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TRANSFER OF ODDITY-FROM-SAMPLE PERFORMANCE IN PIGEONS[1]

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Four pigeons were trained on a modified three-key oddity-from-sample task in which an observing response to the sample (center-key) stimulus lighted a single comparison (side-key) stimulus. If the comparison stimulus was different from the sample stimulus, a single peck to the lighted comparison was reinforced. If the comparison and sample stimuli were identical, the pigeons had to refrain from pecking the comparison for 4.6 seconds to terminate the matching comparison and to produce immediately a nonmatching comparison on the remaining side key. Each peck to the matching comparison reset the 4.6-second delay interval. Three hues were used during acquisition. During tests for transfer of the oddity performance, two novel hues were substituted either individually or together for one or two of the original training hues. For three birds, latencies to novel nonmatching hues were identical to baseline nonmatching latencies. Latencies to novel matching hues were shorter than baseline matching latencies but were consistently longer than novel nonmatching latencies. These transfer data demonstrate that the pigeons learned the oddity concept.

Key words: oddity-from-sample, transfer, oddity concept, hue dimension, key peck, pigeons

Simultaneous matching-to-sample (Cumming and Berryman, 1961) and simultaneous oddity-from-sample (Berryman, Cumming, Cohen, and Johnson, 1965) are two conditional discrimination problems commonly studied in pigeons. The matching-to-sample problem requires that the pigeon choose from two alternative comparison stimuli the comparison that physically matches the sample stimulus. In oddity-from-sample, the complementary problem, the pigeon must choose the comparison stimulus that is physically different from the sample stimulus. Procedurally, reinforcement for both matching-to-sample and oddity-from-sample is arranged in terms of the relationships between stimuli. Behaviorally, the pigeon's choice of comparison stimuli has not been found to be under relational stimulus control. The absence of this control is demonstrated by the failure of pigeons in simultaneous matching-to-sample and simultaneous oddity-from-sample experiments to transfer their learned performances to novel stimuli (Berryman *et al.*, 1965; Cumming and Berryman, 1961; Farthing and Opuda, 1974). During acquisition of these conditional discriminations, the choice of comparison stimuli is apparently controlled by a set of specific performance rules or "S^D rules" (Berryman *et al.*, 1965). In short, the birds learn which comparison stimuli are correct (S^D), but fail to learn which comparisons are incorrect (S^Δ).

Urcuioli and Nevin (1975) reported, however, that if pigeons in a matching-to-sample experiment are explicitly trained to discriminate matching from nonmatching pairs of stimuli (correct comparisons from incorrect comparisons), then they will transfer their performances to novel stimuli. The usual three-key simultaneous matching-to-sample procedure was modified by Urcuioli and Nevin (1975) such that only a single comparison stimulus (rather than two) was lighted following an observing response to the sample stimulus.

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If the initially lighted comparison physically matched the sample stimulus, a single peck to the matching comparison was reinforced with food. If the initially lighted comparison was different from the sample stimulus, however, the pigeon had to refrain from pecking the nonmatching comparison for 4.8 sec to terminate the nonmatching comparison and to produce the matching comparison on the remaining side key. With this modified procedure, the pigeons quickly learned to peck at matching comparisons and not to peck at nonmatching comparisons. During transfer tests, the two response classes, "peck side key" and "do not peck side key", generalized to novel matching and novel nonmatching comparisons, respectively, thus demonstrating stimulus control by the matching relation.

The present experiment sought to determine whether the transfer of performance observed in pigeons trained on a modified matching-to-sample procedure would also be observed in pigeons trained on a similarly modified oddity-from-sample procedure. In the modified oddity procedure, pigeons are given explicit training not to peck matching (incorrect) comparison hues, and to peck nonmatching (correct) comparison hues. Following oddity training with three hues, transfer is assessed by substituting two novel hues, either individually or together, for one or two of the original hues until all possible novel hue combinations are exhausted. Short response latencies to novel nonmatching hue combinations and long response latencies to novel matching hue combinations indicate transfer of the oddity performance.

METHOD

Subjects

Four naive White Carneaux pigeons, 114, 127, 133, and 136, from the Palmetto Pigeon Plant, Sumter, South Carolina, were maintained at 80% of their free-feeding body weights throughout the experiment. Grit and water were always available in the home cages.

Apparatus

The experimental apparatus consisted of a single Grason-Stadler animal chest (Model E3125AA) that contained a three-key operant panel (GS Model E6446CA-1). Mounted behind each response key was a Lehigh Valley Model 465 in-line projection unit (IEE Model 10-10X61-1820L; GE 44 bulbs), which provided red, yellow, green, blue, and violet hues. The animal chamber was located in a sound-attenuating room, with relay programming equipment in an adjacent room. White noise in the experimental room and a blower mounted on the side of the animal chamber supplied masking noise.

Procedure

Preliminary training. Birds were initially given three sessions of magazine training (50 food presentations per session). Over the next eight sessions, the birds were trained to peck each key (left, center, and right) whenever one was lighted by one of the three training hues: red (R), green (G), and blue (B). A single peck to the lighted key was reinforced with 4-sec access to grain. Pecks to unlighted keys had no scheduled consequences.

The houselight remained off at all times during preliminary training. The only illumination in the chamber was supplied by the lighted keys and the food-magazine light. The intertrial interval (ITI) between successive key illuminations was 20 sec.

Oddity procedure. Figure 1 schematically represents the oddity procedure. A trial began with illumination of the center key with either an R, a G, or a B light. A single peck to the

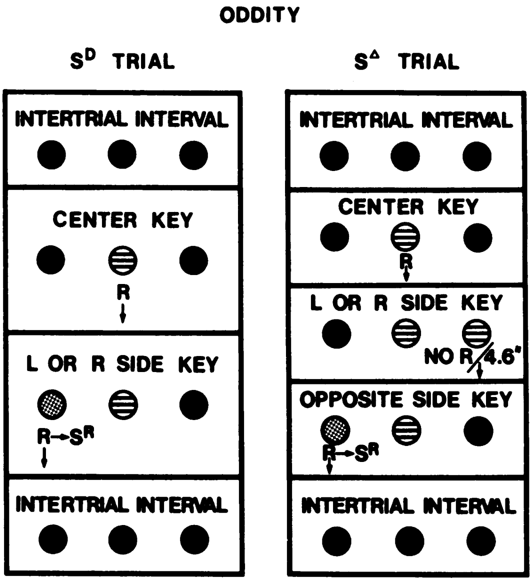

Fig. 1. Schematic representation of the oddity procedure. See text for details.

lighted center key illuminated either the left- or the right-side key. If the side-key hue was different from the center-key hue (a nonmatching comparison), a peck to the lighted side key produced food (S^D trial). If the side-key hue was identical to the center-key hue (a matching comparison), the pigeon was required to refrain from pecking the lighted side key for 4.6 sec to terminate the matching comparison and to produce a nonmatching comparison on the other side key. A peck to the nonmatching comparison then produced food (S^Δ trial). Each peck to the matching comparison, however, reset the 4.6-sec delay interval. The next trial began following an ITI of 20 sec with all keys dark.

The sequences of center-key hues and center- and side-key hue combinations were randomized and punched on eight-channel tapes. The probability of either side key being lighted following a center-key peck was 0.50. The probability of either a nonmatching or a matching comparison hue appearing on the initially lighted side key following a center-key response was also 0.50. Four individual tapes were used during acquisition, each with different random sequences. Seventy-five trials per day were conducted six days per week. The order of the tapes used from day to day was randomized. Birds were not used if their body weights deviated from their 80% weights by more than 15 g.

As during preliminary training, the only illumination in the chamber was provided by the keylights and illumination of the food hopper. Reinforcement consisted of 3-sec access to grain. Individual timers recorded latency to respond to the comparison hue of each nonmatching and matching hue combination. If no response occurred to a matching comparison hue (S^Δ trial), a 4.6-sec latency was recorded. Initially, no upper recording limit was set for latency to respond to nonmatching comparisons (S^D trials).

Birds 114 and 136 were given 36 sessions of acquisition; Birds 127 and 133 were given 34 sessions. Immediately following acquisition, 26 baseline sessions were conducted, during which the first 12 and the last 13 trials of each day's data were discarded to reduce the variability due to warm-up effects and satiation effects, respectively. Also, beginning with Session 19 of the first baseline, a 4.6-sec upper limit (for recording purposes only) was set for nonmatching (S^D) trials. Finally, 10 sessions of baseline were interspersed between each successive transfer test, as described below.

The nine hue combinations (three matching and six nonmatching) used during acquisition and baseline are shown in the left column of Table 1.

Table 1

Matching and nonmatching hue combinations during each phase of the experiment. Novel hue combinations used to assess transfer of the oddity performance are italicized.

Acquisition and Baseline	*Transfer I*	*Transfer II*	*Transfer III*	*Transfer IV*
R-R	R-R	R-R	R-R	Y-Y
G-G	*Y-Y*	*V-V*	Y-Y	G-G
B-B	B-B	B-B	V-V	V-V
R-G	*R-Y*	*R-V*	R-Y	*Y-G*
R-B	R-B	R-B	R-V	Y-V
G-R	*Y-R*	*V-R*	Y-R	*G-Y*
G-B	*Y-B*	*V-B*	*Y-V*	*G-V*
B-R	B-R	B-R	V-R	V-Y
B-G	*B-Y*	*B-V*	*V-Y*	*V-G*

Transfer tests. Four separate transfer tests were conducted, during which a novel yellow (Y) and a novel violet (V) hue were substituted either individually or together for one or two of the original training hues. Each test lasted for four consecutive sessions, 75 trials per session. The reinforcement contingencies during acquisition and baseline remained in effect during transfer testing. Four new tapes that arranged the random sequences of center-key hues and center- and side-key hue combinations were used for the tests. The nine hue combinations that appeared during each transfer test are shown in the last four columns of Table 1. The novel hue combinations used to assess transfer of the oddity performance are italicized.

RESULTS

The primary response measure was latency to respond to the initially lighted comparison hue. Latencies were recorded for each of the nine possible hue combinations: six nonmatching combinations (referred to as nonmatching or S^D latencies) and three matching combinations (referred to as matching or S^Δ latencies). The location (*i.e.*, the left- or right-side key) of the initially lighted comparison

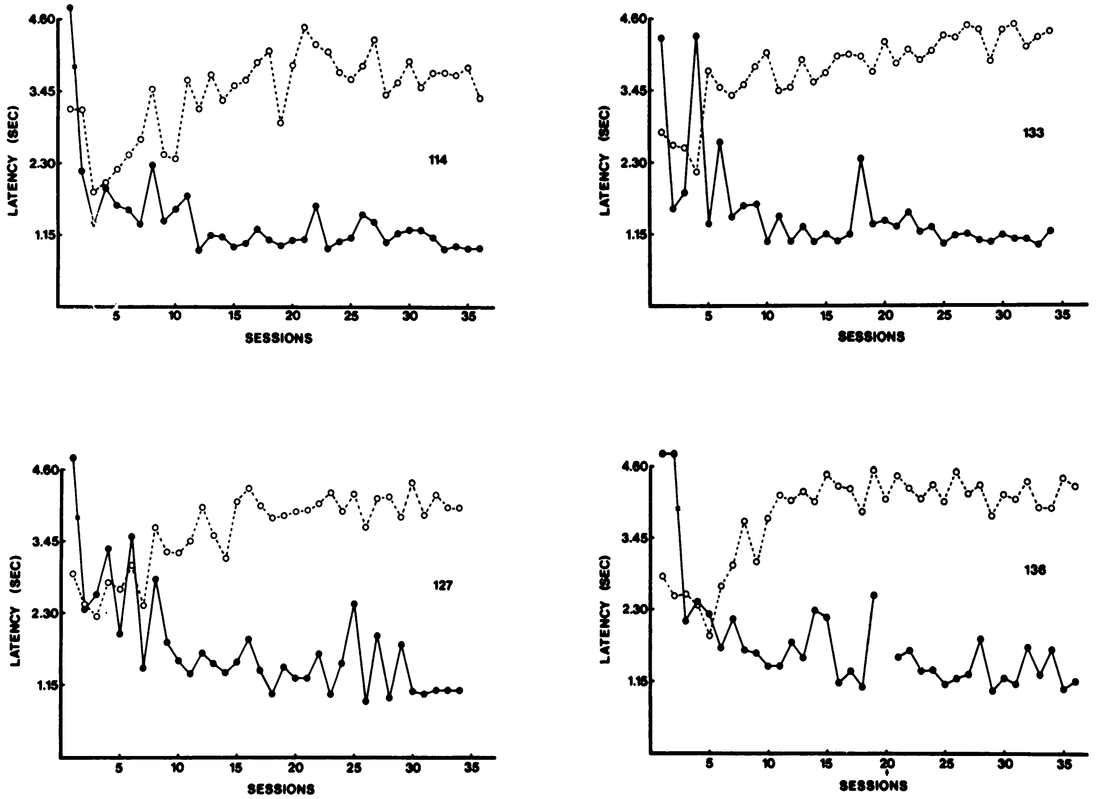

Fig. 2. Acquisition curves for each bird. Filled circles plot the (weighted) mean S^D latency. Open circles plot the (weighted) mean S^Δ latency. The arrow below the functions for Bird 136 indicate a missing datum point (due to apparatus failure).

hue was disregarded. The weighted average of the mean response latencies for the six nonmatching hue combinations is referred to as the mean S^D latency. The weighted average of the mean response latencies for the three matching hue combinations is referred to as the mean S^Δ latency.

The oddity acquisition functions for each bird are shown in Figure 2. The filled circles plot the mean S^D latency, the open circles plot the mean S^Δ latency. The unusually long mean S^D latency for the first acquisition session and for a few subsequent sessions is artifactual: no upper recording limit was set for nonmatching (S^D) latencies during acquisition.

The functions for all the birds are similar. During the initial sessions of acquisition, the pigeons tended to peck both nonmatching and matching comparison hues with equal frequency. The comparable mean S^D and mean S^Δ latencies reflect this performance. Within 10 sessions, however, the oddity discrimination began to appear. The birds consistently pecked nonmatching comparison hues, and did not peck matching comparison hues. The oddity discrimination continued to improve with further training and, by the end of acquisition, both nonmatching (S^D) and matching (S^Δ) latencies were asymptotic. Nonmatching latencies were approximately 1.0 sec, and matching latencies were at least 4.0 sec.

During each of the four blocks of baseline, the oddity performance of each bird was comparable to the performance during the final sessions of acquisition. Performance improved slightly for Birds 114 and 136 across successive baselines, but this was due primarily to a reduction in the variability of both the nonmatching and matching latencies, rather than to any distinct decreases in nonmatching latencies and/or any distinct increases in matching latencies.

In transfer tests immediately after each baseline, one or two novel hues were substituted either individually or together for one or two training hues. Nonmatching (S^D) latencies and

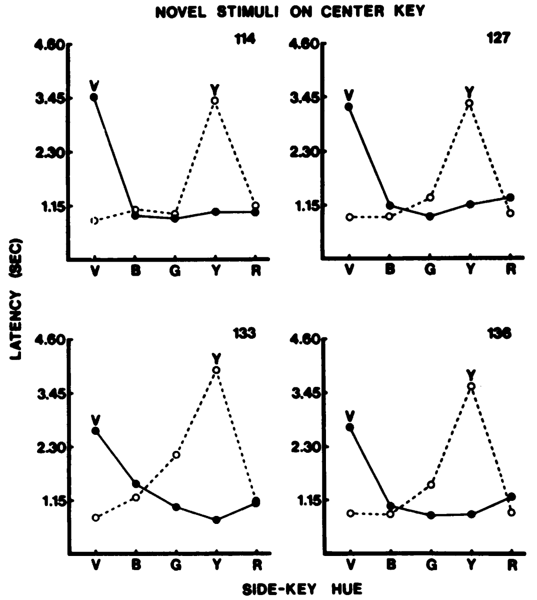

Fig. 3. Pooled transfer data. Latency to the side-key hue when a novel hue appeared on the center key. Filled circles describe the functions for the novel violet stimulus; open circles describe the functions for the novel yellow stimulus.

matching (S^{Δ}) latencies formed with novel hues (*cf.* Table 1) were used to measure transfer. These two sets of latencies were compared to corresponding latencies during baseline: transfer of performance would be revealed if (1) novel nonmatching latencies were as short as baseline nonmatching latencies, (2) novel matching latencies were as long as baseline matching latencies, and (3) novel nonmatching latencies were shorter than novel matching latencies. The latency data for novel hue-combinations pooled over all four sessions of each transfer test are shown for each bird in Figures 3 and 4. Each datum point in the figures is derived from four sessions of a *single* transfer test. Successive data points, however, do not necessarily come from the same transfer test. For example, the data points corresponding to Y-Y and to Y-G come from transfer tests I and IV, respectively.

Figure 3 shows performance with novel hue-pairs when the novel hue (either Y or V) appeared on the center key: that is, when the novel hue was the sample stimulus. The comparison hues are plotted along the x-axis. Using the functions from Bird 114 as an example to help clarify the figures, the filled circle below the letter "V" represents the weighted average latency for the novel V-V combination (a novel matching combination). The adjacent datum point on the V function represents the weighted average latency for trials on which the novel V appeared as the sample stimulus and B appeared as the comparison hue: that is, the novel nonmatching V-B combination. Each individual figure shows two novel matching latencies, V-V and Y-Y, and eight novel nonmatching latencies. In all cases, novel nonmatching latencies are shorter than novel matching latencies. In addition, novel nonmatching latencies are all approximately 1.0 sec and are, therefore, identical to baseline nonmatching latencies. On the other hand, the matching latencies are noticeably less than the maximum 4.6 sec and are shorter than baseline matching latencies.

Figure 4 shows performance with novel hue-pairs when the novel hue (either Y or V) appeared on the side key: that is, when the novel hue was the comparison stimulus. The center-key (sample) hues are plotted along the x-axis. Using the functions for Bird 114 again to clarify the figures, the weighted average latency for the novel V-V matching combination is shown by the filled circle below the letter "V". Note that this latency is identical,

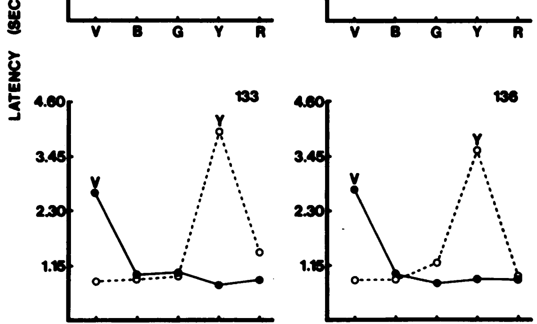

Fig. 4. Pooled transfer data. Latency to the novel side-key hue as a function of the center-key hue. Filled circles describe the functions for the novel violet stimulus; open circles describe the functions for the novel yellow stimulus.

by definition, to the novel V-V latency in Figure 3. The adjacent datum point on the V function represents the weighted average latency for the novel B-V nonmatching combination: that is, the latency for the combination composed of B as the sample (center-key) stimulus and V as the comparison (side-key) stimulus. As before, each individual figure shows two novel matching latencies, V-V and Y-Y, and eight novel nonmatching latencies. All novel nonmatching latencies are again shorter than novel matching latencies. For three birds, 114, 133, and 136, all novel nonmatching latencies are essentially identical (approximately 1.0 sec) and, hence, are also identical to baseline nonmatching latencies. The performance of Bird 127 on nonmatching trials with novel hues was distinctly different from the performances of the other three birds. The latency function for the novel V comparison stimulus appears to be graded: the shortest latency occurring with the novel Y-V combination, the longest latency occurring with the novel V-V combination, and the remaining novel nonmatching latencies at intermediate values. The latency function for the novel Y comparison stimulus defies description.

The hue functions plotted in Figures 3 and 4 suggest that the oddity discrimination for at least three birds, 114, 133, and 136, was successfully transferred to novel hues. Novel nonmatching latencies were shorter than novel matching latencies and were essentially identical to baseline nonmatching latencies. Although novel matching latencies were not as long as baseline matching latencies, there was a consistently clear separation between these latencies and the novel nonmatching latencies. The test data presented in Table 2 show that the evidence for transfer shown in Figures 3 and 4 is not the result of learning new discriminations across test sessions. Day 1 transfer performance data for each novel hue-pair and the pooled data (averaged across four test sessions) for each pair are presented. (Trial-by-trial latencies were not recorded.) Note that novel nonmatching latencies for Birds 114, 133, and 136 on Day 1 transfer do not markedly differ from one another nor from the averaged latencies, with a few exceptions (for example, R-V and Y-B for Bird 114, Y-R and Y-G for Bird 133, and Y-G and V-Y for Bird 136). For these birds, performance on matching trials with the novel Y hue (Y-Y) showed a noticeable decrement from baseline matching latencies but no increase in the Y-Y latency across test sessions. Latencies to the novel matching V-V combination showed an even larger decrement from baseline matching latencies; indeed, for Birds 133 and 136, latencies to V-V were as short as latencies to Y-G

Table 2

Mean response latencies to novel nonmatching and novel matching hue-combinations on Day 1 of transfer testing and pooled over the four sessions of each test (Avg.). The number inside the parentheses indicates the number of trials on which each hue combination appeared on Day 1 transfer.

Novel Hue Pairs	*Bird 114*		*Bird 127*		*Bird 133*		*Bird 136*	
	Day 1	*Avg.*	*Day 1*	*Avg.*	*Day 1*	*Avg.*	*Day 1*	*Avg.*
R-Y	1.5 (4)	1.4	4.6 (4)	2.8	0.6 (4)	1.5	1.0 (4)	0.9
R-V	1.6 (5)	1.3	4.6 (3)	2.0	0.8 (8)	0.9	0.7 (9)	0.9
G-Y	0.7 (5)	0.9	1.3 (5)	1.5	0.7 (5)	0.9	1.2 (5)	1.2
G-V	0.8 (3)	0.8	1.5 (2)	1.2	0.7 (7)	1.0	0.9 (3)	0.8
B-Y	1.2 (8)	1.0	4.0 (8)	2.9	0.6 (7)	0.8	0.8 (7)	0.9
B-V	0.8 (5)	0.9	2.0 (3)	1.9	0.7 (5)	0.9	0.7 (6)	1.0
Y-R	1.1 (5)	1.1	0.9 (5)	1.0	1.9 (5)	1.2	1.0 (5)	0.9
Y-G	1.0 (4)	1.0	1.6 (6)	1.3	2.5 (5)	2.1	2.9 (4)	1.5
Y-B	1.6 (3)	1.0	0.7 (3)	0.9	1.4 (5)	1.2	0.9 (5)	0.9
Y-V	0.6 (5)	0.8	0.9 (5)	0.9	0.9 (7)	0.8	1.0 (3)	0.9
V-R	1.0 (7)	1.0	1.3 (5)	1.3	1.2 (1)	1.1	1.3 (5)	1.2
V-G	0.8 (8)	0.9	0.6 (4)	0.9	1.0 (6)	1.0	1.0 (8)	0.8
V-B	1.3 (2)	1.0	0.9 (6)	1.1	1.0 (4)	1.5	0.9 (5)	1.0
V-Y	1.0 (8)	1.0	1.2 (6)	1.2	0.7 (2)	0.7	1.8 (3)	0.8
Y-Y	3.6 (9)	3.4	4.2 (9)	3.3	3.6 (7)	4.0	3.5 (7)	3.6
V-V	2.2 (12)	3.5	4.4 (9)	3.3	2.2 (9)	2.7	2.4 (3)	2.7

during Day 1 testing. Latencies to V-V tended to increase across test sessions.

Evidence for transfer of the oddity discrimination for Bird 127 was less clear than for the remaining birds. Novel nonmatching latencies on Day 1 transfer ranged from 0.6 sec to the maximum 4.6 sec. A distinct learning trend was observed for the novel nonmatching hue-pairs R-Y, R-V, G-V, B-Y, and Y-G. Surprisingly, the majority of long nonmatching latencies occurred on trials on which the novel hue appeared as the comparison stimulus. Bird 127 transferred performance on matching trials to novel Y and novel V hues almost without decrement on Day 1 transfer. Inexplicably, latencies to Y-Y and V-V on subsequent test sessions were consistently shorter than Day 1 latencies. Transfer of oddity performance for Bird 127 is doubtful.

DISCUSSION

Berryman, Cumming, Cohen, and Johnson (1965) reported that pigeons trained on a simultaneous oddity-from-sample task did not transfer their performances to novel stimulus hues. Berryman *et al.,* concluded that the pigeons were learning only which comparison hues were "correct" (*i.e.,* which were S^D) without learning which comparison hues were "incorrect" (*i.e.,* which were S^Δ). Stated in another way, pigeons learned positive instances of the oddity concept but failed to learn negative instances. The present experiment supports this interpretation. Pigeons in an oddity-from-sample experiment will show transfer of performance to novel stimuli if they are explicitly trained to discriminate nonmatching hues (positive instances) from matching hues (negative instances). The symmetry of the present results from the oddity problem with previous results from the complementary problem, matching-to-sample (Urcuioli and Nevin, 1975), demonstrates the generality of this finding.

Using a modified matching-to-sample task, Urcuioli and Nevin (1975) reported complete transfer of matching latencies to novel hue-pairs but incomplete transfer of nonmatching latencies to novel hue-pairs. The reverse was found in the present experiment: transfer of nonmatching latencies was complete but transfer of matching latencies was incomplete. This asymmetry in transfer performances on the matching and oddity problems is, on closer inspection, only apparent. In both experiments, complete transfer was observed for performances on novel S^D trials (*i.e.,* trials on which a response to the initially lighted comparison hue was reinforced). On the other hand, incomplete transfer was observed in both experiments for performances on novel S^Δ trials (*i.e.,* trials on which the pigeon had to refrain from pecking the initially lighted comparison hue in order to produce the S^D or "correct" hue on the remaining side key). The inferior performance on novel S^Δ trials might possibly be due to the poor ability of the pigeon to withhold responses to lighted keys, a widely recognized phenomenon.

Finally, it is important to note that an explanation of these transfer results by reference to "coding" (Berryman *et al.,* 1965; Wright and Cumming, 1971) is insufficient to account for the observed data. Assume, for instance, that the novel yellow hue used during transfer tests was, in fact, not a novel stimulus to the pigeon but, rather, was equivalent to the familiar red training hue. Assume also that the novel violet hue was "coded" as the familiar blue training hue. These assumptions imply that the supposedly novel R-Y and Y-R hue pairs were both functionally equivalent to the familiar R-R hue pair. Similarly, the supposedly novel B-V and V-B hue pairs would both be functionally equivalent to the familiar B-B hue pair. Latencies to these four "novel" hue pairs should thus be long, since the matching R-R and B-B combinations were occasions for long latencies. To the contrary, however, the observed latencies to these four hue pairs were consistently short (excluding the data for Bird 127), thus ruling out the interpretation that yellow was "coded" as red and that violet was "coded" as blue. Other coding interpretations (for instance, that yellow was "coded" as green, and violet was "coded" as red) encounter similar difficulties in handling the observed data. The transfer data are apparently best explained in terms of stimulus control by hue oddity.

In summary, the present experiment demonstrates that if pigeons in an oddity-from-sample experiment are given explicit training not to peck matching (incorrect) hues, as well as to peck nonmatching (correct) hues, then they will show transfer of performance to novel stimulus hues. The present results, together with previous findings (Urcuioli and Nevin, 1975), suggest that stimulus control by the oddity and the matching relations can be obtained by explicitly training pigeons to discriminate matching from nonmatching stimulus pairs.

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