# Auditory *same/different* concept learning by monkeys

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Two rhesus monkeys learned the auditory abstract concept of *same/different*. They were trained with 38 different environmental and natural sounds, which were arranged in different combinations as training progressed. Upon transfer to 138 different novel stimuli, they performed as well (78.8% correct) on the first exposure to the novel stimuli as they did (77.3%) with their training stimuli. The comparatively large set of training sounds, contact with the sound source, and a special fading procedure are thought to have contributed to the monkeys' being able to learn this concept. Implications for species' similarities/differences in cognitive processing are discussed.

Our ability to abstract general solutions from specific problems influences our ability to reason through problems, to arrive at the proper solutions, and to communicate our thoughts quickly and efficiently. Few would debate that humans are superior to other animals in these skills of abstracting and reasoning. Indeed, debate has centered on whether or not animals have any of this ability to learn such abstract solutions—called abstract concepts—and if so, which animal species do have this ability.

Abstract concepts, also referred to as relational concepts, higher-level/-order concepts, rules, or simply concepts, are to be distinguished from natural concepts (Herrnstein, Loveland, & Cable, 1976; Medin & Schaffer, 1978), class concepts (Bourne, 1970), and property sets (Hayes-Roth & Hayes-Roth, 1977). With abstract concepts, there is a critical relationship among stimuli that determine the concept (e.g., *same/different*, matching-to-sample, oddity-from-sample), and this relationship transcends individual stimuli and individual features. With natural concepts, class concepts, or property sets, the focus is on critical features of individual stimuli (e.g., person, water, or tree; see Herrnstein et al., 1976), and these features determine a category, which is sometimes called a concept.

Considerable research effort and theorizing have been directed toward determining which animal species can or cannot learn abstract concepts, and implications have been drawn regarding phylogenetic differences in cognitive capacity. It has been argued that some classes of species (e.g., avians) do not have sufficient cognitive capacity to learn abstract concepts (D'Amato & Salmon, 1984; D'Amato, Salmon, & Colombo, 1985; Premack, 1978, 1983a, 1983b). On the other hand, others have pointed to a lack of adequate learned skills that prevents some species from learning abstract concepts. For example, it has been suggested that artificial language training promotes abstract concept learning in chimpanzees (Premack, 1978, 1983a, 1983b; Rumbaugh, Savage-Rumbaugh, & Hegel, 1987; Rumbaugh, Savage-Rumbaugh, & Pate, 1988). Finally, there may be a modality specificity with regard to which abstract concepts can be learned. Dolphins, for example, have been shown to learn concepts with auditory but not visual stimuli (Herman, 1980), and monkeys have been shown to learn concepts with visual but not auditory stimuli. We will return to the discussion of the monkey's modality specificity, but first the others will be discussed.

Evidence has accumulated that avians and primates without language training can actually learn abstract concepts (Overman & Doty, 1980; Pepperberg, 1987; Wright, Cook, Rivera, Sands, & Delius, 1988; Wright, Santiago, & Sands, 1984). Furthermore, indications have begun to emerge that dolphins might be able to learn abstract concepts with their alleged nonpreferred visual modality (Forestell & Herman, 1988), and they have been shown, even more recently, to learn visual abstract concepts as easily as they did auditory ones (Herman, Hovancik, Gory, & Bradshaw, 1989). Similarly, indications have emerged that monkeys may be able to learn abstract concepts with their alleged nonpreferred auditory modality (D'Amato & Colombo, 1985; Shyan, Wright, Cook, & Jitsumori, 1987), despite earlier difficulties in auditory discrimination learning and auditory concept learning (see Cowey, 1986; D'Amato, 1973; D'Amato & Salmon, 1982; Dewson & Cowey, 1969; Dewson, Wertheim, & Lynch, 1968; Thompson, 1980, 1981; Wegener, 1964).

The purpose of the present experiment was to extend the findings of Shyan et al. (1987), who showed, through

successive reacquisitions with different sequences of training stimuli and sequences containing novel stimuli, that one monkey could accurately perform an auditory *same/different* task. In the research presented in this article, a second monkey was also trained in the auditory *same/different* task, and transfer results are presented for both subjects showing, for the first time, that monkeys can learn an abstract concept with auditory stimuli. These results demonstrate that the monkeys had learned the *same/different* abstract concept by good first-trial performance with novel stimuli.

## METHOD

### Subjects

The 2 subjects, BW and FD, (*Macaca mulatta*) were 4 and 7 years old, respectively, at the beginning of the experiment. One monkey, BW, had more than 24,000 trials of prior training in earlier and unsuccessful attempts to train the auditory *same/different* task, including visual–auditory compound-stimulus training followed by fading of the visual component. BW also had 1,500 trials of an unsuccessful attempt to autoshape the touch response to the screen in front of the speaker. The monkeys were maintained in accordance with state and federal guidelines. Food and liquid intake was restricted prior to experimental sessions, and for 3 h following each session. Experimental sessions were conducted 5 or 6 days per week.

### Apparatus[1]

The apparatus consisted of an aluminum cage [58.4×58.4× 77.5 cm (w×d×h) inside dimensions] with three speakers (Bang & Olufsen C40) positioned just to the outside of the three cage walls (not including the wall containing the entry door). The center speaker (from which the first sound was played) was located in the center of the wall opposite the entry door and 33 cm from the floor to the center of the speaker. The side speakers (from which the second sound was played) were located 35.6 cm from the center-speaker wall and 47 cm from the cage floor. The vertical cage bar in front of each speaker was removed to allow easy access (6.7×20.3 cm) to touch screens. Round copper touch screens (10.2 cm) were located immediately in front of each speaker and communicated with the control computer (Cromemco Z-2D) via a high-impedance CMOS circuit. Located to one side of each side speaker was a reinforcer dispenser. On the right side, 47 cm from the floor and 43.8 cm from the center-speaker wall was a banana pellet cup. On the left side, 47 cm from the floor and 46.4 cm from the center-speaker wall was a Tang orange-drink spout. The entire apparatus, including the reinforcer delivery mechanisms, was enclosed within a sound-deadening cubicle (109.2×109.2×185.4 cm inside dimensions).

The sound stimuli were recorded on TDK metal-bias cassettes and were presented via two Bang & Olufsen (Model Beocord 8000) random-access tape decks, which were modified to accept computer control (Cromemco Z-2D). The auditory signals from each tape deck were separately amplified and intensity-controlled via Yamaha (Model A-450) amplifiers. Sound levels were adjusted to produce approximately 55 dB (re. 0.0002 dynes/cm$^2$) in the center of the experimental cage (Bruel & Kjaer precision sound-level meter Type 2215).

During the "fading" phase of the experiment, a variable decibel-level control (Realistic AT-50H) was switched by a relay so that it was in series with the incorrect side speaker on each trial. Manual manipulation of this decibel-level control attenuated or completely turned off the sound to the incorrect side speaker. During the transfer phase of the experiment, this device and relay were removed from the circuitry to prevent any possible cuing, however slight, as to the correct/incorrect side response.

### Stimuli

The training stimuli used in the five acquisitions consisted of 38 different sounds, some of which were recorded from a set of 13 sound-effects records (Electra Records, 665 Fifth Ave., New York) (e.g., door buzzer, water pump, cuckoo clock, glass breaking, siren, boat whistle, car engine, gong, telephone ring, ticker tape, car skid). Other sounds were recorded (Nakamichi 550) from our monkey colony (e.g., monkey threat sound, monkey trill, monkey low coo, monkey cage rattle).

The 138 transfer-test stimuli were recorded from the same sources as the training stimuli but were selected to be distinct from the training stimuli and from each other (e.g., baboon call, metronome, christmas chimes, submarine dive klaxon, crow caws, pig grunts, fencing match, mockingbird, dog howling, wood chopping, angry cat yowls, cow mooing, woman laughs, hammering nails, cable car, coyote howls, monkey "ooh ooh," air-raid gliss down, steamboat whistle, horse whinny, man coughing, machine-gun fire, owl hoots, squeaky door, key cutter, windshield wipers, hunting-horn charge, bowling pins, riveting, oil-well pump, buoy bell, toilet flush, ping pong, monkey squeal, rooster crows, guitar, voodoo drum, dinner triangle, sonar pings, French siren, boat creaking).

### Procedure

**Sound-source contact.** A critical aspect of the task may have been the requirement of contact with the sound source, which has been shown to be important in other monkey auditory discrimination tasks (e.g., Downey & Harrison, 1972, 1975; Harrison, 1984; Harrison, Downey, Iverson, & Pratt, 1977; Harrison, Downey, Segal, & Howe, 1971; Harrison, Iverson, & Pratt, 1977; Segal & Harrison, 1978). During the initial response-shaping stage, a sound was played from one of the two side speakers (pseudorandomly chosen). A touch response to the speaker from which the sound emanated resulted in reward: a 1-g Noyes banana pellet for a touch to the right-hand speaker and 3 ml of Tang orange drink for a touch to the left-hand speaker. Touches of the screen in front of the quiescent speaker were ineffective during this response-shaping period. The stimuli used in this phase were the same as those used in later training phases. Both monkeys required encouragement for them to initially touch the copper screens, and a small amount of ripe banana was rubbed on each screen before the first response-shaping session. Each monkey was trained for 350 trials before the sound-localization phase began.

**Sound localization.** An 8-sec sound was played from the center speaker. A touch response turned off the center sound and immediately played a sound from one of the side speakers. When this second sound was the same as the previous center-speaker sound, as it was on half of the trials, it was presented from the right-side speaker, and a touch on the right-side speaker (*same* response) produced a banana pellet; when it was different from the previous center sound, it was presented from the left-side speaker and a left-side speaker touch (*different* response) produced orange drink. Thus, the monkeys had only to localize the side from which the sound was played. An intertrial interval (ITI) of 25 sec separated the trials, except following center-speaker aborts (failures to touch the center speaker during the 8-sec sound), side-speaker aborts (failures to touch a side speaker during the 13-sec sound), or incorrect side-speaker touches; in these cases, the ITI was 45 sec. This training phase lasted for 80 trials and the stimuli used were the 38 training sounds previously described. Following accurate sound-localization responding, the sound from the incorrect side speaker was gradually "faded in," or increased in intensity in the next phase.

**Fading.** This training phase was characterized by a gradual increase in sound intensity from the incorrect side speaker. The in-

tensity of the sound coming from the incorrect side speaker was adjusted every few trials depending upon the subject's performance. The idea here was to increase the intensity as much as possible while at the same time maintaining moderately accurate performance. For example, if the subject was correct on both a *same* trial and a *different* trial, the intensity was increased. On the other hand, if the subject was incorrect on both a *same* and a *different* trial, the intensity was decreased. Occasionally, several trials had to be presented before performance could be assessed on both trial types. Sampling performance on both trial types helped to diminish the role that response bias might otherwise have played. If the subject was correct on one of the two trial types and incorrect on the other, then the intensity usually remained unchanged. The amount of increase/decrease depended somewhat on the level (0–55-dB attenuation) at which the change was made, with the steps being somewhat smaller as intensity equivalence was approached. In the middle range, changes were on the order of 4–5 dB, but the experimenter had continuous control so that the degree of change could be tailored to the demands of the individual situation. Generally, at the beginning of each daily experimental session, a somewhat lower intensity was used than had been achieved at the end of the previous experimental session in order to reaccustom the monkeys to the task.

During the fading phase and thereafter, both center and side sounds were presented with a minimum listening time of 2.5 sec and a maximum presentation time of 13 sec. A short, 0.75-sec, probe delay between center and side sounds that had been used with BW (but not with FD) was eliminated, which reduced a slight response bias. Responses after the presentation time were considered aborts, and like incorrect responses were followed by a long ITI of 45 sec.

The subjects were tested until they could accurately perform an entire 25-trial daily session at 80% correct or better with equal intensity from both side speakers before progressing to the next training phase of the experiment. The stimuli used during this training phase were the 38 training sounds previously described.

**Trial-unique stimulus training**. The 38 training sounds comprised 25 trials (13 *different* trials and 12 *same* trials) of the first sequence to be learned by both monkeys. This particular sequence of sounds was used daily until the monkeys achieved the 80% performance criterion for a complete session with no intensity cuing. These sounds were then scrambled and selected pseudorandomly to make up a new 25-trial session (13 *same* trials and 12 *different* trials). Each new session and sequence, those used in Acquisitions 2, 3, 4, and 5, was first tested with equal intensity from both of the side speakers. Thus, the first session on the new sequence functioned as a test of the *same/different* rule for new combinations of old/familiar stimuli. If performance on this first 25-trial session was less than the 80% criterion, as it was on the first five acquisitions, the subjects were trained with the fading procedure described above until they performed a complete 25-trial daily session at 80% correct or better. This procedure was repeated for the five acquisitions with five different sequences.

**Transfer testing**. Tests of the auditory *same/different* concept were made by presenting trials with novel stimuli. These test trials typically were intermixed with regular training trials while maintaining a session length of 25 trials. The performance criterion for transfer testing was 80% correct or better on training trials from the previous session. Consequently, occasional training sessions were conducted between the test sessions. Throughout transfer testing, new sequences and combinations of sounds were composed for each transfer-test session and for many of the training sessions. In addition to new combinations of the previous 38 training sounds on training trials, the tested transfer sounds were gradually incorporated as training stimuli. By completion of transfer testing, virtually all of the transfer stimuli (except the transfer stimuli of the last test session) had been incorporated as training stimuli. The incorporation of transfer stimuli as training stimuli may have helped to prevent build-up of proactive interference that can occur from

one session to the next when stimuli are repeated over many sessions (Jitsumori, Wright, & Cook, 1988).

A total of 92 test/transfer trials (46 *same* and 46 *different*) were conducted with 138 novel stimuli for each monkey. The transfer stimuli were selected virtually at random for testing. A particular transfer trial was tested only once, and those stimuli were then considered no longer novel and were placed in the training stimulus pool. The number of test trials per test session varied somewhat, but all trials on all transfer sessions were included in the analysis. The testing frequencies per session were 6, 12, 25, 12, 12, and 25 for BW, and 6, 12, 12, 12, and 2 thereafter for FD.

**Requirements for concept learning**. The lack of agreement among researchers over what constitutes concept learning has led us (and others) to take a comparatively conservative stance on procedures used (Premack, 1978; Wright et al., 1988; Wright, Santiago, & Sands, 1984; Wright, Santiago, Urcuioli, & Sands, 1984). The first, and most important, requirement seemed to be to establish procedures from which results would be unambiguous by separating the effects of training from those of transfer. One step in accomplishing this goal was to use a large collection of stimuli that were all very different from one another. A large collection of different-sounding stimuli required that the auditory stimuli be complex and multidimensional. Use of stimuli that are different from one another removes confusions that can otherwise occur and makes for higher task accuracy. Whether or not any similarity existed among the stimuli, it should be pointed out that the nature of the task and the large number of transfer trials makes it untenable to argue that good transfer could be the result of simple stimulus generalization between training and transfer stimuli. Correct responses were dependent upon the relationship of two stimuli (*same/different*). Any similarity between a transfer stimulus and a training stimulus would be associated with the same correct response (*same/different*) only by chance.

Another step in establishing procedures that would give unambiguous results was to test the novel stimuli only once so that the results would not be confounded by a history of reinforcement and possible learning. Both of the above requirements necessitated a large number of stimuli for training and testing, which, with some difficulty, is possible in this and other concept-testing situations. The procedure of repeatedly testing the same transfer stimuli in extinction was rejected because we have found that highly trained subjects quickly learn to discriminate such test trials from training trials (because test trials are always associated with extinction). Although the two requirements of distinctly different stimuli and testing the stimuli only once for transfer should ensure a clear evaluation of transfer performance, they do not resolve the issue of what level of transfer accuracy constitutes concept learning.

The level of transfer performance that constitutes concept learning is not a matter that is easily settled. It might be of some value to consider the extremes. It is unlikely today that a simple difference from chance performance would, in itself, be seriously considered as evidence for concept learning. At the other extreme, transfer accuracy might be as good as, or even better than, accuracy with training stimuli. In the experiment reported in this article, we were fortunate to obtain a transfer that was as accurate as training performance, and this high level of transfer accuracy made the interpretation of concept learning straightforward.

## RESULTS

The number of trials to reach the 80% criterion for both monkeys on each of the five sequences is shown in Figure 1. Both monkeys showed a trend toward more rapid learning with each successive sequence of the familiar training stimuli. These data extend our previous publication of these acquisition results for BW (Shyan et al.,
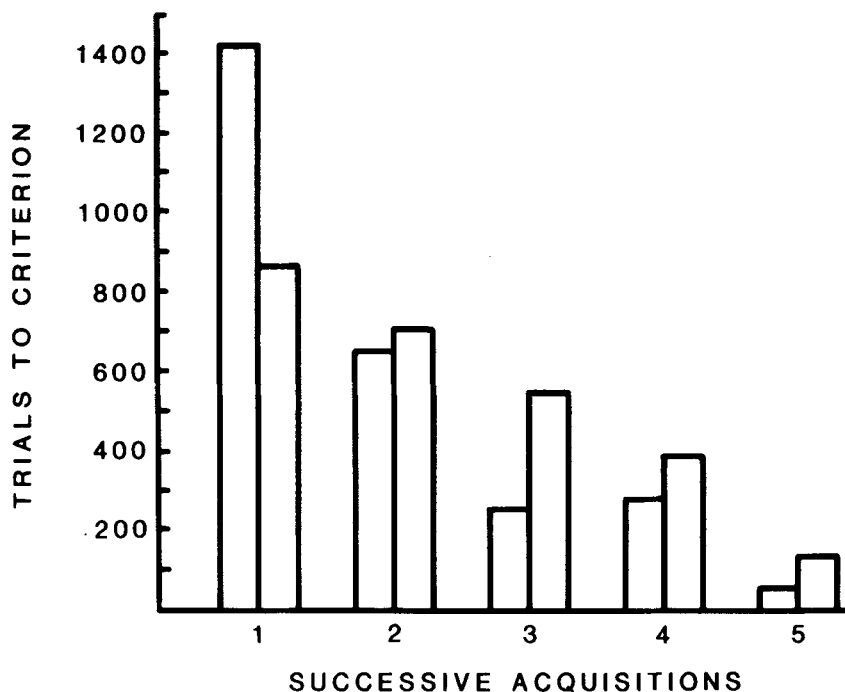
Figure 1. Number of training trials to obtain 80% correct performance for Subject BW (first histogram of each pair) and Subject FD (second histogram of each pair).

1977) by showing that acquisition of the *same/different* task was similar for the 2 monkeys. Notwithstanding the value in showing that monkeys can learn a *same/different* task, these acquisition results do not in themselves say anything directly about abstract concept learning. The important result from the standpoint of concept learning is how the monkeys performed on the very first presentations with novel stimuli. These transfer results are shown in Figure 2.

Transfer-test performance and baseline performance are shown in Figure 2 for each monkey separately. Both monkeys performed as well with novel stimuli (77.2% for BW and 80.4% for FD) as they did with baseline stimuli (78.5% for BW and 76.1% for FD). The baseline performance shown in Figure 2 is a pooled average of baseline performance on training trials during the transfer-test sessions and baseline performance during the criterion sessions immediately preceding each transfer test for trials matched to the ordinal trial position of the test trials.

Statistical tests of the equality of two percentages (Sokal & Rohlf, 1969, p. 608) were conducted on transfer and pooled baseline performance. There were no significant differences for either subject ($p > .8$ for BW, and $p > .3$ for FD).[2] Nor were there any significant differences between transfer and baseline-during-transfer ($p > .7$ for BW, and $p > .4$ for FD), or between transfer and baseline-session-prior ($p > .3$ for BW, and $p > .8$ for FD). There was a slight (but nonsignificant) decrement in the baseline performance during transfer testing relative to transfer performance (75.0% vs. 77.2%,

and 76.5% vs. 80.4% for BW and FD, respectively), but the monkeys' prior-session baseline performance was slightly (but not significantly) in the other direction (82.6% and 81.5%, respectively).

Several additional analyses were also performed. There were no acquisition differences as a function of familiarity with the stimuli; acquisition performance was as good with the man-made industrial sounds (e.g., siren, clock ticking, etc.) as with cries and coos from monkeys of the colony. During the acquisition phase, first-session performance for the new Sequences 2–5 (conducted at equal sound intensities from the side speakers) did not reveal any systematic performance trend (64%, 76%, 48%, and 72% for BW, and 36%, 32%, 68%, and 64% for FD) like the trend in the trials to criterion shown in Figure 1. Finally, both monkeys had a slight tendency to respond *same* more often than *different* on transfer trials (78.3% same, 76.1% *different* for BW; 88.9% *same*, 72.3% *different* for FD) and on baseline trials (pooled) (86.4% same, 70.1% *different* for BW; 79.7% *same*, 74.6% *different* for FD).

## DISCUSSION

The results presented in this article extend those previously presented, in which the number of trials to criterion showed that 1 monkey (BW) was able to perform a *same/different* task with auditory stimuli (Shyan et al., 1987). The important finding shown here is that both monkeys transferred this performance without loss of accuracy
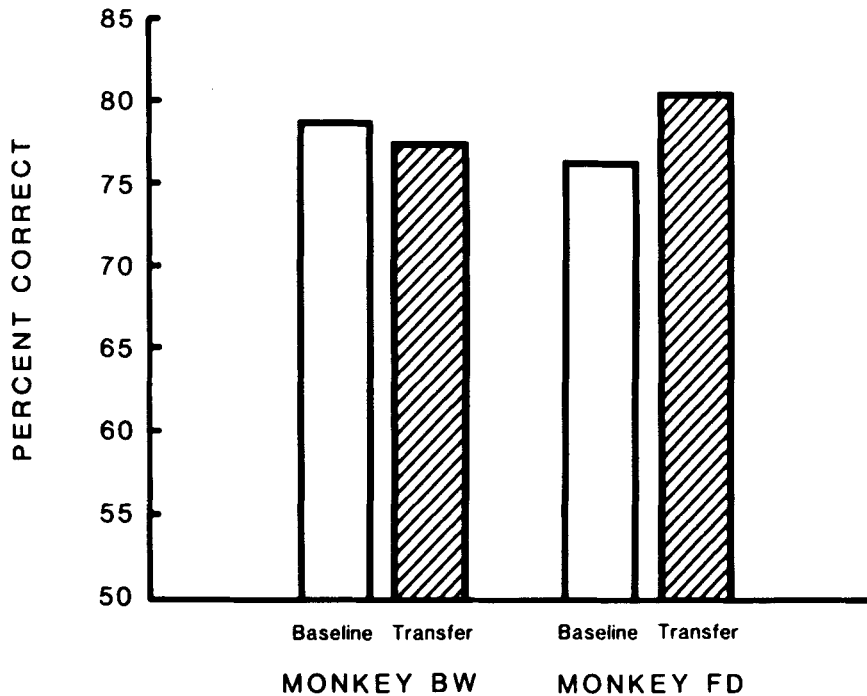
Figure 2. Baseline performance (unfilled) for trials containing training sounds and transfer performance (hatched) for trials containing novel sounds for Subjects BW and FD. Novel stimuli on transfer trials were presented only once each.

to novel stimuli on the very first presentation of the novel stimuli, and thus showed that they had learned an auditory *same/different* abstract concept.

Abstract concept-learning ability is vital to our ability to learn general principles, solutions, or rules from individual instances. Individuals or species that are deficient in this ability could be considered to be less cognitively capable. But if subjects fail to learn some abstract concept that we experimenters define in our (artificial) experimental setting, is this failure a deficiency of the organism's concept-learning capacity, or is it due to our inability as experimenters to design experiments and use procedures that allow the species to express its concept-learning ability? The experiment of this article has shown that, in spite of earlier indications to the contrary, monkeys can learn an abstract concept with auditory stimuli.

In the present experiment, monkeys learned a *same/different* concept with auditory stimuli in about 2,600 trials. Of course, humans learn such concepts much more rapidly than do monkeys, but one could counter such an argument by pointing out that even very young children come to the laboratory with an extended history of game playing and test taking. By this comparison, the monkeys' 2,600 trials might pale somewhat.

The 2,600 trials necessary to learn the auditory *same/ different* concept is almost an order of magnitude fewer than the more than 24,000 trials required by other rhesus monkeys to learn a similar *same/different* concept with visual stimuli (Wright, Santiago, & Sands, 1984; Wright,

Santiago, Urcuioli, & Sands, 1984). On the basis of this comparison we would not want to argue for an advantage of the auditory modality over the visual one for monkeys—a reversal of the previous modality specificity hypothesis for monkeys. The focus of the experiment reported in this article was not how rapidly monkeys could learn an abstract *same/different* concept with auditory stimuli, but was whether or not this species possessed the cognitive capability to learn this abstract concept with auditory stimuli under any conditions. In any case, one would have difficulty maintaining any visual modality superiority over the auditory modality in light of the results of this experiment and this modality comparison. As it now stands with the monkey, and with the dolphin as well, there appears to be no basis for modality specificity, or even modality asymmetry, with these species.

Concept-learning research with monkeys (and also with pigeons) has suffered from procedures that have apparently been inadequate in training the concepts, or have been inadequate in separating evidence for concept learning from other processes, such as rapid learning during transfer. The verification of concept learning is not an easy process, and this is why the conservative approach was taken regarding requirements that the stimuli be distinctly different, tested only once, and that transfer and baseline performances be equivalent. Violations of these requirements cloud the interpretation of the results and leave one unsure about whether or not any concept learning has occurred. For example, in one monkey experi-

ment on auditory concept learning (D'Amato & Colombo, 1985), only two auditory training stimuli were used, only two to six new auditory transfer stimuli were tested (the number is difficult to determine because familiar stimuli were pulsed, alternated with other familiar stimuli, or pulsed and alternated following an octave frequency change), only one of four trial types contained all novel stimuli, only averages for 24 and 48 trials over all four trial types were presented (one of the four trial types actually contained no new stimuli and two others contained only one new stimulus), and only 4 out of 8 monkeys learned the task. Occasionally, these concept-learning requirements have been fulfilled using monkeys as subjects, but only with visual stimuli (Moon & Harlow, 1955; Overman & Doty, 1980; Wright, Santiago, & Sands, 1984).

The history of efforts to obtain concept learning by pigeons is, if anything, more shrouded in controversy than it is with monkeys. Pigeon concept-learning research is mentioned because it has suffered from some of the same problems as the monkey concept-learning research. Studies claiming to have found evidence for pigeon concept learning (Holmes, 1979; Lombardi, Fachinelli, & Delius, 1984; Pisacreta, Redwood, & Witt, 1984; Urcuioli, 1977; Urcuioli & Nevin, 1975) have suffered many of the same methodological problems that rendered the results from the D'Amato and Colombo (1985) monkey study (discussed above) inconclusive (Carter & Werner, 1978; D'Amato et al., 1985; Mackintosh, 1983; Premack, 1978, 1983a, 1983b; Santi, 1978, 1982; Wright et al., 1988). Even highly replicable, although indirect, evidence of identity learning by pigeons (Zentall, Edwards, & Hogan, 1984; Zentall & Hogan, 1974, 1975, 1976, 1978) has recently been shown to be the result of an unlearned predisposition by pigeons to choose the odd stimulus (Wilson, Mackintosh, & Boakes, 1985).

However, pigeons have recently been shown to have the capacity to learn an abstract concept (Wright et al., 1988). Several novel methodological aspects of this study may have contributed to their matching-to-sample concept learning, but it is clear that one important aspect was the number of stimuli. One group was trained with 152 stimuli, and this group transferred their performance to novel stimuli (presented once) at an accuracy level (80% correct) that was equivalent to their baseline training performance, whereas another group trained with only two stimuli showed essentially no transfer (chance performance).

Experiments with humans have also shown that the degree of concept learning varies directly with the number of training exemplars (Homa & Chambliss, 1975; Homa, Cross, Cornell, Goldman, & Schwartz, 1973; Homa, Sterling, & Treple, 1981; Omohundro, 1981). Similarly, experiments with monkeys in visual concept learning have shown the importance of a large number of exemplars (Moon & Harlow, 1955, oddity-from-sample, 512 exemplars; Overman & Doty, 1980, matching-to-sample, 100 exemplars; Wright, Santiago,

& Sands, 1984, 210 exemplars). Thus, evidence from these primate experiments shows a strong correlation between concept learning and the number of exemplars.

In the present experiment, a larger number of auditory exemplars was used than the 2-6 exemplars used in previous experiments of monkey auditory concept learning or auditory discrimination learning. By contrast, the 2 monkeys in the present experiment were trained with 38 different sounds, and by the completion of transfer testing this number had been expanded to more than 150 training sounds.

Although the evidence converges on the necessity of a large number of exemplars for monkey auditory concept learning, it seems that a large number of stimuli is only part of the total requirement. One monkey, BW, had been trained, prior to the experiment of this article, with 72 different sound stimuli to move a lever to indicate whether two sounds presented were the same or different; this monkey never showed any acquisition even after more than 17,000 trials and more than a year's training.

From this discussion of animal concept learning, it should be clear that no single procedural aspect, by itself, can ensure concept learning. A substantial number of exemplars may be a fairly universal requirement. Other requirements will likely depend upon the concept to be learned and the particular species learning the concept. In the case of monkeys learning a *same/different* concept with auditory stimuli, contact with the sound source and use of the fading procedure were probably important factors, in addition to the large number of exemplars. As our animal cognitive/memory tasks become better tuned to take advantage of the species predispositions and "functional incompatibilities," at least with the procedural requirements, are eliminated (Sherry & Schacter, 1987), notions of capacity limitation for certain types of cognitive learning such as concepts may all but disappear, which should put even more pressure on the question of species' cognitive/intelligence differences.

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## NOTES

1. The specifications of the apparatus are in some cases slightly different than those previously specified (Shyan et al., 1987). In some cases, these differences were due to exterior versus interior measurements, and in other cases the measurements previously reported were in error.

2. Since the number of test trials per session varied, the statistical test was based upon the overall frequencies of correct and incorrect choices:

$$t_s = \frac{\arcsin \sqrt{p_1} - \arcsin \sqrt{p_2}}{\sqrt{820.8\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}.$$

Other statistical tests also conducted included an analysis of variance (test trials and training trials were blocked into 15 blocks each containing six test trials) and Fisher's exact test. Like the test for equality of two percentages, the results from these tests did not show any significant differences between baseline and transfer performance.