component initiated the do component after a 1-s delay. Reinforcement occurred at the completion of the choice component independently of whether the colors chosen in the say and do components were the same. This procedure was in effect for nine sessions for Pigeon 445 and seven sessions for Pigeon 702, at which point say-do correspondence of both pigeons had decreased to near-chance levels (50% correct). Finally,

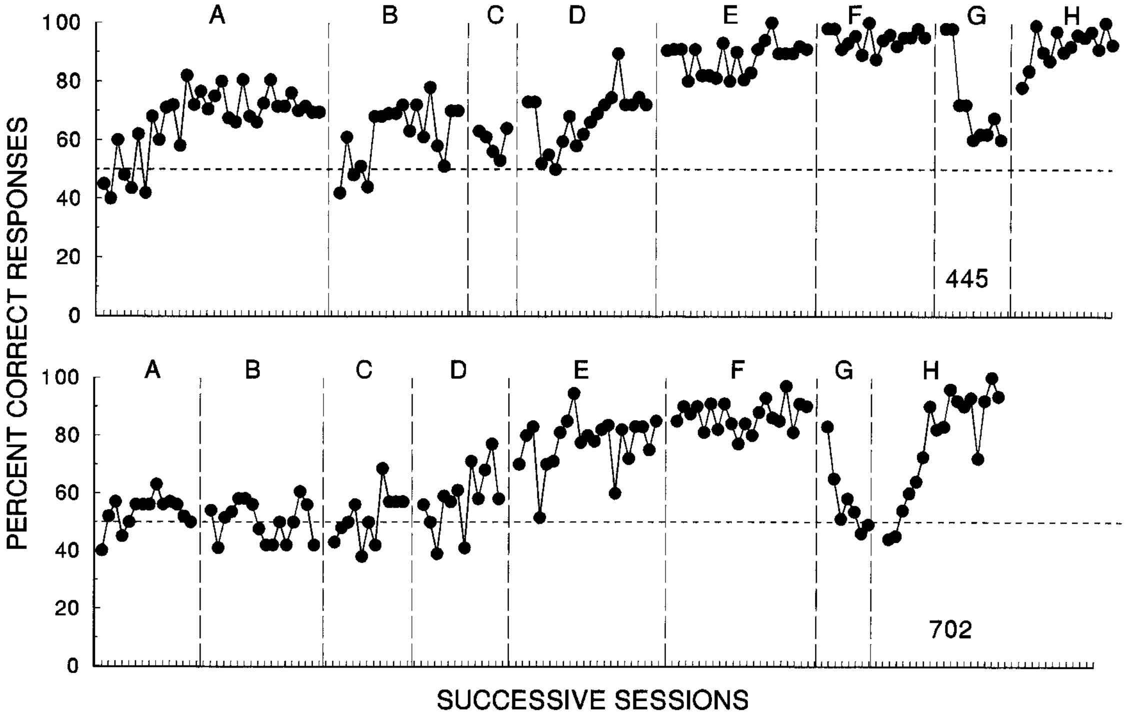

Figure 1. Percentage of correct choice responses for Pigeons 445 and 702 during each session of each condition of the first experiment. For the procedures in effect in each condition, refer to Table 1. During Condition G, correspondence was not reinforced (see text).

the correspondence procedure described in Condition F was reinstated (and now labeled Condition H) for 14 sessions for Pigeon 445 and 17 sessions for Pigeon 702.

Results

Figure 1 shows the percentage of correct (correspondence) responses of Pigeons 445 and 702 during each session of the experiment. Data are from noncorrection trials only. Pigeon 3634 developed a pattern of always responding on the same do key as its say key response and never developed correspondence despite our attempts to break up this sequence bias. For this reason, the data of this pigeon are not presented in the figures. Pigeons 445 and 702 performed variably during the first four conditions of the experiment. When the correction procedure was changed in Condition E, correspondence performance improved to about 80% to 85% correct choice responses. This performance improved or was maintained as the sample response requirement was increased to 15 in Condition F. When the correspondence contingency was eliminated in Condition G, choice performance fell to near 50% correct, that is, to chance levels. Reinstating the correspondence contingency in Condition H increased correct choices to greater than 85%. Correction-trial data were unremarkable throughout all conditions of the experiment for Pigeons 445 and 702.

Figure 2 summarizes the color preferences of each subject in the sample component. Pigeon 702 chose each of the three colors more or less equally. Pigeon 445 selected red and white predominantly early in training, but chose the three colors without bias toward the end of the experiment (Condition H).

The frequencies of different response sequences on the left and right keys in the say and do components are presented for both pigeons in Figure 3. In the absence of any

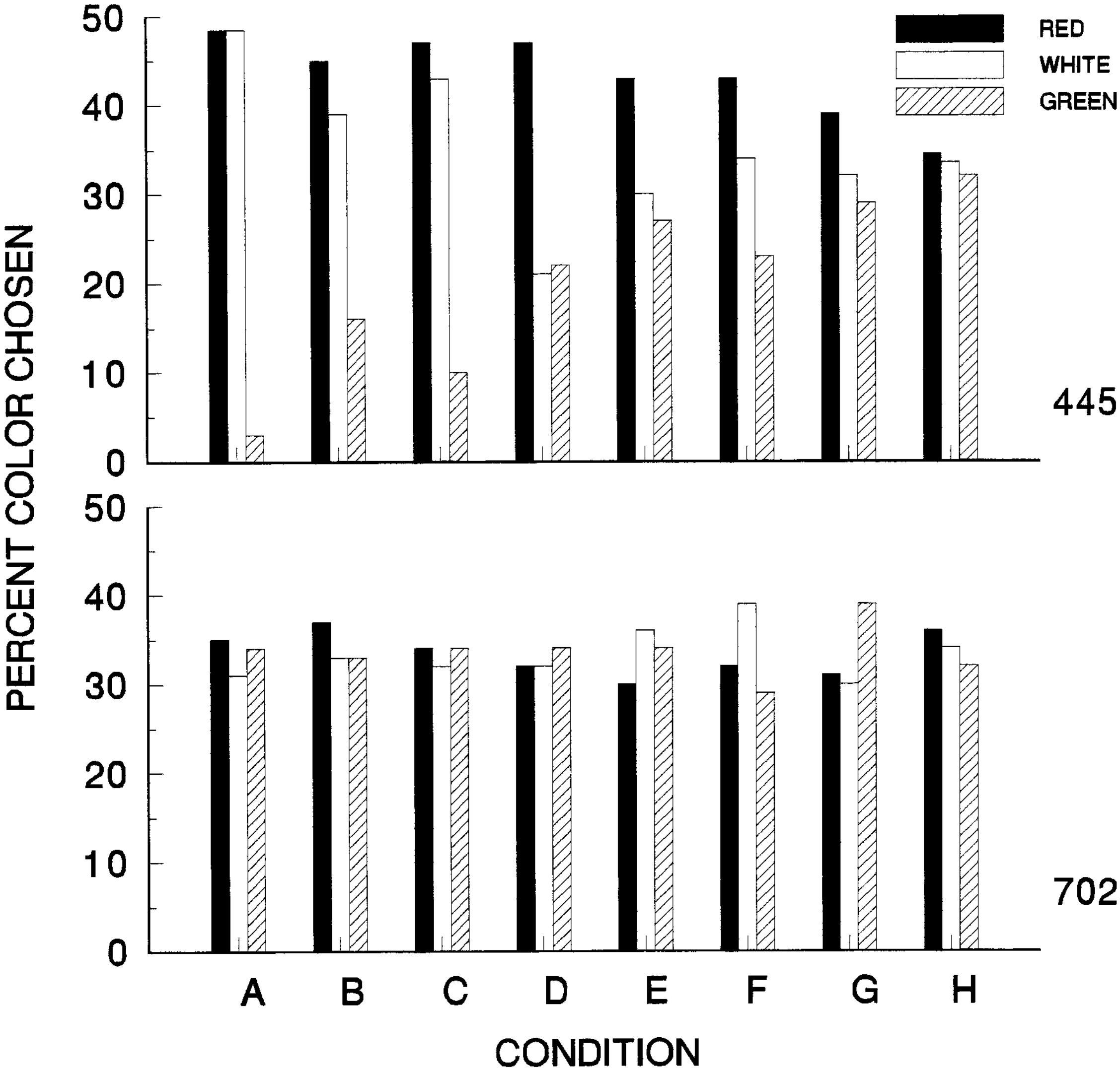

Figure 2. Percentage of color preferences for red, green, and white for Pigeons 445 and 702 during each condition of Experiment 1. Each bar is the mean of the last five sessions at each condition. For the procedures in effect in each condition, refer to Table 1. During Condition G, correspondence was not reinforced (see text).

sequence bias, the response sequences should be 25% right-right, 25% left-left, and 50% right-left/left-right. Both pigeons generally favored either left-left or right-right over left-right or right-left sequences of say and do responses. The occurrence of left-left or right-right sequences became more equal beginning with Condition E, in which the correction procedure was changed. Bias was the greatest in Condition G, in which any sequence that occurred was reinforced. The bias found in Condition G diminished considerably when the correspondence contingency was reinstated in Condition H.

Discussion

Conditional stimulus control was established under conditions in which the subject, rather than the experimenter, controlled which of two stimuli was to be the sample. We suggest that such conditional stimulus control is homologous to say-do correspon-

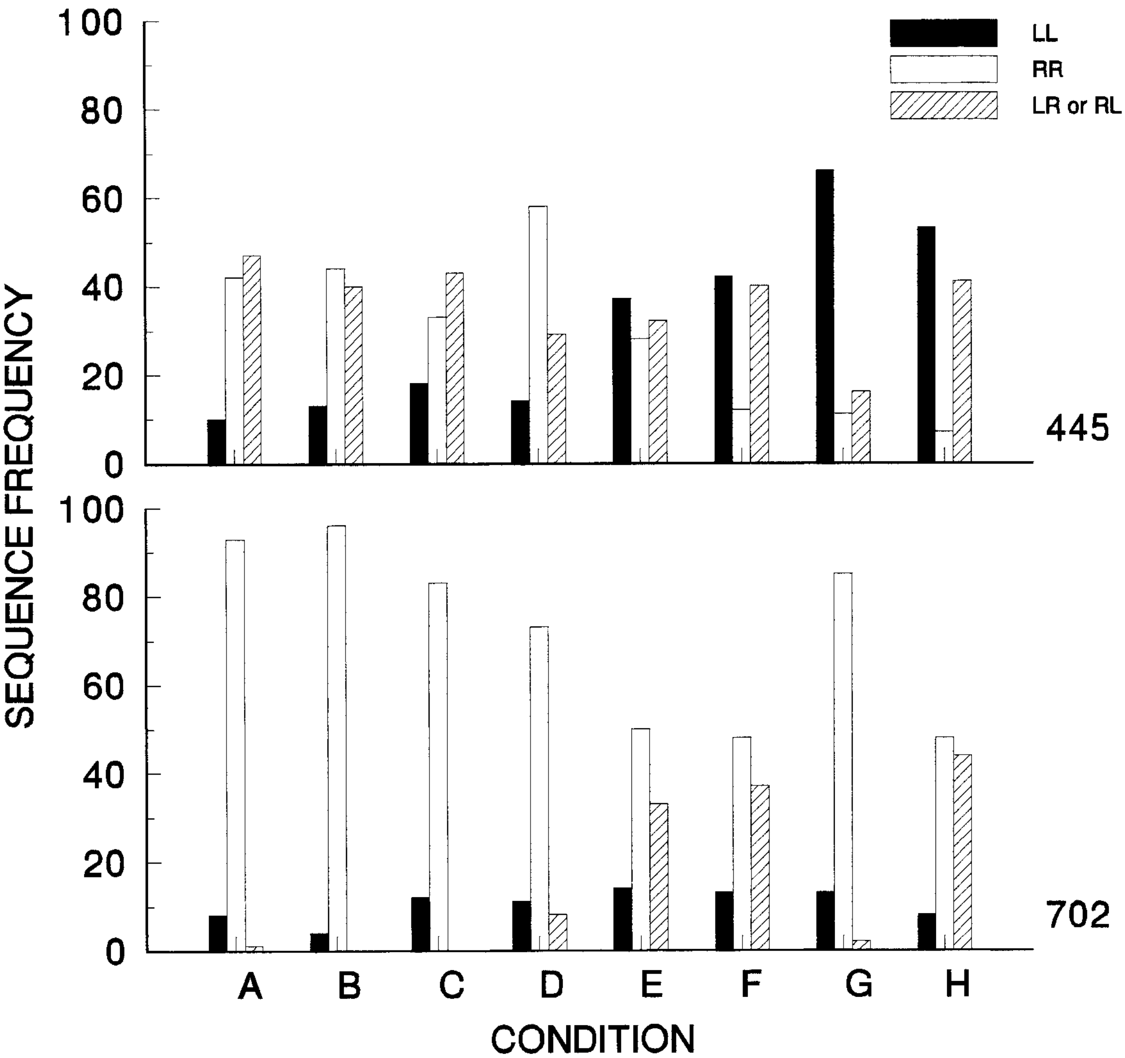

Figure 3. Frequency of say component/do component response sequences Pigeons 445 and 702 during each condition of Experiment 1. Each bar is the mean of the last five sessions at each condition. For the procedures in effect in each condition, refer to Table 1. During Condition G, correspondence was not reinforced (see text).

dence in humans and that the primary differences between the two are topographical.

As in human studies, both the reinforcement of correspondence and correction of noncorrespondence were related to establishing correspondence. In the present experiment, the role of reinforcement is demonstrated by the deterioration of correspondence in the absence of reinforcement and its subsequent recovery when the say-do contingency was reinstated. The correction procedure, as modified in Conditions E and F, established higher levels of correspondence. Such a correction procedure parallels a similar procedure in studies of human correspondence, although the procedure is not necessarily labeled as such and may be applied less systematically than was the case here. When a child selects an alternative that is different than the one reported earlier in the sequence, it is common for the teacher or experimenter to indicate that the choice was incorrect and that the child did not choose the item that he or she earlier indicated (e.g., Risley & Hart, 1968). Because this loosely applied correction procedure is present in studies of human correspondence (e.g., R. A. Baer, Blount, Detrich, & Stokes, 1987; Stark, Collins, Osnes, & Stokes, 1986), it is not clear whether humans would develop correspondence in the absence of corrective feedback, that is, in the presence of reinforcement for correspondence alone. The results of the present experiment suggests that corrective feedback is, if not a necessary component of correspondence training, at least a potentially facilitative element that merits further analysis.

Neither increasing the ITI from 15 to 60 s (Condition B) nor subsequently placing an FR requirement on responding in the say component (Condition D) systematically affected correspondence accuracy. These findings seemingly are at odds with other experiments of conditional stimulus control involving such manipulations (e.g., Grant, 1975; Sacks et al., 1972; see also Mackay, 1991), in which increasing values of both of these variables improved conditional discrimination performance in animals. Perhaps the differences occurred in the present experiment because the conditional discrimination was not yet established, whereas in previous studies of these variables they have been imposed when the conditional discrimination performance is in the steady state. These observations invite a parallel analysis of the effects of different time periods between say-do trials with humans.

The failure of Pigeon 3634 to develop correspondence seemed to be the result of a strong position bias that developed early in training. This bias was reinforced intermittently throughout each phase of the experiment (because selecting one side consistently pays off regularly as a result of the semirandom distribution of stimuli to the different locations) and therefore became insurmountable despite the addition of a correction procedure. Pigeon 702 also developed an extreme position bias early in training, but this position bias diminished with the correction procedure introduced in Condition E. Preexperimental biases and preferences also may influence the ease with which children learn say-do correspondence, and likely contribute to the variability in its acquisition that sometimes is reported (e.g., Burron & Bucher, 1978).

Removing the correlation or dependency between saying and doing as the basis for reinforcement, which Rescorla and Skucy (1969) identified as a form of extinction, in Condition G reduced correspondence to chance levels. Nussear and Lattal (1983) observed a similar reduction in correct responding by pigeons when, in a conventional conditional discrimination procedure, reinforced choice responses were no longer conditional on the sample stimulus (one of two response–reinforcer relations). This finding is similar to that with children when rewards are presented independently of the correlation between saying and doing (R. A. Baer et al., 1984, 1987; Israel & Brown, 1977; Karoly & Dirks, 1977; Rogers-Warren & Baer, 1976). In these studies, after correspondence was established, reinforced responses were dependent on only what the children said. Under these conditions, experimenters reported moderate to rapid declines in correspondence in the majority of participants.

In the present experiment, the procedures were changed frequently in an attempt to establish say-do correspondence with pigeons. Having developed a workable procedure for establishing correspondence, the next question was whether the final procedure of this experiment would yield reliable correspondence in naive subjects that had no exposure to the various experimental training procedures used in Experiment 1. Another question, suggested by the claim that the present results are evidence of functional correspondence in pigeons, is whether the effects are sensitive to other variables that affect both conditional discrimination and correspondence performance. A first step in answering this question would be to show that correspondence varies as a function of environmental change.

EXPERIMENT 2

This experiment replicated the final training procedure from Experiment 1 with naive subjects to establish the reliability of that procedure in establishing correspondence. The generality of the correspondence phenomenon was examined further by subsequently varying the delay between completing the say component and the subsequent do component.

Method

Subjects and Apparatus

Each of 3 male White Carneau pigeons was maintained at 80% of its free-feeding weight. The pigeons had a prior history of key-peck responding on schedules of reinforcement, but had no prior exposure to a conditional discrimination procedure. Each pigeon was housed individually and had free access to water and health grit throughout the experiment.

The apparatus was the same as that used in Experiment 1, except that the response keys were transilluminated yellow, white, and green.

Procedure

Each pigeon was given initial magazine and key-peck training as described in the first experiment. Following this, all 3 pigeons were exposed to a conditional discrimination procedure like that used in Conditions F and H of the first experiment until choice performance stabilized. Stable performance for this condition was defined as a minimum of five sessions with at least 80% correct choice responses.

Table 2
Sequence (Top is First, Bottom is Last) of Conditions and Number of Sessions at Each Condition for Each Pigeon in Experiment 2

	Number of sessions		
Delay (s)	Pigeon 344	Pigeon 1546	Pigeon 2543
1	20	15	10
2	13	14	11
4	14	14	14
8	11	15	18
16	12	10	10
32	12	11	10

Following the attainment of criterion performance with the 1-s blackout between the say and do components (as in Conditions F and H in Experiment 1), the duration of the blackout between the say response and the presentation of the choice stimuli was increased systematically to 2, 4, 8, 16, and 32 s. Correspondence between say and do component stimuli was reinforced with 3-s access to food. The number of sessions for each condition is shown in Table 2. Each delay condition remained in effect until the percentage of correct choice responses appeared to be stable on visual inspection. Sessions occurred 6 days per week and ended after 50 trials or 1 hr, whichever occurred first.

Results

The percentage of correct choice responses, averaged over the last five sessions at each condition, are shown in Figure 4. Only data from noncorrection trials are shown. Correspondence performance reached average accuracy levels of between 80% and 98% correct responses for the 3 pigeons within 7 to 18 sessions of training under the initial condition with a 1-s blackout between the say and do components. Correspondence developed relatively quickly, perhaps in part because of the correction procedure.

In general, for each subject, correspon-

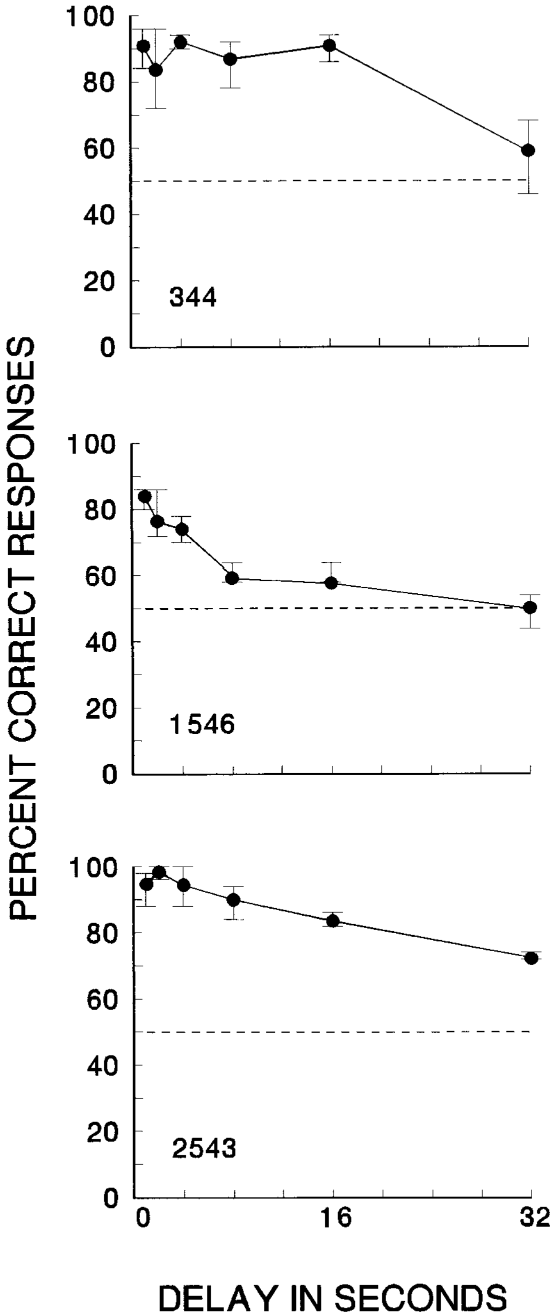

Figure 4. Percentage of correct choice responses for each pigeon during each time interval (delay) between the completion of the say response and the onset of the do component. Each data point is the mean of the last five sessions at each condition. Ranges over these sessions also are shown.

dence between the color selected in the say component and the subsequent choice color selected was a decreasing function of the delay, approaching chance levels for Pigeons 344 and 1546 at the 32-s delay. Even at this relatively long delay for pigeons, Pigeon 2543 maintained over 72% correct responses in the do component.

Discussion

Under what was the final training condition of the first experiment (Conditions F and H), all 3 pigeons in this experiment acquired say-do correspondence with at least 80% accuracy within 20 sessions of the onset of training. This outcome replicates the findings with 2 of the 3 pigeons in the first experiment and demonstrates the reliability of the original procedures in controlling correspondence. The outcome further suggests that the findings for the 3rd pigeon in the first experiment, which did not acquire say-do correspondence, was likely due to idiosyncratic variables and not to a failure of the correspondence procedure as such.

Increasing the delay between the say and do components had effects similar to those in conventional delayed conditional stimulus control procedures (Mackay, 1991). Using the latter procedures with pigeons typically results in random choice responding when delays approach 30 to 60 s (e.g., Cumming & Berryman, 1965; Lattal, 1979). In a variation of the correspondence procedure in which children first played with one of several objects and later reported on their earlier activity, Risley and Hart (1968) reported that the children "differentially responded verbally on the basis of the discriminative stimulus of their own non-verbal behavior 1.5 hr earlier" (p. 280). Such findings are consistent with the general finding of greater resistance to the effects of delays between related events in humans compared to other animals. Apparently the temporal limits of correspondence in humans have not yet been established, but the present results with pigeons suggest that an orderly relation can be expected between the time interval separating the elements of correspondence training and the likelihood of developing correspondence in children.

GENERAL DISCUSSION

This attempt to construct an animal homologue of say-do correspondence was not undertaken to provide an analysis of literal or point-by-point translation of variables from the pigeon chamber to the applied setting, although we have made such points as we deemed appropriate in the preceding two discussion sections. Rather, the overriding function of developing animal homologues is to attempt to connect phenomena of interest to applied researchers and potentially relevant basic behavioral processes, mechanisms, and concepts that have been or are being investigated, particularly those that may not have been related previously or systematically to applied phenomena. In this general discussion, therefore, we consider some more general points deriving from considering say-do correspondence as an instance of conditional stimulus control.

The Labeling of Correspondence

In that many studies of human correspondence involve verbal reports and pigeons are incapable of this report topography, the present correspondence between the behavior of pigeons and children must be considered functional rather than structural or topographical (cf. Catania, 1977, pp. 236–237). The correspondence studied here is most like what also has been labeled *positive* correspondence, as opposed to *negative* correspondence (not saying/not doing; Israel, 1978) or *noncorrespondence* (saying/not doing and not saying/doing; Karlan & Rusch, 1982; see also Matthews, Shimoff, & Catania, 1987). The label of say-do correspondence connects the present research to the largest body of research on positive correspondence; alternative labels would be do-do or do-say correspondence. We suggest that correspondence, however labeled, may be considered an instance of conditional stimulus control, making the label (e.g., do-do or do-say) sometimes discriminative of response topography but not of different underlying behavioral processes. Say-do correspondence is most commonly studied, and by labeling the present example as say-do correspondence we wish to emphasize the functional, as opposed to structural or topographical, similarities between our work with pigeons and that involving humans. Whether the initial choice of one of two keys is labeled a say or a do response is less important than establishing that two temporally distinct responses can be configured together in a conditional discrimination paradigm to form a complex operant that is described as *correspondence.*

Correspondence As a Complex Operant

Conditional discrimination performance was labeled a complex operant by Cumming and Berryman (1965). By this they meant that the reinforced unit consisted of more than a single element. The elements may be different topographies, as is often the case when say-do correspondence involves a verbal say response and a motoric do response, or topographically similar responses may be repeated at different times (e.g., Arbuckle & Lattal, 1988), as in the present example and applied studies of say-say correspondence (Osnes, Guevremont, & Stokes, 1986) or do-do correspondence (Whitman, Sciback, Butler, Richter, & Johnson, 1982). Reinforcing one of the component responses is not sufficient to maintain the other. In Experiment 1, for example, reinforcing a do response in the absence of correspondence between it and the say response diminished correspondence to chance levels. Similarly, many studies of human correspondence (e.g., Risley & Hart, 1968) have demonstrated that reinforcing only the say response did not result in correspondence between what was said and the child's subsequent do response. Correspondence, then, seems to fit well the concept of a complex operant whereby multiple elements must occur for reinforcement. The occurrence of multiple elements raises questions about the organization or structure of these elements.

Say-do correspondence training specifies, and reinforces, an order of first saying and then doing. If a multiple-response sequence is required for reinforcement but order is not specified, it is typical for idiosyncratic but stereotyped orders to develop (Schwartz, 1982; cf. Page & Neuringer, 1985). If an order is specified and learned, might such learning affect the likelihood of performing the reverse order: doing first and thereafter saying what was done, or self-reporting? Such symmetry would suggest that the two elements form not only a sequence but also a class in which order is irrelevant (cf. Matthews et al., 1987).

Conditional Stimulus Control and Generalized Response Classes

Related to the issue of symmetry is the broader question of correspondence as a generalized class of responding, as, for example, imitation has been shown to be (D. M. Baer, Peterson, & Sherman, 1967). In comparing correspondence in humans and animals, the status of correspondence as a generalized response class raises two issues. If the claim of functional similarity between correspondence in humans and animals is to be made, and correspondence is a generalized response class in humans, then optimally, correspondence would have the same status in animals. This raises the question of whether animals exhibit generalized response classes, but it also raises the question of whether correspondence is indeed a generalized response class in humans.

With respect to the first question, in the stimulus control literature some authors have distinguished between conditional discrimination and matching to sample, where the latter involves the control of behavior by a more complex stimulus feature, that of "sameness." That is, in matching to sample there is a general relation of whatever stimulus is presented as the sample and the corresponding choice response. In a simple conditional discrimination, by contrast, the *specific* sample serves as a discriminative stimulus that sets the occasion for the correct choice to be followed by a reinforcer. Matching-to-sample performance has been tested in pigeons by providing extended training on conditional discrimination procedures with different stimuli and then substituting novel ones (e.g., Cumming & Berryman, 1965). If the animal reliably selects the appropriate choice stimulus (i.e., the stimulus that matches the sample stimulus), then the generalized response class of "match the sample" has been established. Conditional discrimination performance of pigeons as matching to sample, that is, as a generalized response class, remains an open question. This question resonates in recent attempts to establish stimulus equivalence in animals for which the results also have been ambiguous and controversial (e.g., Hayes, 1989; McIntire, Cleary, & Thompson, 1987; Saunders, 1989; Vaughan, 1988).

Although it seems likely that many children have considerable exposure to similar say-do reinforcement contingencies in a range of settings that easily could lead to the learning of correspondence as a generalized response class, and despite many applied researchers speaking of correspondence as a generalized response class (e.g., Stokes, Osnes, & Guevremont, 1987), the evidence for correspondence as such a class is at least equivocal. For example, Deacon and Konarski (1987) and R. A. Baer, Detrich, and Weninger (1988) (cf. also Matthews et al., 1987) have suggested that the experimenter's verbal prompts are as likely to control doing by children as are the children's vocalizations of their say responses. Such results question whether many demonstrations of correspondence in humans might be explained by invoking simpler notions of stimulus control. Thus, animals may or may not exhibit generalized response classes, and correspondence in humans may or may not be such a class of behavior. As a result, this aspect of a functional comparison of correspondence in humans and animals must await further empirical evidence with respect to both the status of human correspondence and animal conditional discrimination performance.

The Say Response

Unlike a conventional conditional stimulus control experiment in which the experimenter selects the sample, a conditional stimulus control procedure in which the subject selects the sample raises the question of how the sample or say response is controlled. Reporting by saying in correspondence often is described in terms of its control by future events. For example, Paniagua characterized saying as follows: "Sometimes the subjects' statements about . . . future behavior (i.e., reports about what the subject will do in the future) are recorded" (1990, p. 108). And, with respect to the labeling of one type of correspondence, "a more descriptive label would be report-do, in which a report of future behavior is not a commitment, but an *intention* to behave in a certain way" (1990, p. 109). The difficulty of characterizing reporting as being about future behavior is that it is teleological, that is, the control of the behavior is placed in the future and not with past events.

Alternatively, considering saying followed by doing as elements of a single multielement operant makes correspondence conceptually similar to other multielement operants, such as interresponse times (IRTs, e.g., Galbicka, 1994; Shimp, 1981). It is not necessary, for example, to describe the first of a series of IRTs or the first response in a long chain of responses in terms of their control by responses that have not yet happened. The correspondence unit (operant) is completed only when both elements have been emitted. The results of delayed conditional discrimination procedures, including the present Experiment 2, suggest that as the time between these two elements increases, the second element is less likely to occur. This observation in turn invites other experimental questions about how any such complex operant that is extended in time "holds together" as the time is extended further.

The Selection of Say and Do Responses

Considering correspondence in terms of conditional stimulus control allows a nonteleological account of the say response. Rather than being a report of a future event, saying what one will do next is assumed to be under the control of a combination of phylogenic and ontogenic historical events or contingencies. Phylogenic history could be involved in such things as color preferences or a propensity for certain kinds of objects based on the organism's musculature. Choices in the say component also could be determined by the organism's unique history of reinforcement (e.g., Freeman & Lattal, 1991). In the present experiments, for example, several of the pigeons had idiosyncratic but consistent color preferences in the say component. Whether the preferences originated in phylogenic or ontogenic contingencies are not known; all that is known is that these preferences were consistent over much of the experiment. Similarly, children have a priori preferences for some activities and objects over others, for reasons often unknown but always, in principle, knowable. It would be possible to determine how choice is influenced in the say component by, for example, varying the outcomes in the do component. If, for example, a child picks a preferred toy, he or she can play with it for 1 min but if the child picks a less preferred toy, he or she can play with it much longer. With pigeons, the choice of a preferred color, if subsequently selected in the do component, might yield 2-s access to grain, but choice of a less preferred color in the say component, if later selected in the do component, would result in 6-s access to grain. Such manipulations would demonstrate how saying is not a report of possible future action but rather the product of past and current reinforcement contingencies.

It is sometimes observed that the do response determines the say response by such descriptions as the child "wants" to play with toy *x* and, when given a choice between playing with toys *x, y,* and *z* later, this future desire determines his or her say response to the effect that "I will play with toy *x*." According to the above analysis, toy *x* has been established as a reinforcer in the past, and it is this past interaction, rather than the future one, that controls the say response. By such a process the do response may in fact determine the say response, but it does so not teleologically but rather through past reinforcement contingencies.

Conclusion

The positive correspondence studied in the present experiments is important in understanding child development and in training both young children and individuals of many ages with mental retardation. On the other hand, many failures of, or lapses in, correspondence, depending on the circumstances, may be labeled as instances of *lying, confusion,* or *forgetfulness.* Identifying these instances as failures of correspondence training offers reference to an alternative research and treatment base to that of cognitive, motivational, or mentalistic frameworks for such symptoms. Considering correspondence as an instance of conditional stimulus control avails the applied researcher a wealth of data about how such correspondence might be established, maintained, and eliminated, as the circumstances in applied settings dictate.

Hake (1982) and, almost a decade and a half later, Mace (1994) called for research programs that span the basic-to-applied continuum, but as Mace noted, few such programs exist. Examination of citation patterns reveals remarkably little cross-referencing between basic and applied behavior analysis journals (Bailey, 1987). Despite the obvious limitations of any attempt to directly replicate forms of human behavior in other animals, exercises such as the present one are of value in identifying and analyzing qualitatively and functionally similar potential controlling variables in both. The present experiments thus offer a specific example of how studies with animals of behavioral processes of interest to applied behavior analysts may contribute to the cross-fertilization and better integration of basic and applied research.

REFERENCES

Arbuckle, J. L., & Lattal, K. A. (1988). Changes in functional response units with briefly delayed reinforcement. *Journal of the Experimental Analysis of Behavior, 49,* 249–263.

Baer, D. M., Peterson, R. F., & Sherman, J. A. (1967). The development of imitation by reinforcing similarity to a model. *Journal of the Experimental Analysis of Behavior, 10,* 405–416.

Baer, R. A., Blount, R. L., Detrich, R., & Stokes, T. F. (1987). Using intermittent reinforcement to program maintenance of verbal-nonverbal correspondence. *Journal of Applied Behavior Analysis, 20,* 179–184.

Baer, R. A., Detrich, R., & Weninger, J. M. (1988). On the functional role of the verbalization in correspondence training procedures. *Journal of Applied Behavior Analysis, 21,* 345–356.

Baer, R. A., Williams, J. A., Osnes, P. G., & Stokes, T. F. (1984). Delayed reinforcement as an indiscriminable contingency in verbal/nonverbal cor-

respondence training. *Journal of Applied Behavior Analysis, 17,* 429–440.
Bailey, J. (1987). The editor's page. *Journal of Applied Behavior Analysis, 20,* 3–6.
Baron, A., Perone, M., & Galizio, M. (1991). Analyzing the reinforcement process at the human level: Can application and behavioristic interpretation replace laboratory research? *The Behavior Analyst, 14,* 95–105.
Burron, D., & Bucher, B. (1978). Self-instructions as discriminative cues for rule-breaking or rule-following. *Journal of Experimental Child Psychology, 29,* 565–601.
Carter, D. E., & Werner, T. J. (1978). Complex learning and information processing by pigeons: A critical analysis. *Journal of the Experimental Analysis of Behavior, 29,* 565–601.
Catania, A. C. (1977). *Learning*. Englewood Cliffs NJ: Prentice Hall.
Cumming, W. W., & Berryman, R. (1965). The complex discriminated operant: Studies of matching-to-sample and related problems. In D. I. Mostofsky (Ed.), *Stimulus generalization* (pp. 284–330). Stanford, CA: Stanford University Press.
Deacon, J. R., & Konarski, E. A., Jr. (1987). Correspondence training: An example of rule-governed behavior? *Journal of Applied Behavior Analysis, 20,* 391–400.
Dess, N. K., & Chapman, C. D. (1998). "Humans and animals"? On saying what we mean. *Psychological Science, 9,* 156–157.
Domjan, M., & Burkhard, B. (1986). *The principles of learning and behavior*. Pacific Grove, CA: Brooks/Cole.
Freeman, T. J., & Lattal, K. A. (1992). Stimulus control of behavioral history. *Journal of the Experimental Analysis of Behavior, 57,* 5–15.
Galbicka, G. (1994). Shaping in the 21st century: Moving percentile schedules into applied settings. *Journal of Applied Behavior Analysis, 27,* 739–760.
Grant, D. S. (1975). Proactive interference in pigeon short-term memory. *Journal of Experimental Psychology: Animal Behavior Processes, 1,* 207–220.
Hake, D. F. (1982). The basic-applied continuum and the possible evolution of human operant social and verbal behavior. *The Behavior Analyst, 5,* 21–28.
Hayes, S. C. (1989). Nonhumans have not yet shown stimulus equivalence. *Journal of the Experimental Analysis of Behavior, 51,* 385–392.
Israel, A. C. (1978). Some thoughts on the correspondence between saying and doing. *Journal of Applied Behavior Analysis, 11,* 271–276.
Israel, A. C., & Brown, M. S. (1977). Correspondence training, prior verbal training, and control of nonverbal behavior via control of verbal behavior. *Journal of Applied Behavior Analysis, 10,* 333–338.
Jarvik, M. E., Goldfarb, T. L., & Carley, J. L. (1969). Influence of interference on delayed matching in monkeys. *Journal of Experimental Psychology, 81,* 1–6.
Karlan, G. R., & Rusch, F. R. (1982). Correspondence between saying and doing: Some thoughts on defining correspondence and future directions for application. *Journal of Applied Behavior Analysis, 15,* 151–162.
Karoly, P., & Dirks, M. J. (1977). Developing self-control in preschool children through correspondence training. *Behavior Therapy, 8,* 398–405.
Lattal, K. A. (1979). Reinforcement contingencies as discriminative stimuli: II. Effects of changes in stimulus probability. *Journal of the Experimental Analysis of Behavior, 31,* 15–22.
Mace, F. C. (1994). Basic research needed for stimulating the development of behavior technologies. *Journal of the Experimental Analysis of Behavior, 61,* 529–550.
Mackay, H. A. (1991). Conditional stimulus control. In I. H. Iversen & K. A. Lattal (Eds.), *Techniques in the behavioral and neural sciences: Vol. 6. Experimental analysis of behavior* (Part 1, pp. 301–350). Amsterdam: Elsevier.
Matthews, B. A., Shimoff, E., & Catania, A. C. (1987). Saying and doing: A contingency-space analysis. *Journal of Applied Behavior Analysis, 20,* 69–74.
Mazur, J. E. (1986). *Learning and behavior*. Englewood Cliffs, NJ: Prentice Hall.
McIntire, K. D., Cleary, J., & Thompson, T. (1987). Conditional relations by monkeys: Reflexivity, symmetry, and transitivity. *Journal of the Experimental Analysis of Behavior, 47,* 279–285.
Miller, N. E. (1985). The value of behavioral research with animals. *American Psychologist, 401,* 423–490.
Nelson, K. R., & Wasserman, E. A. (1978). Temporal factors influencing the pigeon's successive matching-to-sample performance: Sample duration, intertrial interval, and retention interval. *Journal of the Experimental Analysis of Behavior, 30,* 153–162.
Nussear, V. P., & Lattal, K. A. (1983). Discriminative stimulus properties of brief disruptions in response-reinforcer temporal contiguity. *Learning and Motivation, 14,* 472–486.
Osnes, P. G., Guevremont, D. C., & Stokes, T.F. (1986). If I say I'll talk more, then I will: Correspondence training to increase peer-directed talk by socially withdrawn children. *Behavior Modification, 10,* 287–300.
Page, S., & Neuringer, A. (1985). Variability is an operant. *Journal of Experimental Psychology: Animal Behavior Processes, 11,* 429–452.
Paniagua, F. A. (1990). A procedural analysis of correspondence training techniques. *The Behavior Analyst, 13,* 107–109.
Rescorla, R. A., & Skucy, J. C. (1969). Effect of re-

sponse-independent reinforcers during extinction. *Journal of Comparative and Physiological Psychology, 67,* 381–389.

Risley, T. R., & Hart, B. (1968). Developing correspondence between the non-verbal and verbal behavior of preschool children. *Journal of Applied Behavior Analysis, 1,* 267–281.

Rogers-Warren, A., & Baer, D. M. (1976). Correspondence between saying and doing: Teaching children to share and praise. *Journal of Applied Behavior Analysis, 9,* 335–354.

Sacks, R. A., Kamil, A. C., & Mack, R. (1972). The effects of fixed-ratio sample requirements on matching to sample in the pigeon. *Psychonomic Science, 26,* 291–293.

Saunders, K. J. (1989). Naming in conditional discrimination and stimulus equivalence. *Journal of the Experimental Analysis of Behavior, 51,* 379–384.

Schwartz, B. (1982). Failure to produce response variability with reinforcement. *Journal of the Experimental Analysis of Behavior, 37,* 171–181.

Shimp, C. P. (1981). The local organization of behavior: Discrimination and memory for simple behavioral patterns. *Journal of the Experimental Analysis of Behavior, 36,* 303–315.

Snapper, A. G., & Inglis, G. (1979). *SKED-R software system* (rev. ed.). Kalamazoo, MI: State Systems, Inc.

Stark, L. J., Collins, F. L., Osnes, P. G., & Stokes, T. F. (1986). Using reinforcement and cueing to increase healthy snack food choices in preschoolers. *Journal of Applied Behavior Analysis, 19,* 367–379.

Stokes, T. F., Osnes, P. G., & Guevremont, D. C. (1987). Saying and doing: A comment on a contingency-space analysis. *Journal of Applied Behavior Analysis, 20,* 161–164.

Vaughan, W., Jr. (1988). Formation of equivalence sets in pigeons. *Journal of Experimental Psychology: Animal Behavior Processes, 14,* 36–42.

Whitman, T. L., Sciback, J. W., Butler, K. M., Richter, R., & Johnson, M. R. (1982). Improving classroom behavior in mentally retarded children through correspondence training. *Journal of Applied Behavior Analysis, 15,* 545–564.

Received April 18, 2000
Final acceptance February 28, 2001
Action Editor, Robert Stromer

STUDY QUESTIONS

1. Describe the relevant features of a correspondence relation and, more specifically, of say-do correspondence. Why have behavior analysts been interested in these relations?

2. What are some similarities and differences between correspondence and conditional discrimination?

3. Describe the basic experimental arrangement.

4. What was the major difference between the two correction procedures used in Experiment 1? Which one appeared to be most effective?

5. How did the authors demonstrate experimental control over the effects of reinforcement in Experiment 1?

6. What do the data in Figures 2 and 3 show, and what is the importance of these data?

7. Briefly describe the delay manipulation that was used in Experiment 2. What were the general results?

8. If one were to apply these procedures to human behaviors, what additional sets of contingencies might one wish to evaluate?

Questions prepared by Rachel Thompson and Gregory Hanley, The University of Florida