

WHAT'S IN A NAME? EQUIVALENCE BY
ANY OTHER NAME WOULD SMELL AS SWEET

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Horne and Lowe (1996) argue that our results demonstrating California sea lion Rio's success on tests of equivalence relations (Schusterman & Kastak, 1993) were likely due to four procedural artifacts (p. 223). However, four lengthy commentaries directly addressed Horne and Lowe's attempt to devalue and explain away our positive findings, and all of them found the alternative explanations and arguments neither persuasive, compelling, parsimonious, nor even accurate (Fields, 1996, p. 280; McIlvane & Dube, 1996, p. 269; K. Saunders & Spradlin, 1996, p. 306; R. Saunders & Green, 1996; pp. 313–314). It is therefore unnecessary for us to further elaborate on either our procedure or the interpretation of our results. Instead, in this paper, we will concentrate our effort on two points made by Horne and Lowe. First, we will focus on their assumption that thought is dependent on words rather than the other way around. Second, we will address their point that one must be cautious about overinterpreting results from a single study (Horne & Lowe, 1996, p. 330) by reviewing the results of recent work at our laboratory as well as other important studies concerning the cognitive capabilities of nonhuman animals.

We believe that Horne and Lowe's basic premise that naming or verbal reasoning is necessary for the emergence or the formation of equivalence classes in an individual is wrong. In our view, the way some nonhuman animals and preverbal children classify the relations between and within objects and events determines whether and how codes, symbols, or words are acquired and used and not vice versa. Nonlinguistic animals have repeatedly

shown that they are capable of reasoning and conceptualizing about relations dealing with time, space, and objects (for reviews, see Cheney & Seyfarth, 1990; Mackintosh, 1994; Schusterman, Thomas, & Wood, 1986; Vauclair, 1996; Wasserman, 1993). Animals, along with nonlinguistic human babies and adults, have been shown to display many abstract types of thinking (for babies, see Wynn, 1992; for adults, see Schaller, 1991; Shepard & Cooper, 1982).

Thinking Without Words

Terrace (1993) would say that Horne and Lowe (1996) have bought into the Cartesian and non-Darwinian belief that the word is the sole sign of thought. However, many investigators believe that there is currently enough empirical data to support the hypothesis that words depend on thinking, or what Pinker (1994) calls "mentalese" and what Terrace (1993) calls nonverbal thinking, and that nonlinguistic cognitive processes may draw upon the same cognitive mechanisms that are used in the processing of language. Indeed, Sidman (1994) thinks that the emergence of equivalence relations does not depend on naming but that some aspects of language like naming do depend upon the emergence of equivalence relations.

The idea that nonlinguistic beings are capable of forming equivalence classes has been our working hypothesis for the past several years (Gisiner & Schusterman, 1992; Kastak & Schusterman, 1994; Schusterman & Gisiner, 1997; Schusterman & Kastak, 1993). In the remainder of this paper we will try to bolster this argument by first describing some additional experiments with California sea lions that support the hypothesis that language and naming are unnecessary for the emergence of equivalence classes. These experiments will show that California sea lion Rio can form equivalence classes in a conditional

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discrimination and transfer them to a simple discrimination and can do the opposite (i.e., form equivalence in a simple discrimination and transfer the equivalencies to a conditional discrimination). Then we will discuss how the emergence of equivalence is likely to play an important role in the social and communicative interactions of social living animals like California sea lions and vervet monkeys.

California Sea Lions: Additional Data

As previously noted, studies showed that Rio, after being trained to relate Stimulus Pairs AB and BC (i.e., choosing Comparison B conditionally upon Sample A and choosing Comparison C conditionally upon Sample B), could then demonstrate emergent reflexive (AA, BB, and CC), symmetrical (BA and CB), transitive (AC), and equivalence (CA) relations among those visually presented stimuli (Kastak & Schusterman, 1994; Schusterman & Kastak, 1993). Two weeks after Rio successfully passed the equivalence relations tests, we switched from a conditional discrimination procedure to a two-choice simple discrimination. The simple discrimination experiment was conducted in order to test the transfer of equivalence relations formed in one context (matching to sample) to a second, novel context (simple discrimination). In terms of the simple discrimination procedure, a stimulus pairing was defined as members from two potential classes pitted against each other as alternate choices. No sample object was presented on these trials. The stimulus configurations for the simple discrimination were formed by pairing the A, B, and C members from each of two randomly chosen three-member equivalence classes that had been learned by Rio in the earlier experiment (Schusterman & Kastak, 1993). Rio's 30 equivalence classes were divided into a total of 15 class pairings, each consisting of three simple discriminations pitting A versus A, B versus B, and C versus C. On the first discrimination (training phase), one of the three possible member pairings was presented to the sea lion, and her choice on Trial 1 was reinforced, regardless of class membership. Following criterional learning of this discrimination (90% correct in a block of 10 consecutive trials), one of the two remaining stimulus pairings from the same two classes was tested (Transfer Test 1). The third pair-

ing from the same classes (Transfer Test 2) was introduced following 90% performance on the second pairing. This procedure was repeated for the remaining 14 class pairings. Our measure of transfer was Rio's performance on Trial 1 of each novel stimulus pairing, giving a total of 30 completely novel trials (15 trials were used in training to establish the class to be denoted as correct for each pairing).

As an example, a potential class pairing might be between Equivalence Classes 1 and 2. In the training phase, the B member from Class 1 (B1) might be pitted against the B member from Class 2 (B2). Rio's choice on Trial 1 then established the reinforcement contingencies for the remainder of the training phase. For example, a choice of B1 on Trial 1 established B1 as the positive discriminative stimulus and B2 as the negative discriminative stimulus. Subsequently, responses to A1 and not A2 would be reinforced on Transfer Test 1 and responses to C1 and not C2 would be reinforced on Transfer Test 2. Stimulus pairings in Transfer Tests 1 and 2 would be completely novel on their first presentation to Rio, in that these class members had previously been paired only in conditional discriminations and never in a simple discrimination. Performance on the first trial of each transfer test constituted the critical measure of the equivalence responding in this experiment.

On the first trial of each of the 30 transfer tests, Rio made 28 correct (i.e., class consistent) responses; such performance is significantly better than that expected by chance (two-tailed binomial test, $p < .01$). These results indicate the sea lion's ability to transfer equivalence relations learned in matching to sample to simple discriminations, a completely novel context.

In the next series of experiments, we attempted to determine whether a modification of the discrimination reversal technique first used successfully to generate two functionally equivalent classes in pigeons (Vaughan, 1988) could do the same for California sea lions. Moreover, we went on to test whether Rio would show conditional discriminations emerging between members of a functional class. Finally, we tested whether the sea lion, after being taught to relate novel stimuli to existing class members, could then

match other class members to the novel stimuli, thus demonstrating stimulus equivalence. This series of experiments was modeled after those designed by Sidman, Wynne, Maguire, and Barnes (1989) to examine equivalence class formation by human subjects.

The subjects of the first stage of testing were 2 female California sea lions, Rio and Rocky. Like Rio, Rocky had extensive experience with other learning tasks, including conditional discrimination learning. For this task, we used 20 different visual stimuli that were divided into two sets of 10. All of the stimuli in the sets were discriminably different, and for our own convenience, we identified each object as either a letter or a number.

The general procedure was a two-choice simple discrimination. In this task, the subject was presented with two different stimuli, one from each set (one letter and one number), and selection of the object designated as correct by the experimenter was reinforced. The letter-number pairings were shuffled so that any member of the letter class and any member of the number class could appear together on a given trial. The sequence of trials in a session consisted of four sets of 10 trials. Each set included one presentation of each class member in a randomized order. The reversal procedure consisted of training a series of simple discriminations in which selection of members of a particular set was reinforced until the subject met a preset criterion (90% correct responses in one session). Subsequently, the contingencies were reversed; choices of members of the previously negative set were reinforced until the subject met the same criterion. This series of reversals from the letter set to the number set continued throughout the experiment.

Like Vaughan (1988), we defined functional classes as groups of stimuli that become interrelated through common behavioral functions, such that when responses to some members of a class change, responses to the remaining members of that class change accordingly. Based on this definition, performance on specific trials following a reversal in reinforcement contingencies may be influenced by the outcome of previous trials with other class members. Both of our sea lions eventually showed evidence of functional class formation in this task, reversing their

choices from members of the letter class to the number class (and vice versa) after several trials with specific class members. Following a reversal, performance on the first exposure of the 10 stimuli from each class should be close to zero, because the last time the sea lions encountered each stimulus, it appeared as an incorrect alternative. However, Rio and Rocky scored an average of 3.4 and 3.1 correct responses out of 10, respectively, on the first presentation of each stimulus following a reversal. This effect was enhanced by the introduction of differential outcomes to each class, such that correct responses to members of the letter class and correct responses to members of the number class were differentially reinforced with specific types of fish. Under this condition, Rio and Rocky scored an average of 6.5 and 6.0 correct, respectively, on the first presentation of each of the 10 stimuli in a class following a reversal in reinforcement contingencies. Further, performance on Trial 1 for the last five class members following a reversal was significantly better than chance, averaging 4.0 of 5 for Rio, and 3.5 of 5 for Rocky. This indicates rapid reversal of choices following exposure to a few exemplars from each class.

Following the formation of functional classes in the first phase of testing, we used a two-choice conditional discrimination procedure to assess whether members of a particular class would be related in a novel context. Specifically, the task was designed to assess whether a sea lion trained to sort stimuli into classes based on contingencies of reinforcement could match stimuli from these functional classes to one another in conditional discriminations on the basis of their class memberships. Rio was the subject in this experiment.

A matching-to-sample procedure was used to test the transfer of functional classes to conditional discriminations. The experiment consisted of presenting one stimulus as a sample object and then two comparison objects, one from each set, as choice stimuli. Correct responses consisted of matching the sample stimulus to the choice object that belonged to the same class. If a number was the sample, then picking a number as the correct match was reinforced, and conversely, if a letter was the sample, choosing a letter as the correct match was reinforced. Correct responses were differentially reinforced, as in the latter

half of the previous test. Performance on each novel stimulus pairing from the two classes was measured to assess transfer. This testing procedure generated a total of 180 novel trial combinations. The presentation sequence of these trials during testing was randomized. Rio scored 154 out of 180 possible correct responses on novel trials in this transfer test. Her performance was significantly better than expected by chance (two-tailed binomial test, $p < .001$).

The final testing phase in this experiment was conducted to determine whether functional classes could also form equivalence classes. Specifically, we tested whether Rio, after being taught to relate novel stimuli to existing class members, could then match other class members to the novel stimuli. The experiment consisted of a training phase and a testing phase, both utilizing a matching-to-sample procedure. The training phase consisted of training four new conditional discriminations in which two new stimuli (K and 11) were mapped onto two existing class members (J and 10). The four conditional discriminations trained were JK, KJ, 10-11, and 11-10. Following training of the new conditional discriminations, the new stimuli, K and 11, were tested against the remaining members of each functional class to determine whether they had become related through equivalence relations. If K appeared as the sample, Rio's selection of another letter (not a number) was reinforced. Conversely, if a letter appeared as the sample stimulus, Rio's choice of K (not 11) was reinforced. The trials testing the transfer of 11 into the number class were set up the same way, and all test trials appeared in a randomized order. Correct matches of stimuli in either class were differentially reinforced, as in the earlier two phases of this experiment. The procedure generated a total of 36 novel trial combinations, and performance on these relations was measured by performance on Trial 1. Rio immediately and accurately matched the new stimuli to each of the remaining functional class members, scoring 36 out of 36 possible correct responses on Trial 1. Her performance was significantly better than would be expected by chance (two-tailed binomial test, $p < .001$).

In Sidman and Tailby's (1982) original formulation of stimulus equivalence, the learned

equivalence of dissimilar stimuli was based on the notion that equivalence relations or conditionally related stimuli (which have become interchangeable in their control over behavior) have characteristics similar to those delineated in mathematics: reflexivity, symmetry, and transitivity. Currently, Sidman (1994) states that equivalence can also be the product of simple discriminations (three-term contingencies) and that responses and reinforcers, as well as discriminative and conditional stimuli, can be members of equivalence classes. The results from the present two experiments, showing that equivalence relations formed by a sea lion under one set of conditions can be transferred to a novel set of conditions, are supportive of the expanded view of stimulus equivalence taken by Sidman. We believe that our results support the notion that behaviorally as well as mathematically, functional classes imply equivalence relations and vice versa (Sidman, 1994, pp. 418–419). All of our work with California sea lions suggests that some members of the species are capable of forming equivalence relations and can do so under a variety of contexts in the absence of any symbolic or "naming" behavior.

Individual Recognition and Cross-Modal Transfer

Pinnipeds. Observations on the natural behavior of California sea lions indicate that equivalence classes may play a role in their social and communicative interactions. We suggest that the evolutionary learning program that promotes imprinting by California sea lion pups on their mother's voice (see Schusterman, Hanggi, & Gisiner, 1992; Trillmich, 1981), her smell, and various aspects of her visual appearance, such as her gait, posture, and facial expression, is likely to facilitate the pup's ability to interrelate these cues with one another and with the powerful reinforcers of milk, suckling, protection, and warmth that it receives from its mother. Thus, individual recognition beginning with mother-pup recognition via a variety of sensory modalities may be a critical developmental requirement in group-living animals such as California sea lions (Schusterman, Kastak, & Reichmuth, 1995). Perhaps the same skills that enable the pup to react differentially to its mother's odor and visual appearance when

it has only heard her voice may later enable the mature sea lion to recognize its sisters through their relationship with the mother and each other. There is evidence that like several other group-living animals, California sea lions discriminate particular kin on the basis of any of several sensory modalities (Hanggi & Schusterman, 1990). Therefore, it is reasonable to suggest that such perceptual learning abilities are related to their skill at successfully passing tests of stimulus equivalence. In contrast, harbor seals are notoriously poor at performing in matching-to-sample tasks (Constantine, 1981; Hanggi & Schusterman, 1995), and harbor seal mothers, during their brief (1-month) period of attending to the pup, do not emit pup attraction calls as do California sea lion females, who attend to their pups for 6 months or longer.

Vervet monkeys. Vervet monkeys have been studied by Cheney and Seyfarth (1990) in Amboseli National Park. They live in stable social groups consisting of a number of adult males, adult females, and their juvenile and infant offspring. These field investigators have pointed out that these animals, like several other social mammals and birds, recognize one another individually, have extended families, and form alliances against one another, like the Montagues and the Capulets. By doing an extensive series of playback studies, Cheney and Seyfarth have demonstrated that vervets place physically dissimilar stimuli consisting of other group members, predators, acoustic signals, responses, and a host of social reinforcers into equivalence classes. For example, when for the first time free-ranging adult female vervet monkeys are played the scream of an absent juvenile from a concealed loudspeaker, the adult females frequently respond to the playback scream by looking at the juvenile's mother. This occurred before the mother looked toward or approached the speaker herself. One could say that adult females, through previous experience, related the sound of the juvenile's scream (A) with the juvenile itself (B) and related the juvenile (B) with its mother (C) and therefore, the first time they heard the scream of the absent juvenile vervet monkey, without any additional experience they immediately oriented to its mother. Thus, responsiveness to the mother by the other adult females in the group emerged in this novel

context, even though these female monkeys may have never explicitly had the experience before.

An equivalence learning model might argue that the existing relation between the scream (A), the juvenile itself (B), and the frequent relations between the infant (B) and its mother (C) resulted in a three-member equivalence class consisting of the scream, the juvenile, and the mother (A, B, and C). That is, under certain circumstances, these events and individuals may all be classified as the same.

Learned equivalence of stimuli can be readily applied to affiliative and aggressive behavior of group-living individuals (e.g., Hanggi & Schusterman, 1990). Following an aggressive interaction between 2 vervet monkeys from two different genetic lineages (A1 and A2), other individuals from those lineages (B1 and B2), having observed A1 and A2 fight, are more likely to fight even though they were not involved in the original conflict (Cheney & Seyfarth, 1990). The aggressive events in this description are interchangeable with one another not because the individuals necessarily resemble one another but because the individuals in each of the lineages have previously shared a common functional association in terms of temporal or spatial proximity and positive and negative reinforcers. In general, kinship- and friendship-based coalitions seem to depend on a history of common functional relations that establish the equivalence of stimuli.

In referential communication studies with vervet monkeys, Cheney and Seyfarth (1990) have used playback-habituation experiments to demonstrate that the subjects classify the following calls as functionally equivalent despite their different acoustic properties: (a) vervet eagle alarm calls and starling raptor alarm calls and (b) calls labeled "wrrs" and "chutters" used to coalesce group members to the approach of another group. Thompson (1995) has recently pointed out that results like these, in which vervet monkeys classify calls on the basis of their common referent, are similar to the way pigeons use a prior association with a common response to produce a class of functionally equivalent but physically different visual stimuli (Wasserman & DeVolder, 1993).

In addition, it has been shown in matching-

to-sample tests that Java monkeys classify individuals into affiliative pairs (Dasser, 1988). Finally, it has been pointed out that nonhuman primates appear to switch from one behavioral social reinforcer to another (e.g., exchanging a mount for tolerance at a food source or grooming for later support in an alliance; Cheney, Seyfarth, & Smuts, 1986). These observations strongly suggest that some species of nonhuman primates, and perhaps other animals living in social groups, are capable of forming an equivalence class consisting of social reinforcers.

Conclusion

In conclusion, we believe that field studies of social nonlinguistic animals provide strong evidence for the formation of equivalence classes without the prerequisite linguistic ability suggested as necessary by Horne and Lowe (1996). Further, we have expanded upon previous experimental evidence for the formation of equivalence relations in California sea lions, and believe that, although the requisite tests for reflexivity, symmetry, and transitivity have not been conducted successfully on other nonlinguistic animals, many such animals are more than likely capable of forming equivalence classes. The most parsimonious explanation for the appearance of equivalence in both humans and other animals is that the ability evolved in a social or ecological context, rather than as a result of linguistic competence. Thus, we believe that naming is not a prerequisite for equivalence, but equivalence is likely to be essential for naming.

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EQUIVALENCE RELATIONS

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When I was asked to reply to Horne and Lowe's (1996) criticisms of my position on equivalence relations, I replied that I did not hold to a *position*. In my recent book, *Equivalence Relations and Behavior: A Research Story* (Sidman, 1994; in the present article, subsequent references to chapters or to pages are citations of that book), I made many suggestions about how to view phenomena that are subsumed under *equivalence relations*. In each instance, I first detailed my reasons for making the suggestion. Then, I outlined experiments that might either support or fail to support the suggestion. If I have any position, it is that data rather than debate will show the way.

With one exception (Rumbaugh, 1995), most of the more important proposals in the book have received little theoretical and no empirical commentary, either from critics or from those who might be favorably

inclined. I suggested, therefore, that I might simply reproduce selected paragraphs from my book. Somewhat to my surprise, this suggestion was received favorably. So here are some isolated paragraphs, repeated. Abstracting them from the general clutter will perhaps make them stand out more effectively.

Still, the surrounding material, although not included here, performs important functions, describing both the origins and possible consequences of each suggestion. Some proposals will not stand the test of data; for those, the originating problems will still remain. And so, I hope that anyone who really wishes to evaluate the following paragraphs will also attend to the context.

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The study of equivalence relations has contributed some new data to behavior analysis and perhaps some new principles, but none

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