

PLEASE PARSE THE SENTENCE: ANIMAL COGNITION
IN THE PROCRUSTEAN BED OF LINGUISTICS

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We recently discussed the performance of sea lions and dolphins on a complex learning task which superficially resembled human language comprehension (Schusterman & Gisiner, 1988a). The task required the animals to form associations between gestural signs and objects in the tank environment, and between gestural signs and actions to be performed on those objects. The task also required the animals to integrate the information of several combined signs into a performance of a specified action on one or two specified objects. We proposed what we considered to be the most parsimonious explanation of the observed performance of the sea lions and dolphins. This explanation required that the animals (a) form connections between signs and their referents, (b) place individual signs into classes, and (c) make conditional discriminations about the relationships between sequentially presented signs. In response to criticism of our position by Herman (1988) we expand our discussion of the role of conditional discriminations in training the sea lions' and dolphins' performance. We continue to question the utility of linguistic terminology in any definition of animal cognitive performance because of the open-ended, "fuzzy" definitions of human linguistic structures like words and grammars. We conclude that, at this time, analyses based on experimentally demonstrated cognitive skills are preferable to analyses based on language metaphors.

Dolphin: I saw a human swimming!

Sea Lion: Great! I'm going to leap out of this enclosure, swim up the coast about 30 miles and dive for some squid. Bring the human along.

Dolphin: Well . . . I didn't mean he could do *that*, I meant that he can

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do some things that look a lot like what we do when we're swimming.

Sea Lion: Oh. I think we need to find out more specifically how the human gets around and how fast it can go, how deep it can dive, and how high it can leap. Then we won't confuse what the human is doing with what we understand to be swimming. And maybe, in the process, we will learn more about what we mean by "swimming."

Introduction

The technique of using a simplified artificial language to elicit complex, cognitively mediated responses, as developed by Herman and his associates, has provided the controls and replicability lacking in many early studies of language learning by animals (Herman, 1980, 1986, 1987; Herman & Forrestell, 1985; Herman, Richards, & Wolz, 1984). We have wholeheartedly adopted this approach in our studies of sea lion cognition and reemphasize our endorsement of this methodology.

Our differences with Herman are primarily in the conclusions drawn from the data. We believe that Herman has overinterpreted his dolphins' performances on certain artificial language comprehension tasks, claiming cognitive and linguistic abilities that have not yet been adequately demonstrated. We ascribe this overinterpretation in large part to Herman's use of linguistic terminology to describe the dolphins' performance, leading him to conclude that the dolphins must be employing grammatical rules and symbolic representations in order to be able to extract semantic information from the sign combinations they were given.

In a response to our criticisms, Herman (1988) defends his use of linguistic terminology as "metaphors" and states that our interpretation "misrepresents the dolphin data" and possesses "shortcomings in interpretations" (p. 349). In this paper we expand on areas where we believe Herman has misunderstood our position, most particularly on the applicability of a conditional discrimination learning paradigm to both his and our studies. We repeat our caveat about using linguistic terminology to describe cognitive performances that fall short of traditional (human) linguistic performance. We hope to convince the reader that Herman has used linguistic terminology in a more than metaphorical sense, that we have not misrepresented data, and that our alternative paradigm does not possess the shortcomings he describes; that it instead better fits existing data and makes more precise predictions than those derived from Herman's linguistic, heuristic model. We refer to this linguistic model as a Procrustean bed because it severs the connection between complex performance and the training and practice required to produce the complex performance. This same Procrustean bed of linguistic theory attempts to stretch incompletely demonstrated conditional relationships into linguistic skills.

A Brief Review

In the artificial language devised by Herman et al. (1984) to study sentence comprehension by dolphins, arbitrary signals served as discriminative stimuli for actions (a stimulus-response relation) and as conditional stimuli or instructional stimuli for objects (a stimulus-stimulus relation) and the properties of objects, referred to as modifiers (also a stimulus-stimulus relation). The only syntactic regularity in this language was the serial ordering or sequentiality of the signals, that is, object signs preceded action signs and modifier signs preceded object signs. Thus, LEFT RING MOUTH instructed the dolphin Ake to place its mouth on the ring to its left and not the one on its right or any other object in the tank. We used virtually the same syntax to study the cognitive processing skills of three California sea lions (*Zalophus californianus*) (Schusterman & Gisiner, 1988a, 1988b; Schusterman & Krieger, 1984, 1986). The sea lions were given sign sequences instructing them either to act directly on a single object when there were many available in the tank (e.g., LARGE BLACK CUBE TAIL-TOUCH) or to relate two objects (again when there were many in the tank) by taking one object to another (e.g., SMALL BALL, WHITE LARGE CONE FETCH). In the relational instruction the second object signaled, the white large cone, is the transport item (TI) and the first object signaled, the small ball, is the destination or goal item (GI).

Herman's description of the process as an acquisition of "tacit knowledge of the syntactic rules underlying the language" or an ability to "parse the sentence" ignores the very direct training efforts employed to induce categorizations and the formation of functional rules.

Connections Between Signs and Their Referents Are Established by Conditional Discrimination Training

Although we are searching for emergent cognitive/linguistic processing skills, it is important to keep in mind the ways in which paired associate or conditional discrimination learning techniques are used to establish the foundation on which the more complex relationships are based.

Actions performed on objects were trained by Skinnerian response shaping techniques. Signs designating objects (e.g., object shapes) and signs designating object properties or "modifiers" (e.g., size or location) acquired their unidirectional functional relation (Signal $A_1 \rightarrow$ Object B_1) in the context of a conditional discrimination paradigm first described by Lashley (1938) and most recently elaborated on by Carter and Werner (1978) and Sidman and Tailby (1982). In Lashley's experiment, if the background was solid black then the rats had to select the upright triangle, and, if the background was striped they had to choose the inverted triangle. This paired associate learning or "if . . . then . . ." rule

learning procedure is similar to arbitrary matching-to-sample tasks in which subjects are presented with sample and comparison stimuli that are physically different (Cummings & Berryman, 1965). In this task, if sample A_1 is presented then comparison B_1 should be selected, and if sample A_2 is given then comparison B_2 should be selected. Such arbitrary matching tasks have also been described as "symbolic" or "nonidentity" matching. In the artificial language comprehension experiments with marine mammals unique gestures (for the dolphin Ake and the sea lions Rocky and Bucky), unique objects (for the sea lion Gertie), or unique acoustic signals (for the dolphin Phoenix) all served as sample stimuli designating one of several available objects (the comparison stimuli). When modifiers were used, contextual control over the animal's choice of stimulus objects was greater because these additional signals helped designate a single unique object from among very similar choices. There are only superficial differences between conditional relations connecting signs and objects in the experiments using sea lions and dolphins and the conditional relations that exist between samples and specific comparison stimuli in arbitrary matching paradigms using pigeons and monkeys as subjects. In both cases, the underlying reinforcement contingencies are the same. The stimulus-response relation, that is, the object "ball" and the orientation to it, is replaced by a stimulus-stimulus or signal-object relation, that is, the sign BALL and the object "ball." Conditional or contextual signals (i.e., the sign BALL) do not control responses directly but determine which stimulus objects will be chosen (see Sidman, 1986, for a recent analysis of second-order conditional control). Thus as Carter and Werner (1978) have noted, the conditional discrimination (and its many variants) is the appropriate paradigm for the comparative study of interrelations among such processes as complex learning, memory, information processing, and perception. As we stated in our original paper (Schusterman & Gisiner, 1988a) these are likely to be the cognitive processes that are necessary, though perhaps not sufficient, for language learning.

One such cognitive process is crucial to our understanding of how dolphins and sea lions comprehend relationships encoded in signs strung together to form sentence-like commands. That cognitive process is "memory coding," which mediates the delay in conditional discriminations between the conditional cue or "symbolic" sample and the discriminative response. Based on Roitblat's recent work on pigeon arbitrary matching tasks (Roitblat, 1982) it seems likely that dolphins and sea lions code these arbitrary signals in working memory *prospectively* rather than retaining *retrospective* information about the preceding conditional cue. That is, following a gestural signal information is retained concerning the features of the anticipated object choice rather than retaining information about the gestural sign: The animals immediately transform gestural signals into representations of objects. Linguistic performance (in humans), in contrast, involves the manipulation of information encoded in symbolic structures (words). This

is what we meant when we said that "sea lions, like dolphins, . . . , code things and dimensions imaginably and not in words or 'grammatical terms.' " (Schusterman & Gisiner, 1988a, p. 346).

Connections Between Signs Are Established by Conditional Sequential Discriminations

Since signs were combined in invariant sequences, for example, Object + Action or Object A + Object B + Relational Action, all five marine mammals developed a *conditional sequential discrimination*, that is, they were sensitive to a particular serial order of signal presentation (see Schusterman & Gisiner, 1988a, 1988b).

First the sea lions, like the dolphins, had been trained carefully in a stepwise fashion to perform a signaled action on one signaled object for a fish reward. We call this the Single Object Rule. Next they were trained to perform an action relating two objects. We call this the Relational Rule. Finally, they were trained to perform a signaled action to one of two paddles—the left one associated with the absence of the signaled object and the right one associated with the presence of the signaled object. We call this the Interrogative Rule. Training and performance variables on the interrogative are described by Herman and Forestell (1985) for dolphins and by Grimm, Schusterman, Gisiner (1988) for sea lions. We, along with Herman and his colleagues (Herman, 1987, 1988; Herman et al., 1984), chose to emphasize the relational instruction because it presents the more difficult cognitive processing problem (for example, see Herman, 1987, pp. 17-18 for a comparison of the "simpler, nonrelational sentences" and the "more complex, relational sentences").

The activities generated by training marine mammals on these three rules are interpreted by us as basically cognitive activities or knowledge purposely directed to achieving goals or eliminating obstacles to those goals (Tolman, 1932). In other words, the animals had learned problem-solving skills. As Terrace (1979) reminds us in his critical review of Premack's book *Intelligence in Apes and Man*, an animal's closeness to man, either in terms of homologous or analogous psychological traits, does not exempt it from Lloyd Morgan's canon stating that an animal's behavior should be explained at the simplest level unless there is overwhelming evidence that an interpretation involving higher or more complex processes is required. We are further reminded by Terrace that "whether problem solving, no matter how elaborate, can ever simulate language is, of course an empirical question" (Terrace, 1979, p. 174).

The Relational Instruction

Animal language researchers frequently train their subjects by using variations and combinations of operant and classical conditioning or social modeling procedures before evaluating their subjects' linguistic skills on what are usually a series of transfer tests. Herman (1988)

states that our training techniques with sea lions were nearly identical to those used with the dolphin Ake:

Because Schusterman has spent extended time at our laboratory observing our procedures and in-progress research, has sought our advice frequently on training procedures for his sea lions as he was conducting his studies, and has had our reports available, the overlaps are no accident. This is all to the good, because it allows, in principle, for meaningful comparisons across studies as any replication should. (pp. 349-350)

We agree entirely. Both private and public acknowledgments of these facts have been made repeatedly (e.g., see Schusterman & Krieger, 1984, p. 3). After all, with verifiability as one of its major goals, science is of necessity a social enterprise.

Unfortunately, in his published material, Herman has been relatively noninformative about training variables. For instance, compare Herman's (1980, pp. 413-418) and Herman et al.'s (1984, pp. 156-159) accounts of how conditional stimulus control was acquired over object orientation in dolphins with that of Schusterman and Krieger (1984, pp. 12-14) who arranged nearly identical contingencies for sea lions. Or contrast the detailed description of how the sea lions were trained to use the "relational rule" (Schusterman & Gisiner, 1988a, pp. 324-326) with the bare bones account of how dolphins acquired a similar skill (Herman et al., 1984, pp. 156-159). A major issue in a comparative analysis of cognitive and linguistic abilities is the use of appropriate training procedures. The techniques employed by Herman and his associates incorporated a combination of three-, four-, and five-term contingencies (see Epstein, 1986; Hull, 1935; Sidman, 1986) which were crucial to the outcomes and, to some extent, the interpretations of their experiments and ours.

What follows are brief comments regarding why we chose to emphasize the *relational instruction*, which stresses both "short-term" or "working memory" and "long-term" or "reference memory," as compared to single object instructions which primarily stress the latter. Brief comments are also addressed to issues regarding the ways signals were combined and organized into the three "rules" governing or controlling the animals' language-like performances.

Relational and Nonrelational Data: Lumping and Splitting

By teaching their dolphins a relational rule that depends solely on sign order (what we have termed a *conditional sequential discrimination*), Herman and his associates have greatly increased the number of unique instructional sequences that can be generated from a limited set of signs (about 23 reported in 1984; about 35-40 reported in 1987) (Herman, 1987; Herman et al., 1984). For example, although the dolphin Ake had the potential of doing only 180 single object instructions, she could be given more than 284 unique relational

instructions. This does not include the five-sign relational instruction, which would have greatly increased the total number of relational instructions. Though they report giving Ake a few trials of five-sign relationals (which include both a modified goal item, GI, and a modified transport item, TI, plus a relational action), Herman et al. (1984) do not provide what they call the "number of unique sentences for this semantic category" nor has Herman ever explained why Ake was never given more than a few initial probe trials with five-sign relational sequences (Herman, 1987). Even more dramatic differences between the number of sequences generated by the relational rule as compared to the single object rule come from our sea lion studies. For example, Rocky could do only 844 different single object instructions as compared to 6223 unique relationals. The comparable figures for Gertie are 100 and 274 (Schusterman & Gisiner, 1988a, p. 329). It is the ability of dolphins and sea lions to acquire this conditional sequential discrimination superimposed on arbitrary matching which makes the relational problem-solving task resemble a language, albeit a simple one.

How well did the dolphins and sea lions do when their behavior was governed by the relational rule as contrasted to the single object (or nonrelational) rule? Although Herman (1987, p. 21) tends to lump the relational and nonrelational results, they can be separated to reveal large differences in performance on relationals compared to nonrelationals. For example, in tests conducted in 1982 (broken down in Herman, 1986, p. 234; Herman et al., 1984, Tables 6 & 7), the dolphin Ake responded wholly correctly to only 66% of her 128 three- and four-sign relational sequences while responding wholly correctly to 95% of her 179 two- and three-sign nonrelational sequences. Comparable data for the dolphin Phoenix shows that she was wholly correct on 81% of 232 three-, four-, and five-sign relationals while being wholly correct on 93% of 136 two- and three-sign nonrelationals. Similar differences in carrying out relational versus nonrelational instructions occurred for sea lions. For example, in tests conducted in September of 1988, Rocky responded wholly correctly to only 47% of her 68 three-, four- and five-sign relationals while responding wholly correctly 96% of the time to her 273 two-, three- and four-sign nonrelationals. Sea lion Gertie shows comparable performance deficits in carrying out relational instructions as compared to single object instructions.

Thus, there are fundamental performance differences on relational instructions compared to performance on nonrelational instructions. It is, therefore, misleading of Herman et al. (1984) to lump relational and nonrelational data under the heading of "All," as they do in Tables 3 through 8, and to imply that Ake, for example, responds correctly on 83% of her trials regardless of which rule was governing her behavior. Instead of the many syntactic rules listed in Table 2 of Herman et al. (1984), there are only two rules (relational and single object) that control an animal's performance on these language-like tasks, as has been pointed out by Premack (1986), who approached this problem logically,

and by Schusterman and Gisiner (1988a, 1988b), who used an empirical approach. Predictably, if the relational instruction takes the form Object A + Object B + Action (as it does with the dolphin Ake and the sea lions Rocky and Gertie), then Object B or the TI which is acted upon directly following the relational action sign should be a source of relatively low error variance, and Object A or the GI, because of the interference generated by encoding and maintaining the TI, should be a source of relatively high error variance. This is exactly what we found and is shown in Table 9 of Schusterman and Gisiner (1988a). The GIs accounted for about 90% of the errors while the TIs accounted for less than 6% of the errors on relationals. This means that the first part of the performance of a relational instruction (fetching the transported item or TI) is comparable to performance on a single object instruction (and is indeed trained that way).

Moreover, we did experiments and data analyses which suggested that sea lions developed biases toward certain GIs. This reference memory strategy frequently enabled them to respond at better than chance to relational instructions. Within the context of these language-like tasks, do dolphins also develop biases toward specific GIs and, if so, do such biases play a role in their better than chance responding? At present this data is unavailable for the dolphins. Herman has provided some nonempirical information that biases do play a role in relational responses. For example, Herman (1986, pp. 239-240) reported that Ake made more errors to the "indirect object" (what we call the GI or goal item), that these errors "occurred mainly when the indirect object was . . . a transportable object," and that "Longer search times for the direct object produced higher error rates to the indirect object," In his 1987 paper Herman states that goal item errors were 3.5 (Phoenix) and 4.4 times (Ake) as frequent as errors in the choice of a transport item and that "for Ake, errors were more than twice as frequent when the destination was a transportable object than when it was a nontransportable object, and for Phoenix errors were more than four times as frequent." The numerical data supporting these statements has not, to our knowledge, been published. We have shown that these data can be reported quantitatively (Schusterman & Gisiner, 1988a, 1988b) and that such empirically based reports also reveal other sources of response bias, such as object type and number of objects in the pool, that have not yet been covered in Herman's linguistically guided analyses.

Working Memory and Relationals

As noted earlier, it seems probable that most animals on arbitrary matching or conditional discrimination tasks code such information prospectively rather than retrospectively. We are puzzled, therefore, by Herman's assertion that transportable objects "must be encoded and remembered retrospectively—solely in terms of a representation of the stimulus" whereas tank fixtures "may be coded prospectively" solely by virtue of the location information they provide (Herman, 1988, p. 355). To

the best of our knowledge, there is no model of working memory that allows only position information to be encoded prospectively. Therefore, Herman's hypothesis that a memory coding conflict between retrospective and prospective processes is responsible for biases in goal item errors is based on a misapprehension about memory coding.

On the other hand, it seems reasonable to suppose that sea lions, dolphins, and most other animals might have difficulty in applying the relational rule (GI + TI + FETCH or TI + FETCH + GI) because of a processing limitation in their working memory. By this, we mean that the memory loss in a relational instruction occurs because the last chunk of information (signs designating the TI) knocks out the previous chunk (signs designating the GI). The ordering of this information is determined by the organization of the response behavior, not by the order of sign stimuli given. Our model is therefore applicable to Phoenix's sign sequences, as well as Rocky and Ake's relational sequence form. This notion would also account for Rocky performing better on reversed relationals than on original relationals (Schusterman & Gisiner, 1988a). Such reasoning further suggests that sea lions might actively think about or attend to the GI and hold it in working memory to a greater degree than usual if they were primed by being signaled to act directly on that object several times immediately before that same object was used as the GI on a relational trial. Results from these kinds of experiments with Rocky and Gertie confirmed this hypothesis (Schusterman, Gisiner, & Hanggi, 1988).

"Belongingness" and Modifiers

We have no disagreement with Herman (1988) about how modifier signals like LARGE, SMALL, BLACK, and WHITE used with sea lion Rocky are attached to the object sign which they precede. Even so, adjacency is not as important as Thorndikean belongingness, as we recently learned in an experiment on Rocky's responses to anomalous sequences (Gisiner & Schusterman, 1988). If Rocky was given an added but inappropriate modifier sandwiched between an appropriate modifier sign and an object sign (e.g., BLACK LARGE WATERWING, FETCH), Rocky ignored the inappropriate modifier (she was never taught to respond to different sizes of waterwings) and responded reliably to the appropriately modified object (i.e., the black and not the white waterwing). In this case, temporal contiguity of stimulus characteristics are neither necessary nor sufficient for establishing an association in long-term memory. What appears critical is that the two mental representations be unified, and this frequently results from situations which promote belongingness of the two events (see Thorndike, 1931).

However, Herman's proposed evidence concerning how the dolphins attach spatial modifiers to objects runs into some difficulty. For instance, if modifiers are used in the relational instruction BALL, LEFT PIPE FETCH and if as Herman (1988, p. 358) states "there was no restriction on referring to paired objects without use of a modifier term," then there

were sometimes (the exact frequency was not specified) two balls and two pipes available for the dolphin Ake. If she responded correctly, did Ake bring the pipe on her left to the ball on her left or to the ball on her right? An answer to this question is crucial if we are to believe, as Herman does, that the relational rule permits construction of semantically contrasting sequences by reordering signs. In the context just previously described, when given the instruction LEFT BALL, PIPE FETCH with two pipes to choose from, a response of fetching the right pipe to the left ball would be a more convincing demonstration of "correct" modifier assignment than bringing the left pipe to the left ball.

Search Strategies and the Processing of Sign Sequences

Related to the problem of choosing an object from two possible correct choices is the question of what the animals are doing while they are being given an instruction. Herman (1988, p. 358) asserts that the dolphins, or at least Ake, attended only to the signaler during signaling and relied solely on memory to guide her performance; what he calls "holistic" processing. This assertion is at odds with his other accounts of the dolphin's performance. For example, Herman et al. (1984, Figure 5) describe Ake as "moving to her left and not waiting for the terminal FETCH gesture" when given the second of two successive object signs in a relational sign sequence. In the second relational sequence depicted in this figure Ake first "leans left toward the ball," then on the second sign "starts right toward the basket, again not waiting for terminal FETCH gesture." Finally, in a modified, four-sign relational sequence of the type discussed in the previous section, Ake is described as "leaning right" while being given a RIGHT sign then "moving toward RIGHT FRISBEE" when the object sign is given. By the time the last sign, the FETCH signal, is given Ake is "already at the frisbee on her right and beginning to transport it" (Herman et al., 1984, Figure 6). These accounts indicate that Ake, like Rocky, is doing some partial processing of the instruction prior to the completion of the signaling process.

Our point when we first described the processing differences between Ake and Rocky (Schusterman & Gisiner, 1988a), and our point here, is that individual animals will differ in the way they process signs given in complex combinations. These differences in processing strategy are, as has been the case with Rocky, capable of revealing important information about complex cognitive performances (Schusterman & Krieger, 1986). Undoubtedly, differences in the number of signs processed in combination, the perceptual abilities of the animal, the delay between signal and performance, and the amount and type of intervening information, plus other variables, will all affect cognitive performance. It is an area of cognitive psychology that merits thorough and careful investigation.

Relational Actions

Herman (1988) expresses concern that, with only one relational

action sign (FETCH), we are unable to determine whether the action sign is contributing any information to the sea lion or whether the two object signs alone might be sufficient to elicit Rocky's sole relational actions: fetching one object to another. This is a valid point of concern, which can be tested in more than one way. One way would be to train a different relational action as Herman has done, giving the animals more than one relational action to choose from. We instead tested the role of the relational action sign by omitting it from random sequences, thereby giving Rocky only the information conveyed by the two object signs (Gisiner & Schusterman, 1988). She failed to produce a response to any of the sequences lacking an action sign. Since relational action signs, like action signs used in single object sequences, acquire their functional role through Skinnerian response shaping techniques, simple performance of the action designated by the sign can actually tell us very little about the semantic function of the signs.

Furthermore, since the dolphins' relational action signs are used only to cue a relational response it is possible that the relational action sign alone, regardless of the number of object signs, could elicit a relational response. That is, if Ake was given the sign for IN/ON and just one object sign, will she nevertheless perform a relational action? We, in contrast, used the same FETCH sign in single object and relational contexts. If Rocky was given one object sign and the FETCH sign she was required to fetch the designated object to the signaler. If she was given two object signs and the FETCH sign she was required to fetch the second signed object to the first signed object. Rocky had to correctly process the conditional cues of one versus two object signs in order to select the correct action in response to the FETCH sign.

Finally, we should point out that Herman et al. (1984) added the relational action IN/ON to Ake's and Phoenix's vocabulary "after completion of the majority of testing reported in the data tables" (p. 144). Herman has never, to our knowledge, done an analysis contrasting the relational action IN/ON with FETCH.

Calculating Probabilities of Correct Response

Our mathematical treatment for deriving chance probabilities of completely correct responses was developed for just one purpose: to test whether performance on a particular task could, *in any part*, be the result of guessing, that is a choice made at random. Our treatments took into account the cumulative training of response behavior and the demonstrated ability of the animals to perform antecedent, related tasks. Our mathematical procedures also took into account the contextual limitations on responses available to the animals. For example, we considered object choices to be limited by the number of objects available for response at that particular time, rather than by the number of object signs taught to the animal, because the animal could not produce a response to an object not in the pool.

We make no claims that our statistical treatment is a "model" of how the animal solves the problem. Our only intent was to provide a statistical test that could exclude chance performance on even one element of the problem, the element of interest in the relational instruction being the goal item. We did so because the statistical test used by Herman et al. (1984) yielded expected values a full order of magnitude lower than what the animals could achieve by partial solution of the problem coupled with random choice of one element (e.g., the GI or goal item). Their model could not, therefore, stand as a useful method for statistically testing complete comprehension of the sign sequence. We felt their mathematical model suffered from a reliance on the assumption that the dolphins must be processing the instructions linguistically and a denial of the trained behaviors upon which the performances were based, but these issues have already been covered. The important point is that their mathematical "model" cannot act as a statistical tool for discriminating correct processing of an *entire* instruction from correct processing of *part* of an instruction combined with guessing.

A Functional Definition for "Word," "Symbol," and "Name"

We gave reasons (Schusterman & Gisiner, 1988a) why we believed that Herman's linguistically phrased explanations of the dolphins' performances were more than "metaphors" and why such linguistic "metaphors" provided a misleading heuristic device for understanding the actual performances achieved by the animals (see Herman, 1986, 1987; Herman et al., 1984). We will expand on that point.

We suggested that conditional cues have become more than conventional discriminative stimuli only when signs and their referents are shown to be immediately interchangeable as are human words and the things they signify (*symmetry*). Another form of symbol use occurs when words or symbols refer to other symbols (the property of *transitivity*). Schusterman and Gisiner (1988a, 1988b) previously stated rather emphatically, and here we repeat, that neither Herman's bottlenosed dolphins nor our California sea lions have yet demonstrated that they can readily interchange signs and referents as is typically the case when humans use symbols. Words, symbols, or names used by humans seem to be far more flexible than the conditional cues or signals used to designate or refer to objects in these language comprehension experiments with marine mammals. We stated that although these animals can correctly choose an object such as a ball or a person when given a BALL sign or a PERSON sign, they have not as yet shown that they can reverse the procedure and immediately choose the appropriate signs when presented with the objects person or ball, and so forth. For example, if an English-speaking child is presented with the written word BALL and learns to choose a ball instead of another alternative object, then that child will probably choose the written word BALL instead of

another alternative written word when first presented with the object ball (Sidman, 1971).

Using Sidman and Tailby's technique (1982), animals reputed to name objects or understand the names of objects, such as dolphins, sea lions, anthropoid apes, monkeys, and parrots, can be tested systematically to evaluate whether they are capable of acquiring equivalence relations or semantic correspondences from the conditional discriminations that they have been taught. The ability to form equivalence relations is likely to be the cognitive skill most crucial to both language acquisition and numerical competence (Schusterman, in press). These equivalencies include the properties of *reflexivity*, *symmetry*, and *transitivity*. Significant comparative work has already begun in this area. For example, Sidman et al. (1982) found that although five-year-old humans have no difficulty reversing previously acquired conditional relations, both adult rhesus monkeys (*Macaca mulatta*) and adult baboons (*Papio anubis*) have difficulty reversing the relation "if A, then B," to "if B, then A." As a hypothetical example, these Old World monkeys would have difficulty reversing the relation "if gestural signal BALL, then choose the object ball" to "if the object ball, then choose the gestural signal BALL." Supporting the notion that symmetry or bidirectionality between signal and referent is one of the defining properties of symbols is the recent finding that language-able children (retarded and normal) showed symmetrical responding to classes of stimulus shapes whereas language-disabled children did not demonstrate symmetrical responding, but were able to acquire conditional discriminations (Devany, Hayes, & Nelson, 1986).

Herman (1988) seems not to have understood our argument (see pp. 317 and 318 in Schusterman & Gisiner, 1988a) about the necessity for the conditional relation between sign and referent to be *symmetrical* in order to have attained the status of a "name," "word," or "symbol," that is, to become in his words "a unique semantic entity." Instead of testing for symmetry between signals and referents, Herman (1986, 1988) has done a not entirely convincing test of *reflexivity*, which requires that each signal be conditionally related to itself. As Sidman and Tailby (1982) point out, reflexivity translates behaviorally into generalized identity matching. Instead of getting the dolphin Phoenix to respond symmetrically to the conditional relation: if A₁, then B₁; and if B₁, then A₁, Herman used a fading technique to get Phoenix to respond reflexively to the conditional relation: if A₁, then B₁; and if B₁, then B₁. Specifically, Herman held the referent constant (e.g., an object such as a frisbee) and switched Phoenix's task from arbitrary matching, where an acoustical signal (A₁) activated a representation of the frisbee, to an identity task where a frisbee (B₁) shown visually to the dolphin activated a representation of the frisbee. We also question the validity of Herman's procedure because, if equivalence within (reflexiveness) and between (symmetry and transitivity) stimulus classes is to emerge, it must do so without additional training and prompting (Sidman & Tailby, 1982). By

pairing A_1 (an acoustical signal) with the object B_1 while requiring a choice of another B_1 instead of B_2 , and so forth, and gradually eliminating the presence of A_1 , Herman was certainly prompting Phoenix. A valid test of whether Phoenix responded reflexively in this situation would be to show her a frisbee (FRISBEE) followed by an action signal (e.g., OVER) and see if she jumps over the frisbee without "acoustical" prompting or training. There is some indication that Herman (1986) did this in six transfer tests and that Phoenix responded appropriately to the identity matching task in five of those six instances. Schusterman reported a similar result with the sea lion Rocky to Gary Bradshaw and Lou Herman (unpublished results presented at the Conference on Dolphin Cognition and Behavior at the Hubbs Marine Research Institute at Sea World, September 1983). We think that bottlenosed dolphins and California sea lions probably show a generalized identity matching within the context of these language comprehension tasks, but Herman has yet to demonstrate that the dolphins Ake and Phoenix are capable of interchanging their signs and referents as most humans do with words and the things they signify.

Animal language researchers, including Herman and his associates as well as ourselves, have yet to experimentally demonstrate conditional relations of signal and referent into the three defining characteristics of equivalence relations (i.e., reflexivity, symmetry, and transitivity) (Sidman & Tailby, 1982). For that reason, single object instructions have much less in common with language than suggested by Herman (Herman, 1987; Herman et al., 1984). Nevertheless, as noted by Catania (1980), conditional discriminations delineate aspects of language which, although not themselves linguistic in nature, create the potential for language to emerge. If equivalence relations are formed, then the relevance of conditional discriminations is greatly extended "to language and other cognitive phenomena" (Sidman, 1986, p. 226).

Summary and Conclusion

We have reiterated our position that animal cognition should be described from the bottom up, taking into account the associationistic basis upon which more complex relations are built. We have described the role we consider conditional discriminations play in the emergence of complex performance. We do not rule out, and indeed look forward to, the demonstration of other learning abilities that may play a role in complex cognitive performance, including language, but we advocate an operational definition of terms. As Skinner said (1935):

The problem of definition is, after all, an experimental one, and the entities which we are to use in the description of behavior are experimental entities. We have placed ourselves at a great disadvantage in trying to find among our data evidence for a preconceived term, when our primary concern ought to be simply with putting the data in order. (p. 40)

References

- CARTER, D. E., & WERNER, T. J. (1978). Complex learning: A critical analysis. *Journal of the Experimental Analysis of Behavior*, 29, 565-601.
- CATANIA, A. C. (1980). Autoclitic processes and the structure of behavior. *Behaviorism*, 8, 175-186.
- CUMMING, W. W., & BERRYMAN, R. (1965). The complex discriminated operant: Studies on match-to-sample and related problems. In D. I. Mostofsky (Ed.), *Stimulus generalization*. Stanford, CA: Stanford University Press.
- DEVANY, J. M., HAYES, S. C., & NELSON, R. O. (1986). Equivalence class formation in language-able and language-disabled children. *Journal of the Experimental Analysis of Behavior*, 46, 243-257.
- EPSTEIN, R. (1986). Bringing cognition and creativity into the behavioral laboratory. In T. J. Knapp & L. C. Robertson (Eds.), *Approaches to cognition: Contrasts and controversies*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- GISINER, R., & SCHUSTERMAN, R. J. (1988). *Sequence and syntax in language trained sea lions*. Presentation to the 1988 Animal Behavior Society meeting, Missoula, MT.
- GRIMM, B., SCHUSTERMAN, R. J., & GISINER, R. (1988). *Two sea lions report presence and absence of "named" objects*. Presentation to the 1988 Animal Behavior Society meeting, Missoula, MT.
- HERMAN, L. M. (1980). Cognitive characteristics of dolphins. In L. M. Herman (Ed.), *Cetacean behavior; mechanisms and functions*. New York: Wiley Interscience.
- HERMAN, L. M. (1986). Cognition and language competencies of bottlenose dolphins. In R. J. Schusterman, J. A. Thomas, & F. G. Wood (Eds.), *Dolphin cognition and behavior: A comparative approach*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- HERMAN, L. M. (1987). Receptive competencies of language-trained animals. In J. S. Rosenblatt, C. Beer, M.-C. Busnel, & P. J. B. Slater (Eds.), *Advances in the study of behavior* (Vol. 17). Petaluma, CA: Academic Press.
- HERMAN, L. M. (1988). The language of animal language research: Reply to Schusterman and Gisiner. *The Psychological Record*, 38, 349-362.
- HERMAN, L. M., & FORESTELL, P. H. (1985). Reporting presence or absence of named objects by a language-trained dolphin. *Neuroscience and Biobehavioral Reviews*, 9, 667-681.
- HERMAN, L. M., RICHARDS, D. G., & WOLZ, J. P. (1984). Comprehension of sentences by bottlenosed dolphins. *Cognition*, 16, 129-219.
- HULL, C. L. (1935). The mechanism of the assembly of behavior segments in novel combinations suitable for problem solution. *Psychological Review*, 42, 219-245.
- LASHLEY, K. S. (1938). Conditional reactions in the rat. *Journal of Psychology*, 6, 311-324.
- PREMACK, D. (1986). *"Gavagai!" or the future history of the animal language controversy*. Cambridge, MA: MIT Press.
- ROITBLAT, H. L. (1982). The meaning of representation in animal memory. *Behavioral and Brain Sciences*, 5, 353-406.
- SCHUSTERMAN, R. J. (in press). Language and counting in animals: stimulus class and equivalence relations. *Behavioral and Brain Sciences*.

- SCHUSTERMAN, R. J., & GISINER, R. (1988a). Artificial language comprehension in dolphins and sea lions: The essential cognitive skills. *The Psychological Record*, 38, 311-348.
- SCHUSTERMAN, R. J., & GISINER, R. (1988b). Animal language research: Marine mammals re-enter the controversy. In H. J. Jerison & I. Jerison (Eds.), *Intelligence and evolutionary biology*. Berlin: Springer-Verlag.
- SCHUSTERMAN, R. J., GISINER, R., & HANGGI, E. (1988). *Priming memory on a language task in sea lions*. Presentation to the 1988 Animal Behavior Society meeting, Missoula, MT.
- SCHUSTERMAN, R. J., & KRIEGER, K. (1984). California sea lions are capable of semantic comprehension. *The Psychological Record*, 34, 3-23.
- SCHUSTERMAN, R. J., & KRIEGER, K. (1986). Artificial language comprehension and size transposition by a California sea lion (*Zalophus californianus*). *Journal of Comparative Psychology*, 100, 348-355.
- SIDMAN, M. (1971). Reading and auditory-visual equivalencies. *Journal of Speech and Hearing Research*, 14, 5-13.
- SIDMAN, M. (1986). Functional analysis of emergent verbal classes. In T. Thompson & M. D. Zeiler (Eds.), *Analysis and integration of behavioral units*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- SIDMAN, M., RAUZIN, R., LAZAR, R., CUNNINGHAM, S., TAILBY, W., & CARRIGAN, P. (1982). A search for symmetry in the conditional discriminations of rhesus monkeys, baboons, and children. *Journal of the Experimental Analysis of Behavior*, 37, 23-44.
- SIDMAN, M., & TAILBY, W. (1982). Conditional discrimination vs. matching to sample: An expansion of the testing paradigm. *Journal of the Experimental Analysis of Behavior*, 37, 5-22.
- SKINNER, B. F. (1935). The general nature of the concepts of stimulus and response. *Journal of General Psychology*, 12, 40-65.
- TERRACE, H. S. (1979). Is problem solving language? A review of Premack's *Intelligence in apes and man*. *Journal of the Experimental Analysis of Behavior*, 31, 161-175.
- THORNDIKE, E. L. (1931). *Human learning*. New York: Appleton.
- TOLMAN, E. C. (1932). *Purposive behavior in animals and man*. Berkeley: University of California Press.