SHIFT LEARNING IN SAME-DIFFERENT CONDITIONAL DISCRIMINATIONS IN RATS

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The present experiment examined the question of whether or not rats formed equivalence classes (or concepts) of same-different and transferred them to subsequent shift problems using a shift-nonshift paradigm. Rats were trained to criterion on 12 same-different tasks (6 same and 6 different tasks) and then given either shift or nonshift learning with 12 novel same-different tasks. Group Nonshift acquired their shift learning faster than Group Shift. Group Nonshift exhibited more saving values in learning than did Group Shift. These findings indicated that rats formed equivalence classes (or concepts) of same-different in Phase 1 training and transferred them to subsequent novel same-different discriminations in Phase 2.

Zentall (1998) has asserted that symbols are not simply associated with the same response as the objects that they represent, but untrained emergent relations appear to develop between the symbol and the object itself. Such emergent relations can also be demonstrated in learning tasks with simpler organisms (e.g., rats and pigeons). For example, when two unrelated stimuli are each associated with a common event, these stimuli may also be treated similarly in other contexts (p. 363). Such functional equivalence classes formation (i.e., untrained emergent relations) between stimuli are demonstrated in both rats and pigeons in either two concurrent discrimination learning tasks using a whole-reversal and partial-reversal paradigm (Delius, Ameling, Lea, & Staddon, 1995; Dube, Callahan, & McIlvane, 1993; Nakagawa, 1978, 1986, 1992a, 1998, 1999a, 1999c, 1999d, 2000b, 2001a) or matching- (or nonmatching)-to-sample discrimination learning tasks using either a shift-nonshift paradigm or the whole-reversal and partial-reversal paradigm (Aggleton, 1985; Edwards, Jagielo, Zentall, & Hogan, 1982; Kaiser, Sherburne, Steirm, & Zentall, 1997; Mumby, Pinel, & Wood, 1990; Nakagawa, 1992b, 1993a, 1993b, 1999b, 2000a, 2000c, 2001b, 2001c, 2002a, 2002b).

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There are also many studies on untrained emergent relations (i.e., stimulus class formation) in same-different discriminations using a transfer design in pigeons (Astley & Wasserman, 1998, 1999; Cook, Cavoto, & Cavoto, 1995, 1996; Cook, Katz, & Cavoto, 1997; Cook & Wixed, 1997; Edwards, Jagielo, & Zentall, 1983; Fetterman, 1991; Santiago & Wright, 1984; Wasserman, Hugart, & Kirkpatrik-Steger, 1995; Wright, Santiago, & Sands, 1984; Wright, Santiago, Sands, Kendrick, & Cook, 1985; Wright, Santiago, Urcuioli, & Sands, 1983; Young & Wasserman, 1997; Young, Wasserman, & Garner, 1997).

Much of the previous research on same-different categorization in animals has involved the classification of just two visual items as same or different (e.g., Edwards et al., 1983; Santiago & Wright, 1984; Wright et al., 1983). Two items are the minimum necessary for a same-different classification. Recently, many researchers, however, reported that pigeons could make same-different judgment with displays involving more than two items and more complex stimulus contexts (e.g., Astley & Wasserman, 1998, 1999; Cook et al., 1995, 1996, 1997; Cook & Wixed, 1997; Wasserman et al., 1995; Young et al., 1997).

There are few studies that suggest rats have the ability to classify just two visual items as same or different using a shift paradigm (e.g., Experiment 3 in Nakagawa, 1993b, Experiment 2 in Nakagawa, 2000c). Nakagawa (2000c) recently reported an experiment in which rats were taught to classify displays involving two items that were either the same as each other or different from each other. In his experiment, rats were trained for 12 trials a day with many same-different visual discrimination tasks (i.e., 8 or 16 stimulus tasks) with an automatic T maze (see Figure 4 in 2000c), in which they were given a same problem with two identical items on six trials and a different problem with two nonidentical items on the other six trials in a random order within each session to criterion, and then they were shifted to novel same-different tasks. The same-different discrimination was relatively rapidly acquired and promoted strong transfer to novel tasks; the discriminative performance on trained tasks averaged 91% correct after approximately 312 trials in Phase 1 and 88% correct on the first trial on transfer test using new tasks. This result was consistent with findings of Experiment 3 in Nakagawa (1993b). Thus, these findings of Nakagawa (1993b, 2000c) produced converging lines of evidence suggesting that rats had an ability to classify just two visual discriminative items as same or different.
Nakagawa (2002c) found that rats mastered their reversal more rapidly when all 12 tasks were reversed than when only half of the tasks (i.e., 6 of the 12 tasks) were reversed in same-different discriminations. This finding of Nakagawa (2002c) makes it clear that rats form associations between stimuli with the same response assignment, and that they establish classes or concepts for functionally equivalent yet perceptually dissimilar stimuli on reaching a criterion in same-different discriminations.

Nakagawa (2002c) asserted that in same-different discriminations, rats associated a configuration of stimuli with lever-pressing responses, and then formed associations between the configurations with the same response assignment. For example, rats learned to associate one configuration of stimuli (i.e., identical stimuli: AA, BB, CC, EE, and FF) with pressing the right lever followed by a reward, and the other configuration (i.e., nonidentical stimuli: AB, BC, CD, EF, and FA) with pressing the left lever followed by a reward (each letter referred to a stimulus item). The rats then formed associations between the configurations with the same response assignment, and it was these configuration associations that mediated the transfer of appropriate responding to a subsequent shift problem.

A specific question, however, remains. Does an equivalence class (or concept) of same-different formed in a same-different discrimination learning transfer to subsequent novel same-different discriminations? That is a very important and fundamental issue in behavior analysis in studying stimulus classes formation in animals. These studies on same and different concepts formation in rats mentioned above (Nakagawa, 1993b, 2000c) did, however, not make it clear that rats formed generalizable same-different concepts in same-different discriminations. Thus, the present study was conducted to investigate directly the question of whether or not an equivalence class (or concept) of same-different formed in same-different discriminations transferred to subsequent shift problems using a shift-nonshift paradigm. Rats were trained to criterion on 12 same-different discriminations in Phase 1 training and then trained on 12 new same-different tasks under either a nonshift condition, in which stimuli changed but rules did not change, or a shift condition, in which both stimuli and rules changed. The expectation according to Nakagawa's view (2002c) is that rats in the nonshift condition learn their shift problems more rapidly than do ones in the shift condition, and that rats in the nonshift condition exhibit more saving values in learning than do ones in the shift condition.

Method

Subjects

Twelve experimentally naive male Sprague-Dawley rats were used. They were about 210 days old, with an initial average body weight of 411 g. The animals were handled for 5 min a day for 12 days and were maintained on a daily 2-hr feeding schedule prior to the experiment. The
amount of food in the daily ration was gradually reduced until the body weight of each animal reached 80% of the baseline weight at the start of the experiment. Water was always available for animals in their individual home cages. Animals were maintained on a 3:21-hr light:dark cycle, with lights off at 7:00 p.m.

**Apparatus**

A Skinner box (15 cm high, 22.5 cm wide, and 15 cm long) was used in magazine training and lever-press training; it contained a square display screen with sides of 5 cm, which was 5 cm above the floor, and one lever beside the screen, which was a 5 cm x 3 cm rectangle and 5 cm above the floor. There was a food tray on the opposite side of the lever, into which a milk pellet was delivered from a feeder when animals pressed the lever. An automatic T maze was used (Figure 1; see Experiment 2 in Nakagawa, 1993a, 1999b). The apparatus was lit throughout the experiment by a 10-W fluorescent lamp suspended 40 cm above the top of a choice chamber. The apparatus consisted of a runway (30 cm high, 12 cm wide, and 42 cm long) with a start box (30 cm x 12 cm x 25 cm) and a choice chamber (30 cm x 56 cm x 12 cm). A hurdle (5 cm x 12 cm x 3 cm) was located at the end of the runway to make animals attend to a sample stimulus. The walls of the apparatus were medium-gray Plexiglas and the ceiling was clear Plexiglas. The start box had a food tray in the center of the end wall, into which a milk pellet was delivered from a feeder when animals made a correct response. The choice chamber contained three display screens, each 12 cm square, which were 10 cm above the floor and 5 cm apart from edge to edge. All stimuli were presented on these screens by means of a computer monitor (Sharp Hi-Vision 32C-HD90). The computer monitor was located 9 cm behind the center screen at its center and 10 cm behind the two side screens at their outer edges (the difference being due to the slight convex curvature of the face of the monitor). There were two response levers in the choice chamber, each 4 cm square and 9 cm above the floor. These levers were located below the center of the side screens. A guillotine door opened and closed automatically to control access to the start box. Whenever animals interrupted a photobeam at the exit of the start box, which was located 3 cm from the guillotine door, stimuli were shown automatically behind the Plexiglas screens. The animals were then allowed to approach and press a response lever, whereupon they had to return to the start box. As they approached they interrupted a photoelectric gate located 5 cm from the end wall in the start box, and the guillotine door closed automatically behind the animals. After 10 sec the guillotine door opened automatically for the start of the next trial. The programming of events and data collection were carried out on line using a laboratory computer. Sound masking was provided by white noise from a blower fan (50 db).
Figure 1. Diagram of the T maze used in this experiment (Units = centimeter). (CC = choice chamber; CS = center screen; FT = food tray; GD = Guillotine door; H = hurdle; L = lever; PB = photobeam; PG = photoelectric gate; RW = runway; SB = start box; SS = side screen).

**Stimuli**

*Training stimuli.* The stimulus was shown behind the side Plexiglas screens and medium-gray stimuli were shown behind the center Plexiglas screen by means of the computer monitor. The stimuli disappeared when
animals pressed a response lever. Six stimuli were used: a circle (with an area of 21.0 cm$^2$), a triangle (with an area of 21.5 cm$^2$), an isosceles trapezium (with an area of 21.0 cm$^2$), a cross ($\oplus$, with an area of 22.0 cm$^2$), a $\blacksquare$ figure (with an area of 21.0 cm$^2$), and a $\Delta$ figure (with an area of 21.0 cm$^2$). A figure was black and ground was white in stimuli. An identical stimulus (i.e., same task) consisted of two same stimuli (i.e., circle-circle, triangle-triangle, trapezium-trapezium, cross-cross, $\blacksquare$-$\blacksquare$, and $\Delta$-$\Delta$). A nonidentical stimulus (i.e., different task) consisted of two different stimuli (i.e., cross-trapezium, trapezium-$\blacksquare$, $\blacksquare$-triangle, cross-circle, circle-triangle, $\Delta$-circle) as illustrated in Table 1 (see also Figure 5 in Nakagawa, 1993a).

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Transfer stimuli. Six stimuli were used: a white stimulus (with an area of 45.0 cm$^2$), a black stimulus (with an area of 45.0 cm$^2$), a diamond figure (with an area of 22.0 cm$^2$), a double-circle figure ($\bigcirc\bigcirc$, with an area of 21.0 cm$^2$), vertical stripes, and horizontal stripes, which had alternating black and white lines, 0.5 cm in width. A same and a different stimulus consists of two out of six stimulus items, as shown in Table 2.
### Table 2

Order of Trials of a Same and a Different Problem and the Random Presentation Sequences of Stimuli Used in Phase 2

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**Procedure**

*Magazine training and shaping of lever press.* All animals received magazine training and lever-press training in the Skinner box for 5 days prior to the beginning of pretraining. In this training stage, animals were trained to press the lever and return to the food tray on the opposite side wall of the lever to obtain a milk pellet which was delivered from a feeder in the Skinner box. On the last day all animals pressed the lever at least 50 times for 10 min a day.

*Pretraining.* After completing both magazine training and lever-press shaping, animals were given pretraining for 8 days prior to the beginning of the training phase until they pressed the lever at least 15 times per day on each side in the automatic T-maze. Animals were given training to press the right side lever 15 times on an odd pretraining day and to press the left side lever 15 times on an even pretraining day. That is, animals were given training such that, after opening the guillotine door, they ran down the runway, pressed a response lever, and returned to the start box. After completing pretraining, all animals returned to the start box in less...
than 2 sec after pressing a response lever. A medium-gray stimulus was shown behind a Plexiglas screen during shaping and shown behind each of three Plexiglas screens during pretraining.

Training. A trial in this experiment is defined as a response-stimulus sequence beginning when animals start from the start box after opening the guillotine door, run down the runway, press a response lever, and return to the start box.

Phase 1 same-different discrimination training. Animals were initially trained for 12 trials a day with 12 same-different tasks, in which they were given a same task with two identical items on six trials and a different task with two nonidentical items on the other six trials in a random order within each session. Training continued until a criterion had been reached of 10 correct trials out of a possible 12 over 2 successive days. A noncorrection training method was used. The stimuli disappeared when animals pressed an incorrect lever, they were, however, allowed to return to a correct response lever and press it, and they were given a reward. Half of the animals were required to press the right lever on the same task trials (i.e., ○○, ○△, ○□) and to press the left lever on the different task trials (i.e., ○△, ○□). The remaining animals were required to press the left lever on the same task trials and to press the right lever on the different task trials. The order of trials with the two tasks of same and different followed eight predetermined random sequences (see Table 1). The trial sequences in Table 1 were randomized across sessions. Animals were given one 45-mg milk pellet accompanied by a click of feeder when they made a correct response. The programmed intertrial interval was 10 sec.

Phase 2 transfer learning. After completing the original same-different discrimination learning, animals were then divided into two subgroups (nonshift and shift), matched with respect to the number of days to criterion. The animals of Group Nonshift were run under a "nonshift" condition, in which they were trained on 12 new same-different tasks, but the rule learned during the initial learning remained unchanged. The animals of Group Shift were run under a "shift" condition, in which they were trained on 12 new same-different tasks, and the rule learned during the initial learning was changed and reversed. That is, animals trained to press the right lever on same task trials were required to press the left lever on same task trials in shift learning, whereas animals trained to press the left lever on different task trials were required to press the right lever. The order of trials with the two tasks of same and different followed eight predetermined random sequences (see Table 2). Other aspects of the procedure were the same as those in Phase 1 original same-different training.

Results

Phase 1 Training
The mean number of days to reach criterion in Phase 1 of the
experiment was as follows: 64.17 (SD = 8.59) for Group Nonshift and 65.00 (SD = 8.39) for Group Shift. A statistical analysis performed on the number of days to criterion revealed no significant difference in the rate of learning between the two groups, t(10) = 0.15.

![Mean days and SEMs to criterion for each group in the Phase 2 transfer as a function of the subsequent shift learning.](image)

**Figure 2.** Mean days and SEMs to criterion for each group in the Phase 2 transfer as a function of the subsequent shift learning.

**Phase 2 Transfer**

Acquisition of Phase 2 shift by Group Nonshift was compared with acquisition of the corresponding shift learning in Group Shift. These data are illustrated in Figure 2. Group Nonshift significantly mastered their shift problems more rapidly than did Group Shift, t(10) = 3.16, p < .02.

In order to examine formation of equivalence classes of same-different, acquisition rate in Phase 2 was compared with acquisition rate
in Phase 1 in either Group Nonshift or Group Shift. Individual score of days to criterion in Phases 1 and 2 and saving ratio \( Q = 100 \times \frac{\text{Phase 1} - \text{Phase 2}}{\text{Phase 1}} \) are summarized in Table 3. Mean saving ratio was as follows: 90.13 \((SD = 3.61)\) for Group Nonshift and 67.05 \((SD = 5.62)\) for Group Shift. Group Nonshift significantly exhibited more saving values in learning than did Group Shift, \( t(10) = 7.72, p < .01 \).

Table 3

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Learning curves of each animal in Phase 2 shift are illustrated in Figure 3. Figure 3 illustrates mean choice accuracy for each animal in Groups Nonshift and Shift as a function of block 24 trials (i.e., 2 days trials). Inspection of Figure 3 reveals that performance of animals in Group Shift dropped to the chance level (40-60% correct level) in their shift learning for a longer duration than those of animals in Group Nonshift, \( t(10) = 6.00, p < .01 \).

In order to examine the tendency to adopt a position preference during shift learning, a special criterion was devised: If animals chose a particular side (right or left) more than 10 times out of the 12 daily trials, the day was regarded as a positional-response day. The number of these days was counted for each animal, and their means and SDs during shift learning were as follows: 1.67 \((SD = 1.49)\) for Group Nonshift and 10.50 \((SD = 7.65)\) for Group Shift. Group Shift exhibited a significantly stronger position preference than did Group Nonshift, \( t(10) = 2.53, p < .05 \).

In order to examine the effect of the rule established during Phase 1 original training on performance in Phase 2 shift in both Groups Nonshift and Shift, a special criterion was devised: The criterion was that animals attained the 50% or more correct response level (i.e., 6 or more correct times out of a possible 12 trials) over 2 successive days after beginning Phase 2 shift learning. Number of days to reach this criterion was taken as a measure of a rule perseveration. The number of these days was counted for each animal, and their means and SDs during Phase 2 shift were as follows: 0.83 \((SD = 1.21)\) for Group Nonshift and 4.33 \((SD =
Figure 3. The panel shows mean choice accuracy for the 6 individual rats (N1, -, -, and N6) in Group Nonshift and the 6 individual rats (S1, -, -, and S6) in Group Shift in Phase 2 shift as a function of block of 2 days' trials. A last block for each rat N1, N2, N5, S3, S4, and S5 consisted of 1 day.
2.13) for Group Shift. Group Shift exhibited stronger rule perseveration than did Group Nonshift, $t(10) = 3.18, p < .01$.

The rate of the acquisition of the same task was compared with that of the different task in the original same-different discrimination learning. The mean number of days to reach the criterion in each task was as follows: 59.50 ($SD = 9.20$) for the same task and 64.58 ($SD = 7.76$) for the different task. A statistical analysis performed on the number of days to criterion revealed no significant difference in the rate of learning between the two tasks, $p > 0.10$.

**Discussion**

The results of the present experiment indicated that Group Nonshift acquired their subsequent shift learning faster than did Group Shift, and that Group Nonshift exhibited more saving values in learning than Group Shift. Thus, in line with the experimental hypothesis, these results made it clear that rats formed an equivalence class (or concept) of same-different on the basis of the same consequence (e.g., food or no food) in Phase 1 original same-different discrimination learning and transferred them to novel stimuli in Phase 2 subsequent shift learning. The results of the present experiment were consistent with the findings of Nakagawa (Experiment 1 of 2000c) in matching- (or nonmatching)-to-sample discriminations by rats, in which rats mastered the nonshift problems more rapidly than the shift problems in matching- (or nonmatching)-to-sample discriminations. These findings suggest that the mechanism of stimulus classes formation between stimuli in same-different discriminations is the same as that in matching- (or nonmatching)-to-sample discriminations.

Superiority of Group Nonshift to Group Shift in saving values in learning provide stronger evidence that rats form an equivalence class (or concept) of same-different in Phase 1 same-different discrimination learning. This result is in line with the findings of Nakagawa (2002c).

Inferiority of Group Shift to Group Nonshift in the days-to-criterion measure in the shift learning in Phase 2 was caused by both stronger rule perseveration and position preference of Group Shift than those of Group Nonshift. Group Nonshift merely needed to generalize their discriminations to a new set of same-different stimuli to solve the problems in Phase 2, whereas Group Shift had to generalize and reverse the L-R response requirement. That is, animals of Group Shift had to extinguish the rule acquired in Phase 1 training and then acquire a new rule to solve the problems in Phase 2 shift. Thus, animals of Group Shift should take more days to extinguish the old rule and to reacquire a new rule relative to animals of Group Nonshift. This account was supported by data of both stronger rule perseveration and position preference of Group Shift over those of Group Nonshift (see also Figure 3).

An appearance of slight positional responses in Group Nonshift could be due to generalization decrement produced by the introduction of novel
stimuli in Phase 2. By contrast, an appearance of stronger positional responses in Group Shift could be due to both generalization decrement produced by the introduction of novel stimuli in Phase 2 and change of the rule to solve given problems between Phases 1 and 2. That is, since the rule acquired in Phase 1 was changed and reversed in Phase 2 in Group Shift, the animals of this group had to extinguish the rule acquired in Phase 1 to solve the subsequent problems in Phase 2 so that they had lost cues to respond and mainly adopted irrelevant responses such as positional responses in Phase 2.

The rule perseveration in Group Shift was significantly stronger than that in Group Nonshift in Phase 2. This difference could be caused by change of the rule to solve the subsequent problems in Phase 2 in Group Shift. That is, the animals of Group Shift were required to extinguish the rule acquired in Phase 1 and to form a new rule to solve the subsequent problems in Phase 2, whereas the animals of Group Nonshift were not required to extinguish the rule acquired in Phase 1 and then they had only to apply the old rule to solve the subsequent problems in Phase 2.

Nakagawa (2002c) asserted that stimuli or stimulus sets that are associated with the same outcome (e.g., food or no food) would be classed together, despite their perceptual dissimilarity. According to Nakagawa's view, rats formed associations between the discriminative stimuli with the same response assignment during overtraining on two concurrent discriminations, and these associations mediated the transfer of appropriate responding when discriminations were reversed. In the case of matching- (or nonmatching)-to-sample discriminations, rats associated a configuration of stimuli with lever pressing response, and then formed associations between the configurations with the same response assignment. For example, in a matching-to-sample task, rats learned to associate one configuration of stimuli (i.e., AAB and BBA) with pressing the left lever followed by a reward, and the other configuration (i.e., BAA and ABB) with pressing the right lever followed by a reward (the two outer letters refer to the comparison stimuli, and the center letter refers to the sample stimulus). The rats then formed associations between the configurations with the same response assignment, and it was these configuration associations that mediate the transfer of appropriate responding to a subsequent shift problem. In the case of same-different discriminations, rats associate a configuration of stimuli with lever-pressing responses, and then to form associations between the configurations with the same response assignment. For example, in same-different discriminations, rats learned to associate one configuration of stimuli (i.e., identical stimuli: AA, BB, CC, DD, EE, and FF) with pressing the right lever followed by a reward, and the other configurations (i.e., no identical stimuli: AB, BC, CD, DE, EF, and FA) with pressing the left lever followed by a reward (each letter refers to a stimulus item). The rats then formed associations between the configurations with the same response assignment, and it was these configuration associations that mediated the transfer of appropriate responding to a subsequent shift problem.
As a result of these configuration associations, the rule acquired in Phase 1 was changed, and reversed in subsequent shift problems so that animals had to extinguish the rule and then to acquire a new rule to solve the subsequent shift problems in the shift condition. That is, the animals in the shift condition had to dissociate configuration associations established in Phase 1 and then to reform configuration associations to solve the subsequent shift problems in Phase 2. Thus, animals in the shift condition should take many days to extinguish the old rule and to acquire a new rule in the subsequent shift problems. However, the rule established in Phase 1 remained unchanged in the nonshift condition so that animals had only to apply the old rule to solve the subsequent transfer problems. Consequently, Group Nonshift should master their subsequent shift learning faster than Group Shift. These proposals were supported by findings of the present experiment and the findings of Nakagawa (2002c).

Alternatively, there is a possibility that alternative features of stimuli besides the same-different relation could have mediated these observed transfer, such as differences in symmetry (i.e., symmetrical/asymmetrical appearance). However, this alternative account could not explain the significant difference in the rate of shift learning between Groups Nonshift and Shift in this experiment. Because there were no differences in symmetry (i.e., symmetrical/asymmetrical appearance) of stimuli in Phases 1 and 2 in either Group Nonshift or Group Shift. That is, this single invariant visual feature of stimuli remained constant during Phase 1 and 2 in either the nonshift condition or the shift condition. And this alternative account could not explain the findings of Nakagawa (2002c).

In Nakagawa (2002c), rats were trained to criterion on 12 same-different tasks (6 same and 6 different tasks) and then given reversal training on either a whole reversal condition (W), in which all the 12 tasks were reversed, a partial reversal-10-condition (P-10), in which 5 same and 5 different tasks were reversed, a partial reversal-6-condition (P-6), in which 3 same and 3 different tasks were reversed, or a partial reversal-2-condition (P-2), in which 1 same and 1 different task were reversed. Group W reversed faster than the three partial groups. Group P-2 reversed faster than Group P-6, which in turn reversed faster than Group P-10. The single invariant visual feature of stimuli remained constant during Phases 1 and 2 in every reversal condition. Furthermore, this alternative account could not explain positive transfer effect of learning between same-different and matching- (or nonmatching)-to-sample discriminations obtained in Nakagawa (2000c). In Nakagawa (2000c), rats were trained with 12 same-different tasks in Phase 1 and then given matching- (or nonmatching)-to-sample discriminations in Phase 2, and vice versa. Antecedent same-different learning significantly facilitated the subsequent matching- (or nonmatching)-to-sample learning. And so antecedent matching- (or nonmatching)-to-sample learning significantly facilitated the subsequent same-different learning. In this experiment of Nakagawa (2000c), if the rats solved the original same-different problems
based on figure symmetry, antecedent same-different should not facilitate the subsequent matching- (or nonmatching)-to-sample discriminations, because stimuli used in the subsequent matching- (or nonmatching)-to-sample discriminations had no single invariant visual feature (i.e., symmetrical/asymmetrical appearance).

The findings of the present experiment were not readily explained by any account grounded in an increased distinctiveness of same and different relation due to the larger numbers of elements used in the displays and the concurrent use of large numbers of stimulus exemplars during training (Cook et al., 1995; Wasserman et al., 1995). The present experiment involved the classification of just two visual items as same or different. According to an account grounded in increased distinctiveness of the same and different relation, rats should not, for example, form functional equivalence classes. But rats formed functional equivalence classes and transferred them to subsequent stimuli in the present experiment. This fact suggests that rats form functional equivalence classes between stimuli on a basis of same response to the stimuli.

There was no significant difference in the rate of learning between the same tasks and the different ones. This finding was not consistent with Young and Wasserman's model (i.e., entropy model). Young and Wasserman (1997) proposed a new unidimensional alternative (i.e., entropy model) for what pigeons might be processing in multielement same-different choice task. Instead of using an abstract same-different concept, these authors presented evidence suggesting that their pigeons were responding to the perceived entropy in their icon-based same and different displays. Entropy was an information-theoretic concept that measured the amount of variability present among a display's component elements. A display in which all of the elements were identical (i.e., a same display) had an entropy of zero. In contrast, a display in which every single element was different from every other one had the maximal possible entropy for that particular organization. In a series of experiments, Young and Wasserman (1997) systematically varied the number and nature of the elements used to create different types of same-different displays. They found that the amount of variability in these displays as described by entropy correlated quite highly with the presentation of different and same responses made by pigeons. According to Young and Wasserman's proposal, rats should learn the same tasks more rapidly than the different ones. But this result was not observed in the present experiment.

Rats in either Group Nonshift or Group Shift mastered their shift learning more rapidly than their initial learning. These findings can be explained by response strategy or response pattern theory advocated by Mandler (1966, 1968; Mandler & Hooper, 1967) and by Hall (1973a, 1973b, 1974) in discrimination learning. Because the same apparatus was used between Phases 1 and 2, animals could use the same response strategy or response pattern to solve both problems in Phases 1 and 2. Thus, the transfer of response strategy or response pattern
acquired in Phase 1 training may have facilitated nonshift and shift performance in Phase 2 shift.

Taken together with both findings of transfer effect in same-different discriminations (Nakagawa, 2002c) and findings of positive transfer effect of learning between matching- (or nonmatching)-to-sample and same-different discriminations (Nakagawa, 2002c), the findings of the present experiment suggest that the solution of both same-different and matching- (or nonmatching)-to-sample discrimination relies on a common underlying process.

The present experiment provides strong empirical evidence that there is little doubt that rats form an equivalence class (or concept) of same-different in Phase 1 same-different discriminations and transfer them to subsequent new same-different discriminations in Phase 2 and that the mechanism of stimulus classes between stimuli in same-different discriminations is the same as that in matching- (or non-matching)-to-sample discriminations, that is, animals form stimulus classes between stimuli that are associated with the same response in either same-different discriminations or matching- (or nonmatching)-to-sample discriminations.

References


