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WHY PIGEONS SAY WHAT THEY DO: REINFORCER MAGNITUDE AND RESPONSE REQUIREMENT EFFECTS ON SAY RESPONDING IN SAY–DO CORRESPONDENCE

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The effects of reinforcer magnitude and response requirement on pigeons' say choices in an experimental homologue of human say–do correspondence were assessed in two experiments. The procedure was similar to a conditional discrimination procedure except the pigeons chose both a sample stimulus (the say component) and a comparison stimulus that corresponded to it (the do component). Correspondence was trained on red, green, and white key colors before the duration of food presentations following correspondence on each key color (Experiment 1) and the number of key pecks required as the say response on each key color (Experiment 2) were manipulated in an attempt to influence the initial say response. The frequency of say responses on each key color coincided with programmed changes in the duration of food presentations and the key-peck requirements assigned to each key color. Correspondence accuracy remained stable in all conditions, even those in which the say responding occurred primarily on two of the three key colors. Implications for human behavior are discussed.

Key words: say–do correspondence, choice, conditional discrimination, pigeons, key peck

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A fundamental feature of behavior is that there are direct relations between prior choices and current behavior. For example, depending on the contingencies in effect, things said in the past can influence what will be done presently and things done in the past can influence what will be reported presently. This positive relation between verbal and nonverbal responses has been labeled *say-do correspondence*, or more generally as *correspondence*, to describe relations between past and present behavior, whether verbal or not. In his call for a revival of research on the topic, Lloyd (2002) noted the central role of say-do correspondence in honesty, compliance, and self-regulation (see also Paniagua, 1989, 1992), among other socially desirable phenomena.

Correspondence also has general significance as a means of controlling behavior indirectly. Given a situation in which correspondence occurs, the likelihood of the do response can be changed by changing the likelihood of the corresponding say response, or vice versa. For example, Rogers-Warren and Baer (1976) increased children's sharing in a classroom by reinforcing only reports of sharing after correspondence between reports of classroom activities and those activities had been established. They thus changed sharing indirectly via their direct control over reports of sharing, which was an effective and practical alternative to reinforcing sharing directly.

To bring the study of correspondence into the realm of nonhuman animal experimentation, Lattal and Doepke (2001) proposed a homologue of say–do correspondence in pigeons based on its analysis as a form of conditional discrimination. They noted that, as in other types of conditional discriminations, correspondence is a complex operant in which the availability of reinforcement for a choice response depends on a higher-order stimulus (Cumming & Berryman, 1965). The

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critically different feature of the correspondence procedure was a choice in the sample component such that the conditional stimulus was determined by the organism. Each trial began with the presentation of two key colors (e.g., red and green) in the sample component (hereafter, the *say component*) and responding to either key color (emitting a say response) terminated that component. After a short delay, the comparison component (hereafter, the *do component*) began with the presentation of the red and green key colors. Responding to one of the key colors (i.e., emitting a do response) terminated the do component. If the do response was to the same key color as the immediately preceding say response, an instance of correspondence was recorded and a reinforcer was delivered. Under these conditions, correspondence developed and was maintained. This homologue is, of course, based on the assumption that the verbal responses characteristic of demonstrations of say–do correspondence in humans are functionally similar to the different nonverbal responses in nonhuman animals. Such a broad definition of correspondence used in Lattal and Doepke's laboratory homologue is consistent with its use in applied settings where neither response in the relation necessarily is vocal, as when Whitman, Scibak, Butler, Richter, and Johnson (1982) trained correspondence between children's demonstration of a target nonverbal response (e.g., sitting in a chair quietly for 10 s) and their subsequent engagement in that task during a 30-min class period. Say–do correspondence procedures, therefore, may involve variations in the topography of responses required and the order in which the different responses occur (see Paniagua, 1990, for a review).

Previous research on say–do correspondence has focused on establishing and generalizing the correspondence between what is said and subsequently done or what is done and subsequently said (e.g., Israel & O'Leary, 1973; Wilson, Rusch, & Lee, 1992). Little research has considered variables controlling the initial choices within the say–do correspondence sequence and/or how attempting to control those initial choices might affect correspondence. Factors that affect say choices presumably are historical (i.e., preexperimental) or contemporary ones in the experimental situation, but their selection has not been subject to differential contingencies of reinforcement. Consideration of these initial choices is important in assessing how specific preferences for events or objects can be manipulated, but also in how changes to those initial choices affect subsequent correspondence. A central question in the present experiments is whether correspondence operates differently when it involves highly preferred choices or less preferred choices. That is, will correspondence develop and maintain simply as a function of the reinforcement contingency between *any* say response, initially preferred or not, and its corresponding do response? These experiments therefore examined the relation between correspondence and initial choices (say responding) as a function of variables designed to influence the choice in the say component. This was done in the first experiment by varying the magnitudes of reinforcement associated with correspondence following different say responses. In the second experiment, the response requirements necessary to select one of the initial choices were manipulated.

General Method

Subjects

Each of 3 adult male White Carneau pigeons was maintained at 80% of its free-feeding weight, with water and health grit available freely in the home cage. Each had a history of responding under various schedules of reinforcement in this same laboratory.

Apparatus

Four standard operant chambers (three in each experiment) constructed of plywood and containing a brushed aluminum work panel were used. In Experiment 1, the work panel in two of the chambers housed three response keys (2.54 cm in diameter) located 25.4 cm from the bottom of the chamber and 8.89 cm apart from each other (all key locations are reported center to center). The center of the two side keys were 6.35 cm from each side end of the panel. A 4.5-cm high by 5.5-cm wide aperture, centered between the sides of the panel with its lower edge 8.89 cm from the floor, provided access to a solenoid-operated food hopper. The work panel in the third chamber housed four response keys (each 3 cm in diameter) arranged in a diamond pattern.

The top center key was located 6.5 cm from the top and 16.5 cm from the bottom of the chamber. The bottom center key was located 7.5 cm below the top key, and both the top and the bottom key were situated 15 cm from the left wall and 16 cm from the right wall of the chamber. The side keys were centered vertically midway between the top center and bottom center keys and were 15 cm apart horizontally. A 4.5-cm square aperture, located in the bottom right corner of the panel (with its right edge 2.75 cm from the right wall and its lower edge 7.5 cm from the floor), provided access to a solenoid-operated food hopper. In this third chamber, the top center key was used as the ''center key'' and is so designated hereafter. The bottom center key was always dark and inoperative. In Experiment 2, a chamber containing a work panel identical to the panels of the first two chambers was used instead of the four-key chamber in Experiment 1. Thus, experimental sessions with Pigeons 974 and 944 were conducted in the same three-key chambers in both experiments, but sessions with Pigeon 901 were conducted in the four-key chamber in Experiment 1 and a three-key chamber (identical to the other two chambers used in Experiment 1) in Experiment 2.

Each of the three operative keys in each chamber could be transilluminated red, green, or white. A white light illuminated the hopper during presentations of mixed grain (hereafter, food). White noise and exhaust fans on each chamber masked extraneous noises. The experiment was controlled and the data were recorded using a MED-PC® interface and MED-PC® for Windows® software. This equipment was located in a room adjacent to the rooms housing the chambers.

Procedure

Pretraining. To establish key pecking, each pigeon was exposed to at least one session of autoshaping (Brown & Jenkins, 1968) consisting of 60 trials, 20 trials for each key color. Each trial began with the presentation of a red, green, or white key in the left, center, or right key position (selected randomly without replacement). The key color was presented for 6 s or until a single key peck occurred, and food was presented for 3 s immediately following the key presentation. Each pigeon then was exposed to at least one session in which a fixed-ratio (FR) requirement on each of the key colors was increased gradually from 1 to 15, with the session lasting until the FR 15 requirement was met on each key color in each position.

Correspondence training. A modified conditional-discrimination procedure, similar to Condition F of Lattal and Doepke (2001), was used to train correspondence. Each session consisted of 40 trials, each separated by a 60-s intertrial interval (ITI) during which the chamber was dark. Each trial began with a say component, followed by a do component. At the onset of the say component, two of three key colors (red, green, or white) were presented in two of three key positions (left, center, or right) at the onset of the say component. The key color and key position were selected using a list of values selected randomly without replacement. Each of the three possible combinations of key color was selected on 2 of every 6 trials; each of the seven possible combinations of key position was selected on 2 of every 14 trials. After a programmed say-response requirement (FR 5 for Pigeons 974 and 944 and FR 8 for Pigeon 901) was met on one of the two keys, the chamber was darkened for a short delay (0.5 s for Pigeons 974 and 944 and 1.0 s for Pigeon 901).

Immediately after the intercomponent blackout, the do component began with the presentation of two of the three key colors, once again positioned quasirandomly on two of the three keys as in the say component. One of the key colors presented in the do component was the color chosen in the preceding say component and the other key color was selected randomly (with 50% probability) from the remaining two colors. When the programmed do-response requirement (FR 3 for Pigeons 974 and 944 and FR 5 for Pigeon 901) was fulfilled by pecking on the key correlated with the color chosen in the immediately preceding say component (i.e., if correspondence occurred), the trial ended and an instance of correspondence was recorded. In both experiments, both keys presented in the say and do components remained lit until one of the FR schedules was completed. Food was presented for a programmed number of seconds immediately following each instance of correspondence.

Table 1

Experiment 1: Number of Sessions Each Pigeon Completed in Each Condition.

Pigeon					
974		944		901	
Condition	Sessions	Condition	Sessions	Condition	Sessions
3/3/3	27	3/3/3	42	3/3/3	64
6/2/2	13	6/3/2	25		
6/2/1	23	6/2/1	11	2/6/1	36
3/3/3	35	3/3/3	21	3/3/3	41
2/1/6	76	1/6/2	20	6/1/2	39
3/3/3	38	3/3/3	35	3/3/3	49

If the do response occurred on the key color not chosen in the say component (i.e., if correspondence did not occur), an instance of noncorrespondence was recorded and a 5-s blackout was presented immediately, followed by a correction trial. The correction trial was similar to a regular trial, except only the key color chosen in the say component of the preceding trial was presented and completion of an FR 12 schedule was required in the say component. The do component of the correction trials was programmed as in regular trials. If an incorrect do response occurred in the correction procedure, no food was delivered and the correction trial was repeated as just described until the correct do response occurred. The correction trials were not included in the 40 regular trials comprising the session on which the data reported here were based. Responses on dark keys at any time during a session were not recorded and had no programmed effect.

EXPERIMENT 1

The use of reinforcement magnitudes to alter choice between concurrently available alternatives can be traced to Catania (1963) who exposed pigeons to concurrent variable-interval (VI) VI reinforcement schedules and manipulated the duration of grain presentations correlated with each key across conditions to produce accompanying changes to responding. This relation between reinforcer magnitude and choice has been replicated repeatedly (e.g., Brownstein, 1971; Neuringer, 1967; Schneider, 1973; Spear & Spitzner, 1969; Todorov, 1973) in the laboratory and in applied settings. For example, Hoch, McComas, Johnson, Faranda, and Guenther (2002) manipulated the amount of time allowed for playing with a toy (reinforcer) to investigate the allocation of playing across two concurrently available play areas: one with a peer (peer area) and one without a peer (no-peer area). Children played more often in the no-peer area until larger reinforcer magnitudes for playing in the peer area increased the time spent playing in the peer area, thereby decreasing the time spent in the no-peer area (see also Neef, Mace, Shea, & Shade, 1992). In the present Experiment 1, choices between key colors in the say component were examined as a function of different reinforcer magnitudes available for correspondence on each key color.

Procedure

Manipulation of reinforcer magnitude. Throughout all conditions, correspondence on each trial was followed by the presentation of food, with the duration of the food presentation varying across conditions. Table 1 contains the order of conditions and the number of sessions that each condition was in effect for each pigeon. The conditions are labeled according to the duration of the food presentations following correspondence on the red, green, and white key colors, respectively. In Condition 6/2/1, for example, 6-s food presentations followed correspondence on the red key color, 2-s food presentations followed correspondence on the green key color, and 1-s food presentations followed correspondence on the white key color. In the first condition, correspondence on each of the three key colors was followed by a 3-s food presentation. In subsequent conditions, the duration of the food presentations varied depending on how often correspondence occurred on each key color in the previous conditions, where the longest food presentation was assigned to the key color chosen least often in the previous condition. Pigeons 974 and 944 were exposed to a set of preliminary reinforcer magnitudes (Conditions 6/2/2 and 6/3/2), but 6-s, 2-s, and 1-s food presentations were used in the remaining conditions where reinforcer magnitudes were unequal. Condition 3/3/3 was in effect before and after each of these unequal magnitude conditions. Conditions were changed after a minimum of 10 sessions in a condition if there was no increasing or decreasing trend in the number of times a key color was chosen across the last six sessions.

Forced-exposure sessions. Forced-exposure sessions were introduced and used before each condition change beginning with the introduction of Condition 6/2/1 for Pigeons 974 and 944 and 2/6/1 for Pigeon 901. During these sessions, a single key color was presented in the say and do components of all 40 trials in the session, but the position of the key color was selected quasirandomly as in regular trials. Forced-exposure sessions were an attempt to facilitate contact with the reinforcer magnitude assigned to a specific key color without altering the contingencies operating in regular sessions. Without the forced-exposure session (e.g., in Condition 6/2/2 for Pigeon 974), it was more likely that changes in the reinforcer magnitudes would not be contacted because some key colors were seldom chosen. The key color presented in the forced exposure sessions was determined by the differential reinforcer magnitudes either in effect in the previous condition or those to be effected in the upcoming condition. When the forced-exposure session preceded conditions where reinforcer magnitudes were unequal (e.g., Condition 6/2/1 or Condition 2/6/1) the session contained the key color on which correspondence would be followed by 6-s food presentations in the upcoming condition. Correspondence was followed by a 6-s food presentation in these forced-exposure sessions. When the forced-exposure session preceded Condition 3/3/3, the session contained the key color on which correspondence had been followed by 1-s food presentations in the previous condition. All food presentations lasted 3 s in these forced-exposure sessions.

Control sessions. Any changes in say choices across conditions in which reinforcer magnitudes were manipulated could not be attributed solely to the manipulation of reinforcer magnitudes because each condition change also was preceded by a forced exposure session. To evaluate whether changes in say responding were due to the forced control sessions rather than the differential reinforcer magnitudes, *control sessions* were conducted during the final exposure to Condition 3/3/3. Each control session consisted of one forced exposure session (programmed exactly as the forced exposure sessions described above) in which correspondence was followed by 3-s food presentations. Each pigeon was exposed to three control sessions (one control session per key color) and each control session was implemented following the same stability criteria used for implementing a condition change. Consequently, each control session was preceded and followed by at least 10 sessions in which correspondence on each key color was followed by a 3-s food presentation.

Results and Discussion

Figure 1 shows the number of say responses to each of the key colors in each of the last six sessions of each condition; one say response represents fulfillment of the FR requirement in the say component of one trial. For the last condition, these six sessions are those that occurred before the control sessions were conducted. Each key color was presented in only two of every three trials, so the pigeons could not respond exclusively to (i.e., choose) any single key color in the say component. In the initial Condition 3/3/3, say responses by 2 of the 3 pigeons (974 and 901) rarely occurred on one key color, whereas Pigeon 944's say responses were distributed more evenly across the three key colors. Because the preliminary reinforcer-magnitude manipulations (Condition 6/2/2 for Pigeon 974 and Condition 6/3/1 for Pigeon 944) produced mixed results, the durations of food presentations were modified to 6 s, 2 s, and 1 s, which were used in all subsequent conditions when unequal reinforcer magnitudes were in effect.

In the conditions in which reinforcer magnitudes were 6 s, 2 s, and 1 s, the number of say responses to each key color (i.e., say choices) varied systematically with reinforcer magnitude. For each pigeon, say responses

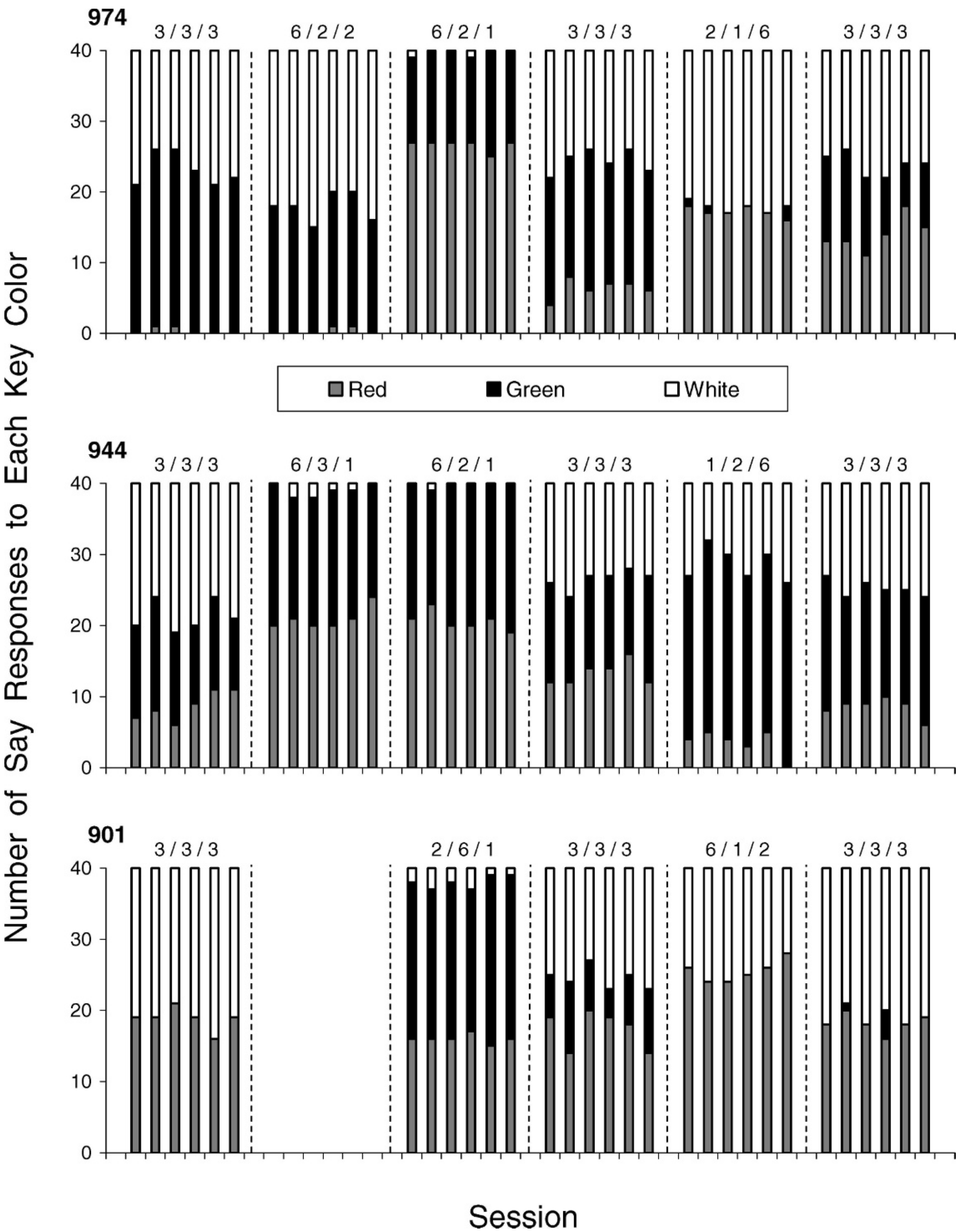

Fig. 1. For Experiment 1, the number of say responses on each key color in each of the last six sessions of each condition for each pigeon. Conditions are labeled according to the duration of food presentations following correspondence on the red/green/white key colors. The last six sessions occurred prior to the introduction of the control probes.

Table 2

Mean (SD) Number of Say Responses to Each Key Color During the Last Six Sessions of Condition 3/3/3 After Each Control Session.

	Pigeon								
	974			944			901		
	Red Key	Green Key	White Key	Red Key	Green Key	White Key	Red Key	Green Key	White Key
Red Session	10.67(2.75)	14.17(1.77)	15.17(1.34)	13.00(1.83)	13.17(2.48)	13.83(1.95)	14.50(1.61)	9.67(0.47)	15.83(1.21)
Green Session	12.83(2.91)	12.50(2.95)	14.67(1.97)	13.33(2.56)	15.67(3.04)	10.83(3.34)	15.17(2.03)	7.67(2.05)	17.17(1.95)
White Session	12.00(2.94)	13.00(2.38)	15.00(1.83)	7.50(1.26)	17.17(1.86)	15.33(1.60)	13.83(1.67)	10.67(1.25)	15.50(0.76)

occurred most often on the key color correlated with 6-s food presentations and occurred least often on the key color correlated with 1-s food presentations for each pigeon. The number of say responses varied across colors in the first exposure to Condition 3/3/3, but became more similar during the second and third exposures to Condition 3/3/3 (except for the last condition for Pigeon 901), suggesting that control by reinforcer magnitude improved with exposure to the contingencies. The final exposure to Condition 3/3/3 was extended to conduct the control sessions. Table 2 contains the distribution of say responses across the key color during the conditions following the control sessions. Say responding did not fluctuate as a function of the control sessions; therefore, the systematic changes to say responding observed in Figure 1 can be attributed to the manipulation of the reinforcer magnitudes assigned to each key color rather than the use of forced-exposure sessions prior to each condition change.

Reinforcer magnitude manipulations did not systematically affect correspondence accuracy. Appendix A (rightmost column) shows mean percent correspondence (i.e., percent correct do responses) for each pigeon during the last six sessions of each condition. Each pigeon acquired correspondence, but accuracy remained lower for Pigeon 901 than for Pigeons 974 and 944. Casual observations revealed that Pigeon 901 pecked the keys with the bottom part of its beak while eyes faced the ceiling of the chamber. Often, Pigeon 901 continued to peck throughout the delay and into the do component such that no behavior changes were noted across the intercomponent delay. These observations were justification for increasing the response requirements and delays for Pigeon 901 when training correspondence, and they may have contributed to the consistently lower percentage correspondence obtained for Pigeon 901.

The finding that reinforcer magnitude influenced choices of the say stimulus is consistent with the previously described research indicating that differential reinforcement magnitude attenuates choice behavior (e.g., Catania, 1963; Hoch et al., 2002). The unique finding in this experiment was that when choice behavior in the say component was influenced the corresponding choice of the same color in the do component also was controlled. This occurred even though there was no direct contingency, but only a conditional one, between the do response and the reinforcer. That is, choice of a particular color in the do component was reinforced only if that response corresponded to the color selected in the earlier-presented say component. That correspondence remained at high levels despite the differential reinforcement of various say responses suggests that the say–do response sequence was functioning as a response unit, and the positive relation between saying and doing was not disrupted by environmental manipulation of choices.

EXPERIMENT 2

Another way of influencing choice behavior is by manipulating the response requirement for each alternative. Piazza, Roane, Keeney, Boney, and Abt (2002), for example, manipulated response requirements to engage in pica (the ingestion of nonnutritive substances) to reliably decrease rates of pica relative to concurrently available appropriate responses

Table 3

Experiment 2: Number of Sessions Each Pigeon Completed in Each Condition.

Pigeon					
974		944		901	
Condition	Sessions	Condition	Sessions	Condition	Sessions
5/5/5	60	5/5/5	60	5/5/5	24
				5/3/8	2
				6/3/10	4
				8/3/12*	4
				10/3/15	1
10/5/15	20	10/5/15	20	10/5/15	20
20/5/25	22	20/5/25	29	20/5/25	36
5/5/5	20	5/5/5	20	5/5/5	22
5/25/20	27	5/25/20	27	20/25/5	38
5/5/5	35	5/5/5	31	5/5/5	31

* A green probe session, like that used in Experiment 1, was implemented after one session of 8/3/12 say ratio requirements. No changes in say choices were observed following exposure to this session.

(but also see Neef, Shade, & Miller, 1994). Other studies conducted in both laboratory settings (e.g., Petry & Heyman, 1995, Experiment 3; Sumpter, Temple, & Foster, 1998, 1999) and applied settings (e.g., Mace, Neef, Shade, & Mauro, 1994; Richman, Wacker, & Winborn, 2001) support the notion that manipulating response requirements alters choices and this was the focus of the present experiment. In Experiment 2, choices in the say component were studied as function of the say response requirements assigned to each key color.

Procedure

Experiment 2 commenced immediately upon completion of Experiment 1. Throughout all conditions for each pigeon, correspondence on each trial was followed by a 3-s food presentation, the delay between the say and do component was 0.5 s, and an FR 3 response requirement was in effect in the do component. Response requirements in the say component varied across conditions. Table 3 contains the order of conditions and the number of sessions that each condition was in effect for each pigeon. The conditions are labeled according to the say-response requirement on the red, green, and white key colors, respectively. In Condition 5/10/15, for example, an FR 5 was in effect on the red key color, an FR 10 was in effect on the green key color, and an FR 15 was in effect on the white key color in the say component. The assignment of say-response requirements to each of the key colors was determined by the number of times correspondence occurred on each key color in the first condition (as for reinforcer magnitudes in Experiment 1). Some preliminary FR response requirements, along with a session of trials in which only a green key was presented during the say component (the same as the green forced-exposure session used in Experiment 1), were introduced for Pigeon 901. These preliminary values did not affect say choices, however, so the values were changed gradually until an FR 5, FR 10, and FR 15 was in effect for each pigeon. After these three intermediate FR values were in effect for 20 sessions, the FR values were increased to FR 5, FR 20, and FR 25. Thereafter, FR 5, FR 20, and FR 25 schedules were used in all conditions where say-response requirements were unequal. Condition 5/5/5 preceded and followed each condition in which say-response requirements were unequal. Following a minimum of 20 sessions in a condition, the next condition could be introduced if there was no increasing or decreasing trend in overall accuracy of correspondence and the number of times each key color was chosen in the say component.

Results and Discussion

Figure 2 shows the number of say responses to each of the key colors in each of the last six sessions of each condition; one say response represents fulfillment of the FR requirement in the say component of one trial. In all conditions in which the say-response requirements were unequal (according to an FR 5, FR

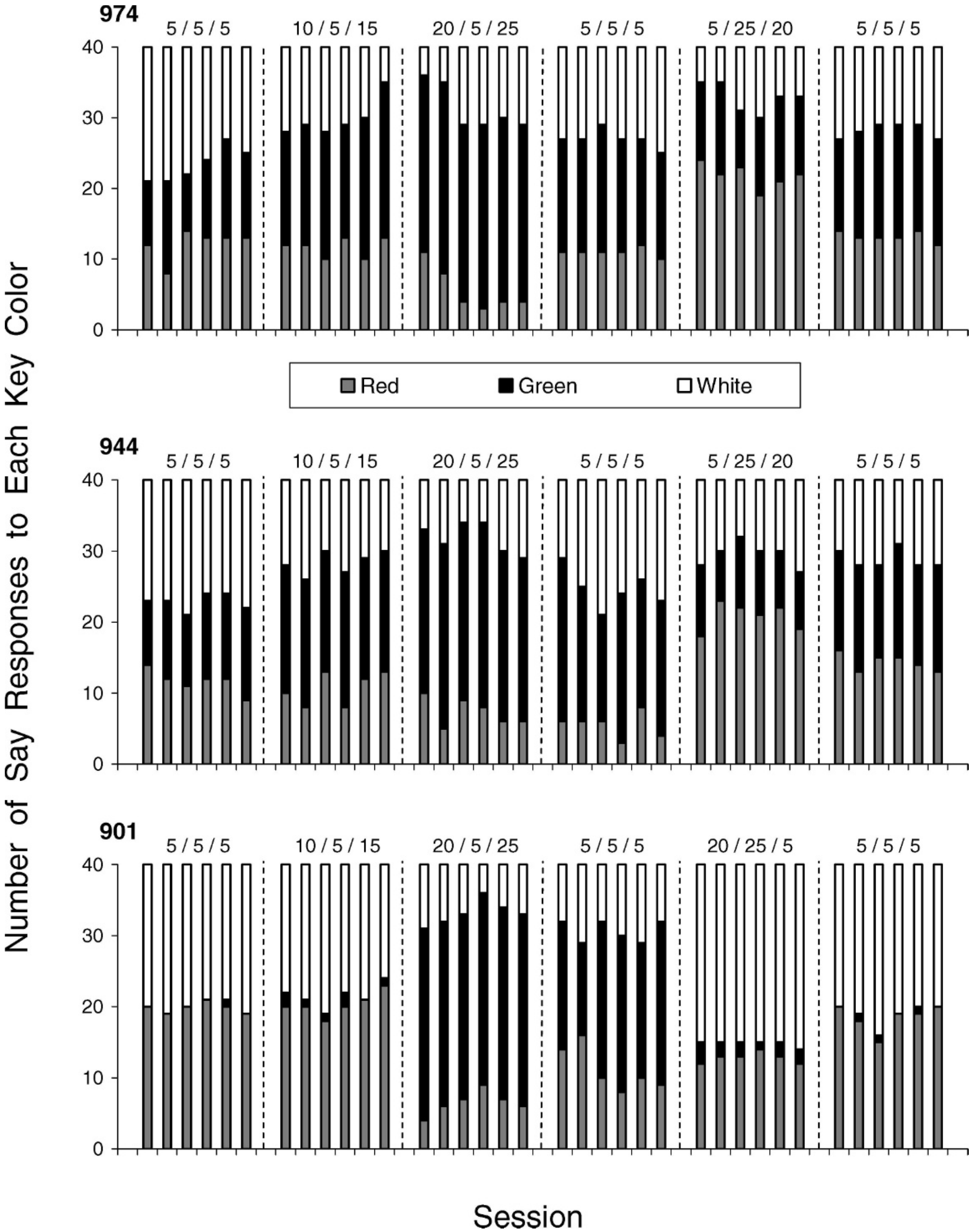

Fig. 2. For Experiment 2, the number of say responses on each key color in each of the last six sessions of each condition for each pigeon. Conditions are labeled according to the say-response requirement on the red/green/white key colors.

Table 4

Experiment 2: Mean (SD) Time to Reinforcement (s) on Each Key Color in Last Six Sessions of Each Condition.

Pigeon	Condition	Key Color		
		Red	Green	White
974	5/5/5	5.16 (0.67)	5.26 (0.40)	4.88 (0.52)
	10/5/15	5.43 (0.36)	4.48 (0.39)	7.31 (1.28)
	20/5/25	11.46 (2.81)	4.57 (0.54)	9.82 (1.39)
	5/5/5	4.07 (0.29)	4.54 (0.70)	3.81 (0.12)
	5/25/20	4.25 (0.24)	8.83 (1.01)	5.85 (0.39)
	5/5/5	3.81 (0.30)	3.69 (0.21)	3.43 (0.22)
944	5/5/5	11.89 (1.09)	8.71 (0.77)	9.32 (1.14)
	10/5/15	12.32 (2.50)	6.77 (1.03)	10.37 (1.97)
	20/5/25	17.22 (1.84)	7.30 (0.27)	12.94 (2.05)
	5/5/5	8.90 (1.47)	8.82 (1.71)	6.85 (0.29)
	5/25/20	8.60 (2.42)	14.63 (1.86)	12.06 (1.81)
	5/5/5	9.63 (2.19)	6.97 (0.65)	6.49 (1.90)
901	5/5/5	4.88 (0.37)	N/A	4.65 (0.27)
	10/5/15	6.29 (0.57)	N/A	7.49 (0.36)
	20/5/25	11.54 (1.89)	5.15 (0.29)	11.14 (0.68)
	5/5/5	5.94 (0.78)	6.01 (0.63)	5.38 (1.01)
	20/25/5	11.15 (0.41)	13.41 (5.38)	4.70 (0.36)
	5/5/5	4.81 (0.26)	N/A	4.63 (0.24)

Note. N/A, not applicable, is used in cases where the key color was not chosen during the last six sessions so that a reinforcer was never delivered for correspondence on that key color.

20, and FR 25 schedule) the greatest number of say responses occurred on the key correlated with the FR 5 response requirement. Say responses to the key colors correlated with the FR 20 and FR 25 were similar in number, such that, functionally, the FR 20 and FR 25 requirements were similar. Say responses in Condition 5/5/5 were distributed fairly evenly across the three key colors for Pigeons 974 and 944 before and after conditions in which the say-response requirements on the key colors were unequal. The same was not true for Pigeon 901 during two of three exposures to Condition 5/5/5; instead, Pigeon 901 responded almost exclusively on the red and white key colors in the first exposure, but most often on the green key color in the second exposure. Moreover, Pigeon 901 again responded rarely on the green key color in the last exposure to Condition 5/5/5 following Condition 20/25/5. These changes in preferences for say responses across successive exposures to Condition 5/5/5 suggest that the manipulation of the say-response requirement had longer-term effects on say responding for Pigeon 901. That is, the shifts in say responses produced by the unequal response requirements persisted into conditions in which the response requirements were once again equal.

Table 4 contains mean times to reinforcement (time from the onset of the say component to the beginning of the food delivery in seconds) on each of the key colors during the last six sessions of each condition. Generally, time to reinforcement was shorter for the FR 5 response requirement than for the FR 20 and FR 25 response requirements, which produced similar times to reinforcement. The present procedure, therefore, precludes comment on whether changes in say responses were a function of response effort during the say component or delay to reinforcement, which was confounded with response requirement. This defines an interesting direction for future research; in the meantime, the present results show clearly that say responding covaried with response requirement in ways that are consistent with previous research on the effects of response requirement on choice.

As in Experiment 1, there were no systematic changes in correspondence accuracy across conditions. Appendix B (rightmost column) contains mean percent correspondence during the last six sessions of each condition for each pigeon. Also, as in Experiment 1, correspondence accuracy was consistently lower for Pigeon 901 than for the other pigeons. The one exception was the second exposure to Condition 5/5/5 for Pigeon 901,

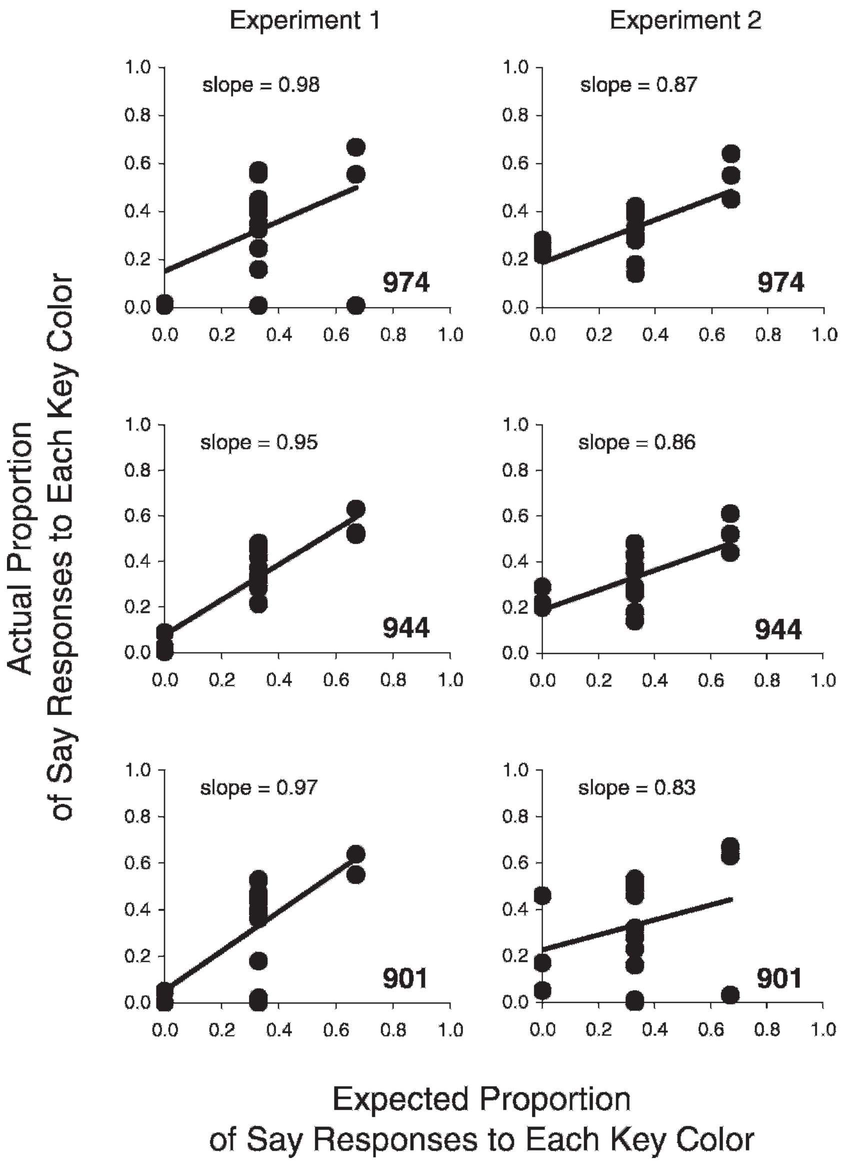

Fig. 3. Actual proportion of say responses to each key color (number of say responses / 40 total trials) as a function the proportion of say responses to each key color that would be expected if choices perfectly matched the reinforcer magnitudes (Experiment 1, left panel) or the response requirements (Experiment 2, right panel). The slope of the best-fitting line is shown on each scatterplot.

where correspondence accuracy occurred at lower levels than in any other condition.

A central issue in assessing the changes to say responding, produced by the reinforcer magnitude and response requirement manipulations, is whether or not choices were optimal in each of the two experiments. In other words, did the pigeons effectively earn the most food possible (Experiment 1) by doing the least amount of work possible (Experiment 2)? Figure 3 relates the actual proportion of say responses (i.e., number of times a key color was chosen out of 40 trials) to the proportion of say responses that would be expected given the reinforcer magnitudes and response requirements in effect in each condition (based on raw data in Appendices A and B). In Experiment 1, the pigeons did not receive the maximum exposure to food in each session, but the slopes of the best-fit lines were close to 1.0 for all pigeons. In most conditions, the key color correlated with 2-s food presentations was chosen more often than 13.3 times per session and the key color correlated with 1-s food presentations was chosen more often than 0.0 times per session. In Experiment 2, say responses occurred more often to the key color correlated with the lowest response requirement than to the other two key colors, but that preferred key color was rarely chosen on every trial it was available. Pigeon 901 chose the green key color frequently in Condition 20/5/25, but this was the only case in which responding on the key color correlated with the lowest say-response requirement (FR 5) was chosen on 2/3 of the trials. The slopes of the best-fit lines were lower in Experiment 2 than in Experiment 1 for every pigeon, which might be considered a crude indicator of reduced sensitivity to differential reinforcement in the second experiment.

In comparing the findings of Experiment 2 to those of Experiment 1, there are several factors to consider in assessing why choices were influenced more predictably by reinforcer magnitudes than by response requirements. One consideration is that response requirements may not influence choice to the same degree as reinforcer magnitudes. This possibility was suggested by Beautrais and Davison (1977), who studied choice between concurrently arranged tandem schedules with both FR and variable-interval properties. When FR requirements were halved on one alternative, responding on that alternative did not double (one response was defined as completion of an FR requirement, as in the present experiments). Neef et al. (1994) also found that response effort (operationally defined as problem difficulty) was the weakest of several variables used to manipulate choice between different sets of math problems. A second consideration involves comparing the difference between a 1-s and 2-s reinforcer and the difference between an FR 20 and FR 25 response requirement. Say responding was affected more readily by the difference between the FR 5 and FR 20 response requirement than the difference between the FR 20 and FR 25 response requirement, and the majority of deviation from the expected say-response frequencies occurred for the key color correlated with the FR 25 say-response requirement. This is evidence of the functional equivalence of the FR 20 and FR 25 response requirements; those response requirements were not discrepant enough to produce discrepant responding to keys correlated with them.

A third consideration is that differences in percent correspondence across the key colors, and therefore the rates of food obtained across the key colors, coincided with the reinforcer-magnitude manipulations in Experiment 1 but not the response-requirement manipulations in Experiment 2. For a summary of this relation for each pigeon, see Figure 4 (based on raw data in Appendices A and B), in which each data point represents the mean during the last six sessions of each condition for a single key color. For all pigeons in Experiment 1, this correlation was significant ($p < .05$), indicating that correspondence was more likely when the ''said'' key color was the most preferred key color. In fact, in every condition of Experiment 1 in which reinforcer magnitudes were unequal except one (Condition 6/2/1 for Pigeon 944 in which white was chosen only once, yielding 100.0% correspondence), the lowest correspondence accuracy occurred on the key color correlated with the shortest food presentation. This relation between say responding and correspondence accuracy was not observed for 2 of 3 pigeons in Experiment 2 (see right panel of Figure 4), but was significant for Pigeon 901 ($p < .01$). Not surprisingly, in Experiment 2, correspondence accuracy was comparable, and on occasion higher, on the key colors correlated with the FR 20 and FR 25 response requirements than on the key color correlated with the FR 5 response requirement, a finding that is consistent with prior reports that increasing sample response requirements or increasing the length of exposure to the sample stimulus increases conditional discrimination accuracy (e.g., Foster, Temple, Mackenzie, DeMello, & Poling, 1995). To summarize these effects, in Experiment 1, the higher percent correspondence on the key color correlated with the greatest reinforcer magnitude could have enhanced sensitivity to the differential reinforcer magnitudes; in Experiment 2, the percent correspondence was not greater for the key color correlated with the FR 5 response requirement so that reinforcement rates were similar across all key colors regardless of the responses required to the key colors.

The finding that the response requirement influenced choices of the say stimulus is

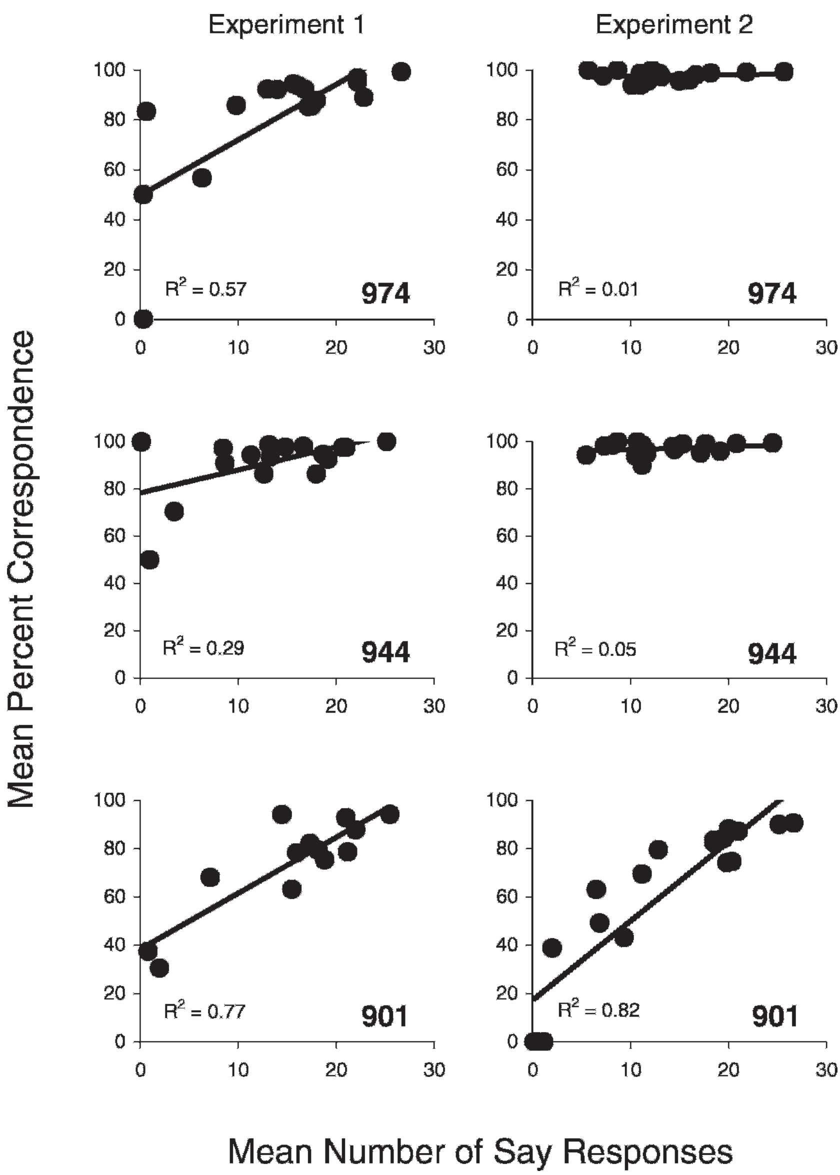

Fig. 4. Mean percent correspondence on each key color during the last six sessions of each condition as a function of the mean number of times each key color was chosen during the last six sessions of each condition in Experiment 1 (left panel) and in Experiment 2 (right panel).

similar to the previously described research indicating that choice can be varied as a function of differential response requirements for the different alternatives (e.g., Piazza et al., 2002; Petry & Heyman, 1995; Sumpter et al., 1998, 1999). The results of the second experiment constitute a systematic replication of the first in that by influencing choice behavior in the say component (here, by varying the number of responses required to produce the do component), the corresponding choice of the same color in the do component also was controlled. This control was indirect in the sense that there was no direct contingency between a particular choice in the do component and reinforcement, only an indirect one in that whatever was selected in the say component had to be repeated in the subsequent do component.

GENERAL DISCUSSION

The present results show that say–do correspondence can be promoted by reinforcing its occurrence. Correspondence was acquired in the absence of experimentally programmed reasons to prefer a given say response (the initial exposure to Condition 3/3/3 of Experiment 1) when, presumably, unspecified historical variables were responsible for say-response preference. Correspondence was maintained under conditions in which preference was explicitly manipulated. In the latter case, say choices were modified by manipulating reinforcer magnitude following correspondence on each key color (Experiment 1) and by manipulating response requirements on each key color (Experiment 2). Importantly, changes in say-response choices had no detrimental effects on correspondence accuracy.

These findings support the notion advanced in the introduction that, once correspondence is established, targeted behavior in the form of do responses can be changed indirectly by altering the contingencies in effect for say responses. This is possible because the say and do responses presumably have become established as two elements of a complex operant (cf. Lattal & Doepke, 2001) such that when the say response occurs its corresponding do response is evoked. It is in this sense that targeted do responses can be controlled indirectly, from a point both spatially and temporally distant from the targeted response. Karoly and Dirks (1977) demonstrated such an effect of correspondence training when they indirectly increased children's pretending to be a scarecrow by directly reinforcing children's promises that they would pretend to be a scarecrow. This indirect control over scarecrow playing was possible only after they established correspondence between saying and doing the scarecrow activity. Similar interventions via reinforcing say responses after first establishing say–do correspondence were used by Paniagua, Pumariega, and Black (1988) and Paniagua (1992), who reinforced correspondence between children's promises that they would inhibit their hyperactive behavior and fulfillment of those promises (this correspondence contingency is similar to what Rachlin, 2002, called a punishment-commitment procedure within the self-control paradigm.) Using correspondence as a self-regulation tool for developmentally delayed food-service employees, Crouch, Rusch, and Karlan (1984) reinforced correspondence between verbal promises to begin and end work tasks (e.g., sweeping) at specified times and their subsequent engagement in the tasks at those times, before controlling work tasks indirectly via reinforcement of only employees' promises (see also Weninger & Baer, 1990). These examples specifically illustrate the utility of correspondence for increasing honesty, self-control, and self-regulation; more broadly, they illustrate how current behavior can be altered by directly manipulating earlier choices when correspondence between those choices and current behavior has been reinforced.

In translating the present procedures and findings to say–do correspondence in humans, two aspects of the procedure warrant consideration. First, both experiments involved elements designed to increase contact with contingency changes across conditions. In Experiment 1, the shortest food presentation used in the preliminary reinforcer magnitudes was changed from 2 s to 1 s for Pigeon 974 (for Pigeon 944, the preliminary value was 1 s) and, in Experiment 2, response requirements were increased systematically, from FR 10 and FR 15 to FR 20 and FR 25 before noted shifts in say responding were obtained. It might be necessary to adjust reinforcement or response parameters until they are sufficiently discrete for each subject. For the pigeons, there was no functional difference (measured by choice) between 2-s access to grain and 3-s access to grain and no functional difference between an FR 5 response requirement and an FR 10 response requirement (the parameters used early on in the experiments). Another element of the procedure in Experiment 1 was the use of forced-exposure sessions before every condition change, which also might be necessary in applied settings to ensure contact with contingency changes (as has been done previously in manipulations of choice, e.g., Mace et al., 1994).

Second, a correction procedure was used in both experiments to train and maintain correspondence. The correction procedure may be important because it (a) required correspondence, and its subsequent reinforcement, on each trial and (b) may have punished noncorrespondence because the 5-s blackout and FR-12 response requirement delayed access to food. Lattal and Doepke (2001) showed that correspondence accuracy was higher when a correction procedure was used than when there was no correction procedure and that correspondence accuracy was higher when the correction procedure contained the say and do components rather than the do component only. Studies of correspondence typically involve punishment of noncorrespondence (e.g., Baer, Detrich, & Weninger, 1988; Wilson et al., 1992), but few studies of correspondence have implemented a correction procedure similar to that employed here, in which noncorrespondence was followed by repeating the entire say–do sequence until correspondence occurs. It is possible that comments such as, ''You don't get a snack today because you didn't really play with blocks'' (Israel & O'Leary, 1973) produce the same effect as having a child repeat the sequence of behavior until correspondence occurs, but the presence or absence of any corrective feedback likely impacts the acquisition and maintenance of correspondence. Without a correction procedure, for example, correspondence did not increase when Osnes, Guevremont, and Stokes (1987) reinforced correspondence between children's saying they would talk with other children during play and their talking with other children during play. Correspondence increased only after a brief timeout was introduced following noncorrespondence. It appears, then, that a systematic assessment of the role played by corrective procedures or feedback on correspondence is needed.

A final, more general, consideration with respect to the translational value of the present experiments concerns the social validity of the homologue itself. Many natural cases of say–do correspondence involve the independent reinforcement of saying and doing; the relevant reinforcers might be different from, and even compete with, the reinforcer(s) available for correspondence itself. In the present homologue, the programmed reinforcer was presented only after the do response and only if there was correspondence between saying and doing. It might be informative to expand Lattal and Doepke's (2001) homologue to incorporate explicitly arranged conditioned reinforcers or additional unconditioned reinforcers for saying and doing alone that are separate from the reinforcement processes maintaining correspondence. It is likely that in applied settings when established correspondence fails to occur, the noncorrespondence could be attributed to the power of the immediate reinforcers available for making a promise or lying about what was done, over the delayed reinforcers available for correspondence and delayed punishers produced by noncorrespondence.

The present experiments also invite further consideration of the conditional discrimination paradigm. The say–do homologue examined herein not only provides a framework for assessing correspondence in nonhuman animals, it introduces a different method for studying choice and stimulus control, and the interactions between them. The say response serves the same discriminative function as the sample stimulus in other conditional discrimination procedures where the conditional stimulus is arranged by the experimenter. Whether or not *choosing* the conditional stimulus affects the acquisition or maintenance of the conditional relation is a question for further investigation. The interaction between the effects of response and reinforcer parameters, delay between the consequence and the previous say choice, and incorrect responses (or, trials without reinforcer delivery) also seem ripe for further analysis. Lattal and Doepke (2001) noted that, as an instance of conditional discrimination, correspondence also may be considered a complex operant composed of two topographically distinct responses that are functionally tied by reinforcement. Considered in this way, the present experiments also invite further analysis of the malleability of the elements of complex operants as a function of the differential reinforcement of the different response elements of which they are composed.

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APPENDICES

APPENDIX A

Say Choices and Correspondence Accuracy for Each Pigeon in Each Condition of Experiment 1

Pigeon	Condition	Expected Number of Say Responses on Each Key Color (Red / Green / White)	Mean (SD) Number of Say Responses on Each Key Color		
			Red	Green	White
974	3/3/3	13.3 / 13.3 / 13.3	0.33(0.47)	22.83(1.67)	16.83(2.11)
	6/2/2	26.7 / 6.7 / 6.7	0.33(0.47)	17.50(1.50)	22.17(1.86)
	6/2/1	26.7 / 13.3 / 0.0	26.67(0.75)	13.00(1.00)	0.33(0.47)
	3/3/3	13.3 / 13.3 / 13.3	6.33(1.25)	18.00(1.15)	15.67(1.49)
	2/1/6	13.3 / 0.0 / 26.7	17.17(0.69)	0.67(0.75)	22.17(0.69)
	3/3/3	13.3 / 13.3 / 13.3	14.00(2.16)	9.83(2.41)	16.17(1.46)
944	3/3/3	13.3 / 13.3 / 13.3	8.67(1.89)	12.67(1.89)	18.67(1.97)
	6/3/1	26.7 / 13.3 / 0.0	21.00(1.41)	18.00(1.29)	1.00(0.82)
	6/2/1	26.7 / 13.3 / 0.0	20.67(1.25)	19.17(1.57)	0.17(0.37)
	3/3/3	13.3 / 13.3 / 13.3	13.33(1.49)	13.17(1.07)	13.50(1.26)
	1/6/2	0.0 / 26.7 / 13.3	3.50(1.71)	25.17(1.34)	11.33(2.13)
	3/3/3	13.3 / 13.3 / 13.3	8.50(1.26)	16.67(1.49)	14.83(1.07)
901	3/3/3	13.3 / 13.3 / 13.3	18.83(1.46)	0.00(0.00)	21.17(1.46)
	2/6/1	13.3 / 26.7 / 0.0	16.00(0.58)	22.00(1.29)	2.00(0.82)
	3/3/3	13.3 / 13.3 / 13.3	17.33(2.43)	7.17(1.95)	15.50(1.38)
	6/1/2	26.7 / 0.0 / 13.3	25.50(1.38)	0.00(0.00)	14.50(1.38)
	3/3/3	13.3 / 13.3 / 13.3	18.17(1.21)	0.83(1.46)	21.00(1.15)

APPENDIX B

Say Choices and Correspondence Accuracy for Each Pigeon in Each Condition of Experiment 2

Pigeon	Condition	Expected Number of Say Responses on Each Key Color (Red / Green / White)	Mean (SD) Number of Say Responses on Each Key Color		
			Red	Green	White
974	5/5/5	13.3 / 13.3 / 13.3	12.17(1.95)	11.17(2.11)	16.67(2.28)
	10/5/15	13.3 / 26.7 / 0.0	11.67(1.25)	18.17(2.19)	10.17(2.41)
	20/5/25	13.3 / 26.7 / 0.0	5.67(2.87)	25.67(0.75)	8.67(2.98)
	5/5/5	13.3 / 13.3 / 13.3	11.00(0.58)	16.00(1.00)	13.00(1.15)
	5/25/20	26.7 / 0.0 / 13.3	21.83(1.57)	11.00(1.53)	7.17(1.86)
	5/5/5	13.3 / 13.3 / 13.3	13.17(0.69)	15.00(1.00)	11.83(0.90)
944	5/5/5	13.3 / 13.3 / 13.3	11.67(1.49)	11.17(1.34)	17.17(1.07)
	10/5/15	13.3 / 26.7 / 0.0	10.67(2.13)	17.67(0.75)	11.67(1.49)
	20/5/25	13.3 / 26.7 / 0.0	7.33(1.80)	24.50(1.26)	8.17(1.95)
	5/5/5	13.3 / 13.3 / 13.3	5.50(1.61)	19.17(2.48)	15.33(2.49)
	5/25/20	26.7 / 0.0 / 13.3	20.83(1.77)	8.67(1.11)	10.50(1.61)
	5/5/5	13.3 / 13.3 / 13.3	14.33(1.11)	14.50(0.96)	11.17(1.21)
901	5/5/5	13.3 / 13.3 / 13.3	19.83(0.69)	0.17(0.37)	20.00(0.82)
	10/5/15	13.3 / 26.7 / 0.0	20.33(1.49)	1.17(0.69)	18.50(1.50)
	20/5/25	13.3 / 26.7 / 0.0	6.50(1.50)	26.67(0.47)	6.83(1.57)
	5/5/5	13.3 / 13.3 / 13.3	11.17(2.85)	19.50(3.40)	9.33(1.37)
	20/25/5	13.3 / 0.0 / 26.7	12.83(0.69)	2.00(0.58)	25.17(0.37)
	5/5/5	13.3 / 13.3 / 13.3	18.50(1.71)	0.50(0.50)	21.00(1.41)

APPENDIX A

(*Extended*)

Mean (SD) Percent Correspondence on Each Key Color			Percent Correspond Across All
Red	Green	White	Key Colors
0.00(0.00)	89.00(6.32)	92.17(5.58)	89.67(2.98)
50.00(50.00)	85.50(5.52)	96.83(5.18)	91.83(4.14)
99.33(1.49)	92.33(4.35)	50.00(50.00)	97.00(1.41)
56.67(25.26)	87.83(5.27)	94.50(5.88)	87.00(4.69)
85.33(5.47)	83.33(23.57)	95.33(2.62)	91.17(4.14)
92.17(4.06)	85.83(10.16)	93.67(7.36)	91.00(3.70)
90.83(4.45)	86.33(5.06)	94.50(4.54)	91.67(1.97)
97.50(2.50)	86.33(8.92)	50.00(35.36)	91.50(4.54)
97.50(3.82)	92.50(8.54)	100.00(0.00)	95.67(3.40)
93.50(5.74)	98.67(2.98)	97.33(3.77)	97.00(1.41)
70.40(16.93)	100.00(0.00)	94.33(5.93)	96.00(1.41)
97.17(6.34)	98.00(2.83)	97.67(3.30)	98.17(1.67)
75.33(11.80)	N/A(N/A)	78.67(8.83)	77.00(6.48)
78.33(2.26)	87.83(6.67)	30.50(36.53)	81.17(7.99)
82.17(6.89)	68.00(19.73)	63.17(9.58)	73.17(4.41)
94.17(3.76)	N/A(N/A)	94.17(4.84)	94.33(3.04)
79.33(9.50)	37.50(37.50)	92.83(3.39)	86.50(3.73)

APPENDIX B

(*Extended*)

Mean (SD) Percent Correspondence on Each Key Color			Percent Correspond Across All
Red	Green	White	Key Colors
100.00(0.00)	98.67(2.98)	98.17(2.61)	99.00(1.00)
98.67(2.98)	98.80(2.24)	93.83(7.27)	98.17(1.67)
100.00(0.00)	99.33(1.49)	100.00(0.00)	99.67(0.75)
94.00(6.71)	96.00(4.47)	98.50(3.35)	96.33(2.69)
99.17(1.86)	98.67(2.98)	97.67(5.22)	98.83(1.86)
97.33(3.77)	95.67(7.34)	95.67(6.77)	96.50(2.99)
95.83(5.96)	98.67(2.98)	95.17(5.18)	96.33(2.69)
100.00(0.00)	99.00(2.24)	95.00(7.64)	98.50(2.57)
98.17(4.10)	99.33(1.49)	98.50(3.35)	99.00(1.00)
94.33(8.01)	95.83(3.72)	99.00(2.24)	97.00(1.41)
99.17(1.86)	100.00(0.00)	94.00(4.32)	98.33(0.75)
97.83(3.08)	96.67(3.35)	90.00(5.86)	95.17(1.46)
74.17(7.15)	0.00(0.00)	88.17(3.72)	81.17(4.88)
74.67(5.53)	0.00(0.00)	83.50(4.15)	76.83(5.34)
63.00(22.92)	90.67(3.50)	49.17(16.78)	79.50(6.83)
69.50(19.22)	84.17(4.06)	43.17(11.80)	71.17(6.36)
79.50(7.34)	38.83(18.44)	90.00(3.06)	84.50(1.80)
82.50(5.62)	0.00(0.00)	87.17(6.77)	84.50(2.87)