"Same/different" symbol use by pigeons

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Pigeons learned to respond at one spatial position when a pair of stimuli matched and at a different spatial position when they mismatched. All birds were then transferred to novel stimuli on an orthogonal dimension. For the positive-transfer group, the correct positions for matching and mismatching stimuli remained as they were during training. For the negative-transfer group, the correct positions were reversed. In Experiment 1, the birds were trained with shape stimuli and transferred to hue stimuli. Significant group differences were found, in spite of considerable stimulus-specific learning. In Experiment 2, when the same birds (counterbalanced for Experiment 1 transfer group) were transferred to steady-intermittent stimuli, even larger group differences were found. The data indicate that pigeons have some capacity for representing the concepts "same" and "different" with arbitrary stimuli (i.e., symbols). The data further suggest that distinctions that have been made between matching/odddity transfer tasks and same/different tasks may be procedural rather than conceptual.

A fundamental characteristic of human language is the ability to use arbitrary symbols (i.e., words) to indicate class membership or concepts. Premack (1971, 1976) has clearly demonstrated that chimpanzees can learn to use arbitrary symbols to represent the relational rules or concepts "same" and "different." In Premack's procedure, a chimpanzee is trained to place a token representing "same" between pairs of objects that are alike (e.g., A-A) and another token representing "different" between pairs of objects that are unlike (e.g., A-B). Having learned this task, chimpanzees are capable of appropriately choosing between the tokens when novel pairs of objects (e.g., C-C and C-D) are presented.

Premack has presented these and other data to argue for the ability of chimpanzees to learn a rudimentary form of abstract language. According to Premack (1976, p. 133), the "same/different" concept was "not singled out arbitrarily, but is demonstrably representative of the kind of predicate a species must be able to acquire in order to acquire language."

Whether or not "same/different" concept performance is an important precursor of language acquisition or linguistic competence, it is clearly indicative of a cognitive capacity not typically attributed to nonhumans. Yet, not only chimpanzees, but pigeons, too, can show a significant degree of "same/different" concept transfer (see Zentall, Edwards, &

Hogan, in press, for a review). Much of the pigeon research has used a procedure that involved matching to sample and oddity from sample to train the rules "same" and "different," respectively (see, e.g., Zentall & Hogan, 1976). For both matching and oddity tasks, pecks to a sample stimulus resulted in presentation of two comparison stimuli: One had the same stimulus value as the sample, and the other was different from the sample. In the matching-to-sample task, responses to the comparison that was the same as the sample were reinforced, whereas in the oddity-from-sample task, responses to the comparison that was different from the sample were reinforced.

Zentall and Hogan (1974, 1978) first trained pigeons on either a matching-to-sample or an oddity-from-sample task. When novel stimuli were substituted for the training stimuli, pigeons for which the task remained the same (matching to matching, or oddity to oddity) transferred to the new stimuli at a higher level of performance and acquired the transfer task at a faster rate than did pigeons for which the task was changed (matching to oddity, or oddity to matching).

Similar results were found under conditions more similar to those used by Premack (1976). Zentall and Hogan (1975) trained pigeons to respond to a single response key, either half of which key could be independently illuminated. For half of the birds, responses to the key were reinforced when the two halves matched, whereas responses were nonreinforced when the two halves mismatched (for the remaining birds, the reinforcement contingencies were reversed). New stimuli were then substituted for the training stimuli, and again, birds for which the task remained the same performed at a higher level than did those for which the task was reversed. Thus,

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the data suggest that pigeons have some capacity to acquire the "same/different" concept.

Recently, however, Premack (1983a, 1983b) has argued that procedural differences between the "same/different" task and the matching-to-sample task produce important conceptual differences in what is learned. According to Premack, although monkeys and even pigeons can show generalized matching-to-sample performance, only language-trained chimpanzees (and humans) readily can learn "same/different."

What follows is an attempt to identify the major procedural differences between the two tasks.

First, with Premack's (1976) "same/different" task, the tokens with which the animal was trained remained present when the novel transfer stimuli were presented. If one defines a symbol as an arbitrary stimulus that represents a class of conceptually related stimuli, then the tokens that Premack used became symbols for the concepts "same" and "different." In Zentall and Hogan's (1974, 1976, 1978) experiments, no such symbols were present. On test trials, no familiar stimuli to which the pigeon had already learned to peck differentially in the presence of matching or mismatching stimuli were present. The use of symbols in Premack's procedure may make his "same/different" task qualitatively different from the matching and oddity tasks used by Zentall and Hogan.

Second, in Premack's (1976) procedure, across training trials, the chimpanzee was required to discriminate between pairs of stimuli that provided instances of "same" (e.g., A-A) and instances of "different" (e.g., A-B). Thus, with Premack's procedure, animals are given explicit training with both the "same" concept and the "different" concept. On the other hand, with a matching-to-sample task (and similarly, with an oddity-from-sample task), pigeons appear to learn very little about the nonmatching alternative; that is, pigeons appear to learn the "same" rule, but they may learn very little about the "different" rule (see Carter & Eckerman, 1975, Cumming & Berryman, 1965, and Zentall, Edwards, Moore, & Hogan, 1981).

This asymmetry in learning "same/different" rules produced by matching- and oddity-task learning appears to reduce the extent to which pigeons use a generalized rule when novel stimuli are presented (Zentall & Hogan, 1978). In that study, pigeons were trained on a matching-to-sample or oddity-from-sample task. For some birds, training included "negative-instance" trials, that is, trials for which there were no correct comparisons. In the matching task, a negative-instance trial involved, for example, presentation of a red sample and two incorrect green comparisons. Pigeons were required to withhold responding to these negative-instance displays. When transferred to novel stimuli, pigeons whose training in-

cluded negative-instance trials exhibited more concept transfer than did pigeons whose training did not include negative-instance trials. Negative-instance training appears to have encouraged the birds to learn both the "same" and "different" relations.

One additional feature of Premack's (1976) procedure that differed from Zentall and Hogan's (1974) procedure concerns the extent to which symbols were differentiated prior to "same/different" training. Premack (1978, p. 434) indicated that chimpanzees must first be taught to use tokens as names for objects or actions before the symbols can be used successfully to represent "same" or "different." The importance of this manipulation is not entirely clear. However, the manipulation is reminiscent of the acquired-distinctiveness-of-cues effect obtained with children, in which abstract nonsense figures are more easily discriminated if the figures are first associated with a different verbal response (see, e.g., Reese, 1972). Perhaps more relevant are related findings obtained with pigeons. Brodigan and Peterson (1976) reported that when pigeons were trained on a delayed two-choice conditional discrimination, those birds for which different outcomes (food or water) were correlated with each conditional-cue/correct-choice component of the task showed enhanced discriminative performance relative to birds for which there were no correlations between the conditional cues and the two available reinforcers (see also Edwards, Jagielo, Zentall, & Hogan, 1982). Pairing each conditional cue with a different outcome appears to enhance the discriminability of the cues, and this factor may underlie the symbol differentiation that, according to Premack (1976), is a necessary component of "same/different" symbol-use training.

The purpose of the present experiments was to determine whether pigeons have any capacity for symbolically representing the concepts "same" and "different." In the procedure used in the present experiments, pigeons were required to peck one response key (e.g., to the right of the stimulus display) when a pair of stimuli presented on display keys matched and to peck the other response key (e.g., to the left of the display) when the display stimuli mismatched. Following training, the birds were divided into positive- and negative-transfer conditions and were transferred to novel stimulus displays. For the positive-transfer group, the choice positions (and stimuli) that represented "same" and "different" were the same as those used in training. For the negative-transfer condition, the meaning of positions (and stimuli) that represented "same" and "different" were reversed (i.e., if "same" was defined as the right key during training, it was defined as the left key during transfer). Thus, in the present experiments, the response keys were logically analogous to the "same" and "different" tokens used by Premack (1976). To further differentiate "same" and "dif-

ferent" response keys, correct responses to one key were reinforced with one outcome, and correct responses to the other response key were reinforced with a different outcome.

EXPERIMENT 1

Method

Subjects

Twelve experimentally naive female White Carneaux pigeons, each approximately 1 year old, were deprived of food until they had reached 75%-80% of their free-feeding weights. They were maintained at this weight throughout the experiment. Free access to water and grit was provided.

Apparatus

The apparatus was an operant chamber that measured 30 cm wide, 35 cm high, and 35 cm across the stimulus panel. On the stimulus panel were two contiguous, centrally located, rectangular (3.2 × 2.5 cm) pecking keys (display keys), on which various stimulus hues or shapes could be rear-projected. The stimuli used in Experiment 1 were *plus* and *circle* (annulus) shapes (line drawn, white on a black background) and red and green hues (Kodak Wratten filters No. 26 and No. 60, respectively). On either side of the central display keys was a round (2.5-cm-diam) pecking key that recorded "same" or "different" responses. A locally manufactured U-shaped harness was mounted behind the intelligence panel. The harness supported two solenoid-operated grain feeders that could be independently raised to a common 5.8 × 5.0 cm reinforcement access hole.

Procedure

Pretraining. The pigeons were first trained to eat from the food tray when it was raised. They were then trained to peck each of the four singly lit pecking keys for 2-sec access to peas following some pecks and to wheat following others.

Training. "Same/different" training consisted of presentation of two shape stimuli, a *plus* or a *circle*, which could be independently projected onto either display key. For half of the pigeons, when the two stimuli matched (circle-circle or plus-plus), a peck to the left response key (which had vertical stripes projected onto it) was reinforced with 2-sec access to peas; when the two stimuli mismatched (plus-circle), a peck to the right response key (which had horizontal stripes projected onto it) was reinforced with 2-sec access to wheat. For the remaining pigeons, correct matching responses were to the right response key and correct mismatching responses were to the left response key. The response keys could thus be differentiated by any of three redundant cues: location (left or right), projected-stripe orientation (vertical or horizontal), and reinforcer for a correct response (peas or wheat). The redundancy was included to facilitate learning by maximally differentiating the response alternatives.

Pilot data that we had collected indicated that a "same/different" task involving the four stimulus configurations plus-plus, plus-circle, circle-circle, and circle-plus was extremely difficult for pigeons to learn. When one of the "different" configurations was removed, however, learning was quite rapid. For this reason, it was decided to omit circle-plus configuration trials and to double the number of plus-circle configuration trials. Thus, there was an equal number of "same" and "different" trials.

To ensure that the birds observed both display stimuli on each trial, we presented the left display stimulus and required 10 pecks to it, then presented the right display stimulus (the left stimulus remained on) and required 5 pecks to it, and then illuminated the circular response keys.

Throughout the experiment, a correction procedure was in effect. Correct (reinforced) side-key responses were followed by a 5-sec intertrial interval and then presentation of the next trial. In-

correct (nonreinforced) side-key responses were followed by a 5-sec intertrial interval, and then the previous trial was repeated. To compute performance level, trials were counted as correct only if a correct response was made on the first presentation of a trial. Each training session consisted of 48 trials (24 "same" trials and 24 "different" trials). The training phase consisted of 46 sessions.

Transfer. For the transfer sessions, the shape stimuli were replaced by red and green hue stimuli that either matched or mismatched. Half of the pigeons from each of the training groups were then assigned randomly to one of two transfer groups: (1) positive, for which the "meanings" of the "same" and "different" keys were as they were during training and (2) negative, for which the "meanings" of the "same" and "different" keys were reversed. For both groups, the response-key stimuli (vertical or horizontal) and outcomes (peas or wheat) were as they were during training. Thus, for the negative group, for example, if in the presence of matching display stimuli responses to vertical stripes on the left response key had been reinforced with peas during training, then during transfer sessions, in the presence of matching display stimuli, responses to horizontal stripes on the right were reinforced with wheat.

Aside from these changes, transfer sessions were the same as training sessions. Transfer sessions each consisted of 12 trials with red-red configuration, 12 trials with green-green configuration, and 24 trials with green-red configuration. The red-green configuration was not included in the transfer displays. The transfer phase consisted of 18 sessions.

Test. During the test phase, trials with the red-green configuration were interspersed with trials that involved the three transfer configurations (red-red, green-green, and green-red). The purpose of this test was to determine the extent to which specific associations were learned during transfer sessions. If the pigeons learned independent associations to the configurations, one would expect performance on the novel configuration to be at chance (50% correct). If, on the other hand, the pigeons learned a biconditional rule (e.g., if the first stimulus is red, then respond to the left; if the second stimulus is green, then respond to the left; if the first stimulus is green and if the second stimulus is red, then respond to the right), then one would expect performance on the novel configuration to be below chance. Finally, if *only* the relational ("same/different") properties of the stimulus displays (and not the absolute properties of the displays) controlled responding, then one would expect performance on the novel configuration to be above chance.

On test sessions, each of the four hue configurations was equally represented (12 trials each). In all other respects, test sessions were the same as transfer sessions. The test phase consisted of 18 sessions.

Results

Training

The three shape configurations were learned at about the same rate. Mean performance pooled over the last five training sessions was 87.8% correct.

Transfer

Performance differences between the positive- and negative-transfer groups on the first transfer session were small (mean_{pos} = 59.4% correct; mean_{neg} = 55.9% correct). On the second transfer session, however, the negative-transfer group showed a slight decline in performance level, whereas the positive-transfer group showed an increase in performance level (mean_{pos} = 68.4% correct; mean_{neg} = 53.8% correct). When the data were pooled over the first

Figure 1. Acquisition of the hue transfer task for the positive group (positions of "same" and "different" were consistent with those during training) and the negative group (positions of "same" and "different" were inconsistent with those during training).

two transfer sessions, they indicated that there was a significant difference in performance between the positive- and negative-transfer groups [$F(1,10) = 6.57$, $p < .05$]. Data from the first 10 transfer sessions are presented in Figure 1.

Mean performance pooled over the last five transfer sessions was 93.0% correct.

Test

On the first test session, mean performance on trials with novel red-green configuration was 31.9% correct. The introduction of the novel configuration did not have a detrimental effect on performance on trials with green-red configuration (99.3% correct); however, it did produce a large drop in the performance on trials with red-red and green-green configurations (58.3% correct and 61.8% correct, respectively). Apparently, to some extent, the pigeons had learned the transfer task by learning to respond "same" whenever red was on the left or green was on the right. Since the novel configuration involved both red on the left and green on the right, performance was well below chance.

On the other hand, it is clear that the pigeons were not dependent on this "strategy" (i.e., if red on the left or green on the right, respond "same"), because acquisition of the novel stimulus configuration was relatively rapid. By the second test session, performance on the novel red-green configuration was at 43.1% correct, by the fourth test session, it was at 66.7% correct, and by the sixth test session, it was at 75.7% correct. There was also a rapid improvement in performance on trials with red-red and green-green configurations. By the second test session, performance on trials with red-red and green-green

configurations was 73.6% correct and 64.6% correct, respectively, and by the fourth test session, performance was at 82.6% correct and 79.2% correct, respectively.

Discussion

The transfer data indicate that pigeons show significant transfer of the "same/different" concept under conditions analogous to those used by Premack (1976) in his language-training research with chimpanzees. The failure to find a significant difference in performance on the first transfer session is not atypical of concept-transfer research in which pigeons are transferred to novel stimuli that involve orthogonal dimensions (Zentall & Hogan, 1975, Experiment 2; Zentall & Hogan, 1976). When transfer stimuli are familiar, greater initial transfer effects have been found (Zentall, Edwards, Moore, & Hogan, 1981; Zentall & Hogan, 1978). The fact that the concepts "same" and "different" were each symbolically represented by a stimulus compound (involving distinctive spatial, visual, and outcome cues) does not appear to have reduced the magnitude of concept transfer found, when compared with that reported in earlier research that involved a matching-to-sample/odddity-from-sample procedure and the same training and transfer stimuli (Zentall & Hogan, 1976). Furthermore, the fact that only three of the four possible training and transfer configurations were used in the present study did not appear to affect the magnitude of the concept-transfer effect, as compared with the magnitude of transfer effects with the matching/odddity procedure.

The test data indicated, however, that considerable stimulus-specific learning also occurred during task acquisition. Not only was performance on trials involving the novel configuration well below chance, as suggested by the biconditional-rule hypothesis, but performance on trials involving both of the "same" configurations was disrupted as well. The fact that performance on trials involving the "different" configuration remained undisrupted indicates that the disruptive effect of novel-configuration trials was not a general (e.g., emotional) effect resulting from configurational novelty, but, rather, it reflects something about the specific associations learned during transfer-task acquisition. The data suggest that the pigeons learned the transfer task in terms of those elements in each configuration that provided relevant information. For example, in the red-red configuration, the red on the left provided no relevant information because the green-red configuration also involved this cue. Similarly, in the green-green configuration, the green on the right provided no relevant information because the green-red configuration also involved this cue. The task could be solved by pecking the "same" key whenever red appeared

on the left *or* green appeared on the right. Thus, when the novel red-green configuration was introduced, performance was low because it involved both red on the left *and* green on the right. When this strategy did not work with the novel configuration, the birds abandoned the "or" rule and started to respond to the "same" configurations as if they were "different" configurations. Apparently, the effects of extinction for "same" responses on trials with red-green configuration generalized to the previously well-learned trials with red-red and green-green configurations.

Although the test data indicate that, to a large extent, original learning involved stimulus-specific associations, if this were all that the birds had learned, no differential transfer should have occurred. Thus, the results of Experiment 1 suggest that significant transfer of the "same/different" concept can be found in spite of the occurrence of considerable stimulus-specific learning.

EXPERIMENT 2

The purpose of the second experiment was to replicate the concept-transfer effect found in the first experiment under conditions expected to amplify the effect.

Zentall, Edwards, Moore, and Hogan (1981) argued that transfer tests that involve novel stimuli may mask the extent to which transfer effects are demonstrated because pigeons tend to avoid pecking novel stimuli. It was felt that because birds that had already served as subjects in the present study had already been transferred to one set of novel stimuli, they might thus show less avoidance of the novel stimuli in Experiment 2 than would experimentally naive birds. It was also felt that the chances of observing significant transfer might be increased if the birds were exposed to additional exemplars of the "same/different" concept. This was accomplished by adding a blue stimulus to the stimulus projectors and presenting the birds with three new color configurations (blue-blue, red-blue, and blue-green). This procedure allowed us not only to increase the number of exemplars of the concept, but also to equate the number of "same" and "different" configurations without including any "mirror-image" different configurations.

The transfer stimuli selected for Experiment 2 were intermittent and steady white (incandescent) lights.

Method

Subjects and Apparatus

The subjects and the apparatus were the same as in Experiment 1. A blue hue (Kodak Wratten filter No. 38A) was added to each of the display stimulus projectors.

Procedure

Training. Experiment 2 began about 4 weeks after the termina-

tion of Experiment 1. All pigeons were exposed to "same/different" training involving equal numbers of the following stimulus configurations: red-red, green-green, blue-blue, green-red, red-blue, and blue-green. Thus, each color appeared equally often in each position. The task for each bird ("same" on the left, "different" on the right, or "different" on the left, "same" on the right) was the same as it had been during the transfer sessions of Experiment 1. Training consisted of 22 sessions.

Transfer. Again the birds were divided into two groups: those for which the "meanings" of the response keys were consistent with training (positive) and those for which the "meanings" of the response keys were inconsistent with training (negative). Each of the groups also contained an equal number of birds from the two original training groups from Experiment 1. For the transfer sessions, the color stimuli were replaced by white (incandescent) lights that either flashed on and off at the rate of 5 Hz (intermittent) or remained on continuously (steady) during a trial. The intermittent (i) and steady (s) stimulus configurations that were presented during transfer sessions were i-i, s-s, and i-s. As in Experiment 1, an equal number of "same" and "different" stimuli were presented during each session. The transfer phase consisted of 14 sessions.

Test. During the test phase, s-i configurations were interspersed among trials that involved the three transfer configurations. Each of the configurations was represented 12 times in each of the 20 test sessions.

Results and Discussion

Training

Performance on the training sessions of Experiment 2 actually represented a delayed test of transfer to the novel stimulus configurations blue-blue, red-blue, and blue-green. It also provided a relative test of the effects of the new configurations on performance with old configurations. Performance on red-red and green-red control trials remained at a relatively high level (82.2% correct and 86.4% correct, respectively). Performance on green-green control trials, however, was considerably lower (57.3% correct). The decline in performance on green-green trials appears to have been caused by considerable generalization between the green and blue stimuli. Performance on blue-blue trials (55.2% correct) was comparable to performance on green-green trials, and performance on blue-green trials was also quite low (37.5% correct). Finally, performance on the trials with red-blue configuration was surprisingly low (42.7% correct). The low performance on these trials was probably due to a combination of (1) blue-green stimulus generalization (red-blue trials were initially treated as red-green trials), and (2) the facts that the pigeons performed poorly on trials with red-green configuration when such trials were first presented during the test phase of Experiment 1 and that they were not as well learned as the other configurations that involved red or green stimuli.

Overall, the pigeons showed very poor transfer to the configurations involving the new blue stimulus. Not only did the pigeons tend to treat the novel blue stimulus as a green stimulus, which resulted in poor performance on blue-green and red-blue configuration trials, but also the low rate of reinforcement on

these trials appears to have had a generalized disruptive effect on the performance of blue-blue and green-green trials.

Transfer

Performance differences between the positive- and negative-transfer groups on the first transfer session were larger than those found in Experiment 1 ($\text{mean}_{\text{pos}} = 57.3\%$ correct; $\text{mean}_{\text{neg}} = 48.9\%$ correct), but the differences were still not significant [$F(1,10) = 2.11$]. Larger first-session transfer differences might have been obtained if the pigeons had been preexposed to the transfer stimuli (see Zentall & Hogan, 1978).

As in Experiment 1, much larger performance differences were found on the second transfer session ($\text{mean}_{\text{pos}} = 65.6\%$ correct; $\text{mean}_{\text{neg}} = 43.1\%$ correct). A significant difference in performance was again found between the positive- and negative-transfer groups when the data were pooled over the first two transfer sessions [$F(1,10) = 11.26$, $p < .01$]. In Experiment 2, the group difference persisted when the data were pooled over as many as the first 10 transfer sessions [$F(1,10) = 7.24$, $p < .025$].

An analysis was also performed on the number of sessions required until a criterion of 80% correct had been achieved. Two birds (one from each group) showed little evidence of learning the transfer task and therefore were dropped from this analysis. A Mann-Whitney U test indicated that the positive-transfer group took significantly fewer sessions ($\text{mean}_{\text{pos}} = 4.8$) to reach the 80% criterion than did the negative-transfer group ($\text{mean}_{\text{neg}} = 8.2$) [$U(5,5) = 3$, $p < .05$]. Thus, reliable concept-transfer effects were also found in Experiment 2. Data from the first 11 transfer sessions are presented in Figure 2.

Mean performance pooled over the last two transfer sessions was 83.0% correct.

Test

On the first test session, mean performance on trials with on novel s-i configuration was 28.5% correct. Performance on trials with i-i and i-s configurations was relatively unaffected by the introduction of the novel trials (74.3% correct and 88.9% correct, respectively), but performance on trials with s-s configuration was substantially disrupted (43.1% correct). Apparently, the pigeons had learned the transfer task primarily by learning to respond "same" whenever s was on the left or i was on the right. Since the novel configuration involved both s on the left and i on the right, performance was well below chance. Again, the effects of extinction for such "same" responses appeared to have generalized back to trials with s-s configuration and to some extent to trials with i-i configuration as well. Again, acquisition of the novel stimulus configuration was relatively rapid. By the second test session, performance on the novel s-i configuration was 41.7% correct, by the fourth test session, it was at 54.2% correct, and

Figure 2. Acquisition of steady-intermittent transfer task for the positive group and the negative group.

by the sixth test session, it was at 67.4% correct. Performance on trials with s-s configuration recovered rapidly as well. By the fourth test session, performance on trials with s-s configuration was at 70.1% correct.

Again, in Experiment 2, performance was primarily under the control of stimulus-specific associations; however, as in Experiment 1, significant concept learning was found as well.

GENERAL DISCUSSION

The two experiments presented here provide evidence that pigeons can show reliable amounts of concept transfer under conditions analogous to those described by Premack (1976) as being able to qualitatively distinguish humans and language-trained chimpanzees from other animals. Pigeons appear capable of using the symbols "same" and "different" to categorize new exemplars of the concepts in a manner qualitatively, if not quantitatively, similar to that of language-trained chimpanzees. Although the relation between the "same/different" concept and language use is not clear (see Terrace, 1979), it appears that the matching/odddity procedure results in conceptual performance by pigeons that is neither qualitatively nor quantitatively different from that which results from the "same/different" procedure. Thus, the present findings argue against Premack's (1983b) assertion that although matching/odddity concept transfer can be demonstrated in a variety of species, among nonhuman species, only language-trained chimpanzees can show "same/different" concept transfer.

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