JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1970, 14, 107-125 NUMBER 1 (JULY)

A FUNCTIONAL ANALYSIS OF LANGUAGE[1]

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Language has been given a largely structural definition by linguistics, but in order to have a psychological theory of language, the structural emphasis must be replaced by a functional one. What must an organism do in order to give evidence that it has language? More specifically, when is a response a word? A sequence of responses a sentence? What makes one response sequence an assertion or predication, another an imperative, still another a question? In this paper I try to give these questions the most general answers possible, general in the sense of relieving them of their exclusively human form.

The functions an organism carries out when engaged in language need to be separated from the form these functions take in man. Not only human phonology but quite possibly human syntax may be unique to man; both may encompass mechanisms not found in any other species (Chomsky, 1965; Lenneberg, 1968). But if this is so, it does not commit the mechanisms of logic and semantics to the same status. The latter may be more widely distributed and it may be them, not the human form of syntax and phonology, upon which the basic functions of language depend.

Strict Training Procedure: A Recipe for Teaching Language Functions

This paper is organized around two interlocking lists. The first is the list of functions, the things an organism must do in order to give evidence of language. The ideal list of this kind will be exhaustive, although presently it is acceptable simply if it avoids glaring lacunae and contains only items that are patently important. The second is a parallel list of strict training procedures. For each function on the first list, the second gives at least one and preferably several alternative ways of producing the function. A strict training procedure is essentially a recipe. Given a decision as to what constitutes, for example, competence in the interrogative—the ability to ask and answer questions—the second list offers a set of instructions showing how to train an organism so as to instill the competence in question. Clearly the difficulties of the first list greatly exceed those of the second. It is far more elusive a task to explicate what interrogation or predication consist of than, given a decision on the former, to produce a training procedure that will inculcate the competence in question. Indeed, a strict training procedure is no more than an ordered series of steps, each one to be accomplished before the next one is begun, and each one so small as to be atomic, *i.e.*, manageable by a docile organism. Although certain species, man notably and even other higher primates, may be capable of taking many steps at a time—so that for them an atomic decomposition of the task was not a necessity to begin with—the strict training procedure is happiest when it reaches the lowliest organism; it knows no other way of doing this than by breaking the task into the smallest steps possible. It should be recognized from the beginning, however, that there is no mechanical procedure for generating recipes. The notion of an atomic step is a primitive. Furthermore, a strict training procedure is not an explanation of how, as a result of carrying out the prescribed steps, the organism accomplished the function in question. A recipe is a method, not a theory, though by merit of its success, often a method in search of a theory.

[1]Based upon an invited APA address (Div. I), 1969, Washington, D.C. Mary Morgan, J. Olson, Randy Funk, and Deborah Petersen are the exceptionally patient and ingenious research assistants who made the study possible. The research was supported by NIH grant MH-15616. Reprints may be obtained from the author, Dept. of Psychology, University of California at Santa Barbara, Santa Barbara, California.

Chimpanzee as a Drawing Board

The chimpanzee will be our drawing board. I will take only four items from the first list, which elsewhere I am attempting to deal with comprehensively, and show how application of the corresponding training procedures to the chimpanzee results in the functions in question. The functions considered are: word, sentence, question, and metalinguistics. Each one opens out into further topics, some of them classical such as displacement—talking about things that are not present—and predication—asserting a state of affairs (as opposed to requesting it). Displacement and predication have both been cited as uniquely human, as hallmarks of man and language. Certainly they are impossible without language but, as we will see, they are not unique to man. It is unfortunate in a sense to use the chimp as the drawing board, for it is too close to man. It will be more illuminating if later the same functions can be instilled in nonprimates. But teaching an organism language amounts in part to mapping the built-in knowledge of its species; this will be brought out here in a number of examples. And this knowledge is difficult, even perhaps impossible, to disinter in species far removed from man. The greater accessibility of this knowledge in the case of the chimp is the main reason we start with it, more than the fact that it is bright and playful.

Physical Basis of Language: Plastic Words

The physical basis of the language used with the chimp is plastic varying in shape, size, texture, and color. Each word is a metal-backed piece of plastic that adheres to a magnetized slate (see Fig. 1). The sentences are written on the vertical, an ancient form of writing once used by certain human groups (Hewes, 1949), but adopted here simply because in the beginning it appeared to be the chimp's preferred style. The two sentences shown in Fig. 1 can be paraphrased in English as follows: "Sarah take honey-bread," and "no Sarah take jam-cracker," respectively. Since the language is written rather than spoken or gestured, words are permanent not evanescent, and sentences are displaced in space not time. This has overwhelming advantages for short-term memory. Once written on the board, the sentence can remain indefinitely, giving the chimp time to pick its bizarre profile and think the matter through before responding. The permanence of the sentence not only makes it possible to study language without a memory problem, but to study memory in the context of language by regulating the duration for which the sentence remains on the board.

In addition, because the experimenter makes the words—the chimp merely uses them—he can control their supply. The words available to the chimp at any moment in time can be varied in number, kind, type/token ratio, *etc.* as the experimenter chooses. The adult animal, or one proficient in the language, can be given an unlimited supply of words along with the opportunity to produce sentences at will. Then the physical organization of its vocabulary can be observed; whether, and if so how, it lays the words out in piles to enhance their availability for sentence construction, or the degree to which it can be trained to adopt favorable organizations. But the main advantages are to the training of the naive animal; since the number of alternatives can be controlled, so can the difficulty of the problem.

There are no phonemes in the language, the most elementary unit being quite deliberately the word. Elsewhere we have described a phonemic system suitable for the chimp (Premack and Schwartz, 1966), and can also describe a system intermediate between the present one and the earlier phonemic one, a system of words with an implicit phonemic structure that can be made explicit at any time the experimenter considers propitious. But the implications of these different systems are merely practical. Although the systems vary in their assets and liabilities, no one of them is in any sense a necessary condition for the general functions of language.

Human phonology is an adaptation to specific needs that are intrinsic to the human condition but not to language. These needs can be eliminated, obviating the need for mechanisms to resolve them, and the system that remains is still language. For example, the principal traits of human phonology, the phoneme and the auditory channel, are both parts of a solution to a common problem. Limitations on man's memory on the one hand, and ability to generate discriminably different responses on the other, make it impossible or highly inefficient for him to attempt to map a large world by devising an irreducibly different re-

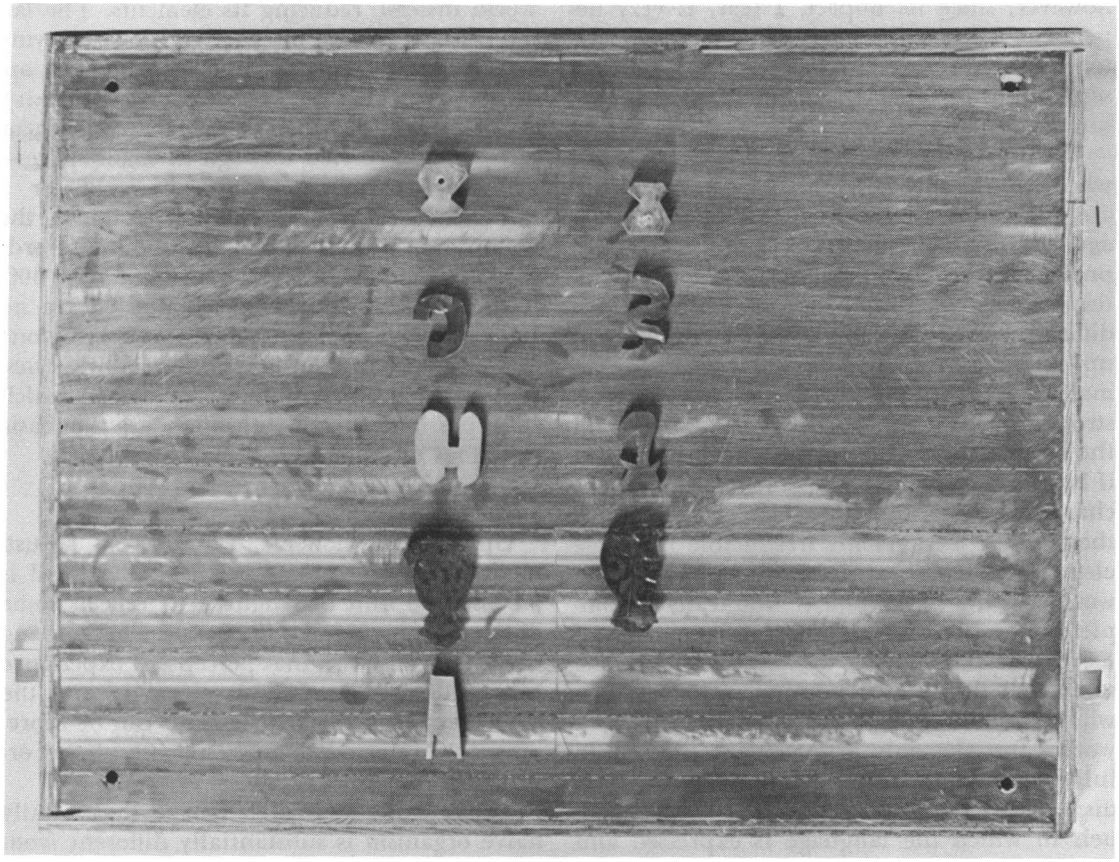


Fig. 1. The physical basis of the language is plastic, varying in color, size and shape. Each piece of plastic is a word; the pieces are metal-backed and adhere to magnetized slate. Sentences are written on the vertical. A word-by-word translation of the two sentences is: Sarah honey bread take; No Sarah jam cracker take. Notice the occurrence of "no" or the negative particle as a free morph (independent word) in both Fig. 1 and 3, and in the bottom half of Fig. 4 as a bound morph appended to "name of" forming "not name of".

sponse for each word. Rather than attempt to generate and store 40,000 or even 5,000 different words, he produces instead only about 50 or so different phonemes. By combining these manageably few responses, he produces the large number of words needed to map his complex world.

The auditory channel also makes its contribution to the same problem; indeed, in an important sense it makes the combinatorial approach possible. Not the auditory channel *per se,* but the fact that the modality of man's language is different from the primary modality in which he perceives his world. Man is predominately visual, while his language is auditory. It might be thought that an auditory language is merely a profound convenience—conferring the possibility of whispering while copulating or speaking while writing on the board—but the contribution is of a far deeper nature. To begin with, if the modalities were not different, it would be impossible to distinguish at a glance a member of the language system from a member of the system referred to by the language. This simple distinction—telling a word from that which the word refers to—would require an inquiry of a kind that is nearly impossible to appreciate if your experience with language is confined to the human case. You must work in an artificial system to appreciate this problem; in Fig. 3 I have deliberately included a case where a member of the language system and a member of the world referred to by the language not only both belong to the same modality, but overlap so markedly in dimensional values that one can barely be told from the other. There is no sense in dwelling on this point,

however, since its impact, I fear, is very dependent upon experience with artificial systems that do not provide for those critical separations so much taken for granted in the human system.

But the minor confusions that can result when words and designata are not immediately distinguishable is the least of the damage that could be done the combinatorial approach. If the language modality and that of the primary perception of the world did not differ, the language would very probably end up ikonic not phonemic. The tendency to match items on the basis of similarity is as strong as the tendency to associate them on the basis of contiguity, probably stronger. But if language elements were to match the salient characteristics of the objects which they name, there would be as many irreducible language elements as there are objects named in the world. Such a development would be in complete opposition to the need for a small set of meaningless elements—meaningless in the sense that they match nothing in the world—whose combinations are used to produce words. But the only arrangement that could fully guard against this ikonic possibility is a disparity in modality, a difference in the channels in which the language is expressed and the world is perceived. Nothing could more effectively preclude matching and thus allow for the emergence of language elements fewer in number than the number of elements named by the language. Thus, a primarily visual organism like man would require an auditory or at least a nonvisual language, even as an auditory organism if there were one might end up with a visual language.

But this whole set of problems reflects limitations on human information processing; it has little to do with the logically necessary properties of language. Neither the need to map a "large" world nor a limitation in operating characteristics leading to the desirability of a combinatorial approach to lexicon, are pressures which a system must accommodate in order to qualify as language. An artificial subject (computer) or prosthetics added to an experimental subject might extend memory or make for a superior response generator; or we might simply accept a thoroughly ikonic language: no general language function would appear to be precluded by an ikonic lexicon. Alternatively, we might operate upon the world instead, reducing its elements. The latter is an attractive alternative, since carrying out the basic language functions does not appear to require a world of human complexity. All the essential functions of language apparently can be carried through in small spaces—arbitrary "corners" of a real world, or a diminished artificial world. For example, the chimp to be described here has about 40 words at present. In all likelihood, this could be 400, if the focus were vocabulary. But I have no interest in vocabulary *per se,* not a large one in any case. Indeed, the more intriguing question is: what is the smallest lexicon in which it is possible to carry through all the basic functions of language?

General Functions: Word

Unlike the phoneme, which is an adjustment to a nonessential problem, the word is an essential unit of language. It reflects some of the most basic features of experience, among them the consensus that perceptual experience can be divided into stable elements, and the agreement that all such elements can be represented or referred to by responses of the organism.

The introduction of language to a totally naive organism is substantially different from introducing new words to an organism already equipped with a bit of language. "X is the name of Y" is a powerful device that can be used to teach words to the advanced subject, as is shown in the section on metalinguistics. But here we are talking of first words and a totally naive subject. With this subject, a vital first step is to establish a simple social transaction between the subject and the trainer. We establish this transaction well, assuring ourselves that it holds no concepts of which the subject is incapable, for it is this transaction we will map with language. Mapping, as the many examples to follow will show, amounts to dividing a routine into its component classes, displaying the range of values that each class can take, and assigning a name to each of the values.

A feeding routine makes an effective transaction with a young chimp. The trainer places an edible item on the table between him and the subject and looks by benevolently while the chimp takes it and eats it. Once or twice, after giving the fruit to the chimp, the trainer may "request" that the fruit be given back to

him; he extends a cupped hand and extrudes his lip to the best of his ability, mimicking the supplication chimps direct at one another, but the imitation is unsuccessful. The chimp looks puzzled, even hesitant, but never gives back the fruit, so the trainer goes on with that part of the routine that is successful, laying fruit out and watching the chimp eat it.

Then one day, after the transaction is well established, the trainer places an element from the language system, a piece of colored plastic, alongside a piece of fruit, say, a banana. The banana is now farther back than usual, out of reach, while the plastic chip is forward, easily within reach. The animal is induced to make a prescribed response with the language element, in this case, place it on the language board, after which she is given the fruit. The chimp is almost immediately proficient in this act. Causing objects to adhere to a vertical surface is something it does readily in contrast, for example, to producing human sound. (Notice that in this system, unlike the human one, production need not lag behind comprehension. The subject does not make but merely uses the words, and can do so from the beginning without having to undergo elaborate motor learning. Thus, the earliest training can occur in the production, as well as in the comprehension, mode. This can be an advantage in training young subjects, since the control of attention is more certain when the subject is required to respond rather than merely observe.)

What does the piece of plastic mean to the chimp? The question is hopelessly premature at this stage for, in a sense, all of the training that lies ahead is an attempt to inculcate a system that will make it possible to answer questions of that kind. The question is one to which the subject's own answers can contribute importantly, provided we can make the subject susceptible to questions. How to confer question-answering ability upon a chimp is illustrated in the section on the interrogative.

The rest of the training consists of making simultaneous changes in some aspect of the transaction and in some aspect of the language system, so as to establish a correspondence between the two systems. For example, we may start with the fruits that are offered. The set of possible objects is defined by offering different fruits on different trials and each time with a corresponding change in the language element. When the fruit is banana the plastic chip is of one kind, when apple of a different kind, and when orange still a third kind. On each trial the chimp's task is the same: place the piece of plastic that is alongside the fruit on the board before receiving the fruit.

Two kinds of tests will show whether or not the subject has formed an association between members of the object class and of the corresponding language class. Trials on which the chimp is given two would-be words but only one piece of fruit will determine whether it can match the word with the fruit. But the subject may know more than such choice trials reveal. If the subject is less interested in the fruit that is offered on a particular trial than the fruit that is not offered, it may use the "wrong" word essentially as a request for the fruit that it prefers. This possibility can be detected by obtaining independent preference orderings on the fruits and on the words. For example, allow the subject to choose between all possible pairs of fruits and on another occasion all possible pairs of words. If its preferences among the words agrees with its preferences among the fruits, then the subject must know what word goes with what fruit, whatever its choice behavior may suggest to the contrary.

The next perceptual class is mapped in the same fashion. Each change in fruit was accompanied by a change in the language element; now, in similar fashion, each change in donor —the person giving the fruit—is accompanied by a change in the second language element. For example, when Mary is present and the fruit is apple, the chimp (Sarah) must write, "Mary apple," to receive the apple; with Randy present, "Randy apple," *etc.* Associations for members of the donor class can be tested in the same way as for members of the object class. With one trainer present but two or more donor words, the subject must match the word to the trainer. Similarly, if necessary, a preference ordering can be determined for donors' and would-be donors' names, and the concordance between the two orderings taken as evidence of an association.

In addition to being required to place two pieces of plastic on the board, the chimp is required to observe a proper order. "Mary Apple" is accepted but "apple Mary" is not.

In the sentence toward which she is progressing, words will occur in the one order but not in the other. Thus, in the target sentence, "Mary give apple Sarah" we find "Mary apple" but not the reverse. The correct order is required from the beginning so that incorrect orders will not have to be unlearned later. In addition to the order requirement, we observe an anti-regression rule. Once she reaches a two-word state, we reject one-word fragments, even as we reject two-word fragments when she reaches a three-word stage, *etc.* (This rule is rigidly enforced only at this tender stage, when there is uncertainty not only in her use of language but, more important, in our estimate of how much language she actually knows. At a later stage, fragments are welcomed, it being of interest to see what the proportionality may be between her use of fragments and the redundancy in the situation.)

The fruit and the donor are easily mapped; the other two classes in this example present difficulty, though of a practical kind. For example, the attempt to map the recipient by varying who it is that receives the fruit runs into difficulty of a predictable kind; the chimp is reluctant to produce response sequences calling for a recipient other than herself. Similarly, the attempt to map the operator, by varying the action upon the fruit—sometimes giving it as before but other times cutting it or inserting it in a pail—encounters the same problem; some of the outcomes are so nonpreferred that, once she has associated the language element with the undesired action, she will not form the sentence. These are strictly practical problems, however; they can be dealt with for the most part by arranging appropriate contingencies; *e.g.,* when Sarah writes "Mary give apple Jim," thereby effectively denying herself the apple, she can be given a tidbit more preferred than apple. If reinforced, altruism can become quite reliable.

The order in which the transaction is mapped—fruit, donor, operator; or donor, recipient, *etc.*—is not something we have tested yet. Also, it may make a difference how many members of one class are established before a new class is introduced; this too remains to be tested. Notice, however, that while we may puzzle these minor parameters, we have no comparable hesitation in deciding a far more basic matter, *viz.,* how to partition the transaction in the first place. Why is this so?

The effect of the order of the mapping can readily be converted into an experimental question, as can the number of entries that should be established in one class before proceeding to another, for we have no difficulty in proposing alternative orders or numbers. But the effect of alternative partitionings, of dividing the transaction one way rather than another, does not go over into an experimental question, for we are incapable of proposing significantly different partitionings. We see the situation one way and one way only. There is a recipient, a donor, the object that is exchanged, and the act of giving. All alternative partitionings that we may propose will turn out to be trivial variations on this one, proposals either to omit a class or to slice an existing class more finely. Our freedom in this matter consists in our choice of situations to map; thus, rather than start with feeding, we might begin with body care and lead into the operator "wash" and names for parts of the body. We are not free in how to divide this situation. We are free to choose the situation but not free in our choice of how to divide it.

These perceptual constraints must have a great practical advantage, however. The organism being trained in language could not be less circumscribed perceptually than we are. If both organisms see the situation the same way this must greatly facilitate the training, in ways that we have not yet fully worked out.

In summary, while many variations remain to be explored, the basic procedure for teaching words to a naive organism is extremely simple. A transaction is established between the subject and the trainer and a decision is made as to the salient perceptual classes into which the transaction should be divided, a decision that will prove to be remarkably easy. Then each class is rotated through a series of values, in the present case, apple, banana, *etc.;* Mary, Randy, *etc.;* give, insert, *etc.;* Sarah, Jim, *etc.,* the other classes being held constant. As the value of the perceptual class is changed, a corresponding change is made in the language element. And as each new class is mapped, the language requirement is increased. In the beginning, the chimp merely took the fruit, looked over benevolently by the trainer. Then one word was required, two, three, until finally target sentences were realized such as "Mary give apple Sarah."

General Functions: Sentence

The subject may produce properly ordered strings of words and yet give no essential evidence that the string is a sentence. A sentence differs from a string of words in that it has an internal organization, a knowledge of which is a necessary condition for correctly responding to it. The knowledge can be represented by a tree diagram of the sentence or the application of parentheses, both of which will show the dependencies between any one word in the sentence and all the others (e.g. Chomsky, 1965). I will deal with this topic under two headings—two-term relations and hierarchical organization—in the course of which we will see some examples of the dependencies that distinguish a sentence from a string of words.

Symmetrical Relations

The conditions leading to the necessity for syntax are general, involving information that is commonplace rather than exotic. Perhaps the simplest condition is the symmetrical two-term relation such as can be found in geometrical propositions, for example, and in some of the verbs of social behavior. These semantically disparate topics have in common relations whose terms can be interchanged. For example, A on C but also C on A; X talks to Y but also Y talks to X. This interchangeability makes it impossible to distinguish physically the class of items that can take one position in the relation from the class that can take the other position. In the limiting case the membership of the two classes can be completely interchanged, so that, for example, anything that can be on top can also be on the bottom, and anything that can talk can also be talked to. In cases of this kind there is no other way to identify the position of the item in the relation than by the order of the corresponding word in the sentence. This state of affairs contrasts with what we may call a *closed* relation, where there is a well-marked difference between items that take one position in the relation and those that take the other position, and for which a semantic covariation rule is a sufficient kind of organization.

For example, the verb "insert" as we have used it with Sarah involved a closed relation and could be dealt with by a semantic rule. In Sarah's experience as in ours, she (and Mary and Randy and Jim) insert(s) pieces of fruit in dishes and pails, but pieces of fruit do not insert her (or Mary or Randy or Jim). Inserters are one kind of thing, insertables a different kind. "Insert" could therefore be treated as a relation between two classes defined on the basis of physical or functional properties of the membership, which is what a semantic covariation rule amounts to. On this treatment "Sarah insert banana," "banana insert Sarah," "insert banana Sarah," *etc.* should not differ from one another; if the subject's training included experience with variable word order, so as to safeguard emotional reactions to novel forms, its response should be the same to all possible forms of the string. (Notice that one limitation of semantic covariation rules is already evident. The world need not change, and oranges begin to insert Marys, in order that we may want to talk about such possibilities. But such talk would not be possible with semantic covariation rules; semantic rules set limits on speculative discourse that syntactic formulations do not.)

The prepositions "on", "under", and "to the side of" involve physical relations which we do not doubt that the chimp can discriminate and which can be trained in a manner that will assure a complete interchange of the items that take the two positions in the relation. To evaluate the chimp's capacity for syntax we must make certain that the prepositions are in fact learned on a syntactic basis. This is possible only if the application of the preposition is restricted to so-to-speak semantically neutral domains—cases where one form of a relation is as sensible as the other. For example, objects that differ only in their color will fulfill this condition, for red on green has no semantic edge over green on red, unlike, for example, fly on horse, which is notably more probable than the reverse. This restriction is necessary because, although prepositions are in principle symmetrical, they may be used asymmetrically in the beginning and defined improperly as a result. For instance, the regularity with which children go on bikes, cups on saucers, plates on tables, lamps on floors, *etc.* may lead the child to define "on" as a semantic rule in which the larger of two items goes on top and the smaller on the bottom. Only accidents in which, for example, bike ends up on child or plate ends up on food, not to mention later sexual experience, may induce the child to abandon the initial

semantic formulation and redefine the word on purely syntactic grounds. Since, however, our control of the training sample is better than that of the average parent, we need not rely on accidents to assure that our subject uses syntactic definitions from the beginning.

Four color words—"red", "green", "blue", and "yellow"—had been taught the subject earlier, and we used them in training the prepositions. Two by four cards, painted one of the four colors, but indistinguishable otherwise, were used as the objects. The cards were placed on top of each other with the top one offset a bit so that the bottom one could be seen. The four color words make possible 12 different cases, *e.g.*, "red on green", "green on red", "blue on red", *etc.* "On", "under", and "to the side of" have special interest in a language written on the vertical. The order of the elements in the sentence and the order of the elements referred to by the sentence are the same in the case of "on", opposite in the case of "under", and unrelated in the case of "to the side of". We are interested in determining whether the isomorphism between the two orders or the lack of it will affect the rate of learning; unfortunately, at the moment, "on" is the only one for which the training has been completed.

Using the colored cards as described, we trained her in the comprehension mode, where she was required to respond to our sentences and then subsequently tested her ability to produce the same sentences herself. The training proceeded in three steps, the first restricted to one pair of colors, the second dealing with her ability to generalize to new colors, and the last examining her transfer from comprehension to production.

In the first step of the training, the red card was placed on the table before the subject, the trainer wrote on the board, "green on red", handed Sarah the green card and then induced her to place it on the one that was already there. I describe this procedure, which is in no way unusual, simply to illustrate the general strategy of a strict training procedure: to bring about the desired behavior by limiting the possibility for other kinds of behavior. The step used is hardly the only possible one, and had it failed we would have tried others, which illustrates a second characteristic of strict training procedures: they are based on judgment not algorithms.

Next, the opposite sentence "red on green" was presented, now with the green card down and the red card handed to the subject as the one to be placed on top. Subsequently, the subject was given both cards and presented first with one form of the sentence and then with the other. Once she was proficient at producing the card arrangement called for by the sentence, she was given sentences using all four color words, *e.g.*, "yellow on blue", "red on yellow", *etc.* She performed as well on the 10 new cases as on the two training cases (red, green), demonstrating that she had not simply memorized the training cases but could apply the preposition to new cases. (These tests do not demonstrate that she could use "on" in any domain other than color—or indeed even with colored blocks rather than cards—but that question, though intriguing, is not germane to the present discussion of syntax.)

The last step concerned her ability to produce sentences appropriate to the trainer's behavior, rather than, as in the initial training, to behave in ways appropriate to the trainer's sentences. On each trial she was given three words, two color words and "on", and required to place them on the board in a way that corresponded to, or described, the trainer's placement of the cards. Thus, if the trainer put the blue card on the green one, Sarah, who held the words, "green", "blue", and "on" in her substantial hand, was required to write "blue on green" and not *vice versa*. Her proficiency at this was 80% in the first set of 10 trials, which is indicative of a high order of transfer, since about 80% correct is her usual asymptotic performance level for essentially all problems.

Hierarchical Organization

Consider the sentence, in chimp language, "Sarah insert banana pail apple dish." Translated into English this is the instruction to separate the banana and apple, to put the former in the pail and the latter in the dish. But to carry out that quite simple instruction, or instructions of that general kind, requires a knowledge of the internal organization of the sentence. That organization can be shown by using parentheses to indicate the dependencies among the words. For example, {Sarah insert [(banana pail) (apple dish)]} shows that "banana" and "pail" go together, likewise "apple" and "dish"; that "insert" applies not only to

"banana-pail" but to both cases, and finally that it is Sarah who is to carry out the action.

This example carries us beyond word order to a second contribution of syntax—hierarchical organization of the sentence. How essential is that factor? What would be lost if, for example, the strings of words in the language were sensitive to order but were not organized hierarchically? We can answer that question by comparing the subject's behavior to the above sentence under conditions in which an understanding of it was based on either of three levels of organization: (i) word knowledge or gross semantic rule, (ii) refined semantic rule, or (iii) hierarchical.

Several years ago in working with psychotic children, R. Metz and I devised some tests of language comprehension to determine whether the severely impaired speech production, which characterized these children, was owed to performance factors or to something deeper. Having earlier confirmed Lenneberg's (1967) surprising claim that the feeble-minded child is grammatical, I was distinctly surprised when some of the psychotic children failed all of the comprehension tests (while at the same time performing adequately on nonlanguage tests). They had what we ended up calling "word knowledge" but, so far as our tests could determine, little else. Response to the sentence in question at the level of word knowledge would amount to the following.

Understanding of the word "Sarah" would result in Sarah's carrying out whatever action was carried out rather than waiting for, say, Mary to act, as she would on the occasion of sentences that began with "Mary". Secondly, an understanding of the word "insert" would assure action of one kind—putting one thing into another—as opposed to cutting, taking, giving, some of the other verbs or operators that she knows. Third, the objects acted upon would be confined to those named. But with no more than word knowledge, there would be great latitude in what was inserted into what. Every object could be inserted into every other; thus, the dish could go into the pail as readily as the banana go into the dish, *etc.* Clearly, the specific pairing of banana with pail and apple with dish that would alone constitute evidence of an understanding of the (hierarchically organized) sentence would not be guaranteed by a knowledge limited to individual words.

A higher level of organization could be provided by semantic covariation rules; they could limit the possible outcomes, bringing them closer to the desired one, but would still fall short. Actually, what we have called word knowledge could be formulated as a coarse semantic covariation rule; the second level of organization would then amount to the addition of a second semantic rule which would have the effect of refining the first rule. Thus, the first case could be analyzed in a manner already suggested above, as a rule in which the verb was the predicate and the agents and objects were the arguments taken by the predicate. This could be diagrammed as:

insert

agents objects

emphasizing the focal role of the verb or operator and the secondary role of that which instanced the verb, inserters on the one hand, and objects of insertion on the other.

The addition of a second semantic rule could differentiate the object class, separating the containers (dish, pail) from that which gets contained (apple, banana, *etc.*). This better defined situation could be diagrammed as:

insert

agents objects

fruits containers.

The additional definition of the semantic space would further delimit the subject's behavior, *e.g.*, it would keep the dish out of the pail, but it would no more assure the exact outcome indicative of an understanding of the hierarchically organized sentence than the first organization. Indeed, no combination of semantic rules could assure that outcome since, so to speak, pails and dishes will accept one kind of fruit as readily as the other.

Training Procedure for the Compound Sentence

I will now describe the procedure we used to teach the chimp to respond correctly to the sentence in question, though without claiming that she is therefore unquestionably proficient in syntax. Proving competence in syntax is ticklish, not impossible, but difficult or at least arduous. Testing any highly inferential

matter is, of course, more troublesome than when the hypotheses lie closer to the surface of the data. The problem is aggravated by a factor which the reader might guess simply by recalling his own childhood. Grammar is not the chimp's favorite subject. There is a limit to the number of tests she will accept on a grammatical topic, and that limit is not always sufficient to include all the control sentences one might desire.

The training proceeded by three steps, all in the comprehension mode. First, she was trained individually on each of the four simple sentences of which the compound sentence in question could be composed. These included:

Sarah insert banana pail.
Sarah insert apple pail.
Sarah insert banana dish.
Sarah insert apple dish.

The trainer wrote each sentence on the board, at the same time offering a choice of fruits and containers, and requiring the subject to place the designated fruit in the designated container. Next, she was given all possible pairs of the sentences, side by side, in the manner of a paragraph. For example,

Sarah	Sarah
insert	insert
banana	apple
dish	pail.

Since no change was made in the composition of the individual sentences, this step was intended merely to accustom her to carrying out two acts of insertion, as is required by the compound sentence.

In the final step, all possible pairs of sentences were again combined, this time one immediately above the other, and this conjunction of two simple sentences was gradually converted into one compound sentence. The procedure generated sentences of this kind:

(i)	*(ii)*	*(iii)*
Sarah	Sarah	Sarah
insert	insert	insert
banana	banana	banana
pail	pail	pail
Sarah	insert	apple
insert	apple	dish
apple	dish	
dish		

Neither the deletion of the second use of "Sarah" nor the subsequent deletion of the second use of "insert" disrupted her performance. She was performing at between 75 and 80% correct, her customary level, and continued to do so when the changes were made. Nor was the subject disrupted by the subsequent generalization tests we have carried out. These tests are incomplete in that while we have substituted fruit names (*e.g.*, grape, apricot, orange for those used in training, we have not yet changed the verbs, and these may present more difficulty. Also, there are some *ad hoc* rules that she might be using in processing the compound sentences, not all of which have been explicitly eliminated by test. I will describe just one as an example of the several that could apply.

For example, she might use a rule that said, in effect, apply the container word to the object word above it. This would work for the individual sentences but would run into trouble when one sentence was written above the other; then the bottom-most container word would apply to two object words, one directly and one indirectly above it. In the compound sentence in question, the rule would lead her to apply dish correctly, but pail incorrectly, for pail would apply to both apple and banana both of which are above it. There was no evidence for an error of this kind.

This error could be overcome, however, if the rule were expanded to read apply the container word to the fruit word *immediately* above it. But this modification would fail in the case of sentences of this kind:

Sarah
insert
apple
dish
apple
banana
pail

for apple would go into dish but would fail to make it into pail. That is, the effect of "immediately" would be to confine pail to banana. This is one of the control cases we have not yet tested.

Notice that these *ad hoc* rules, though not yet explicitly eliminated by test, are *not* necessarily more parsimonious than the kind of rules that could generate the hierarchical organization which could equally well account

for her present performance. Nevertheless, the question of her syntactic competence must remain undecided for the time being, until we have examined a larger portion of the sentences that she is capable of making.

Interrogative and the Concept of Sameness or Identity

Except for formulations like "red on green," *etc.,* which the chimp produced in conformity to the trainer's placement of the cards, and which can be interpreted as declaratives, the other sentences—both those of the trainer and the subject—were in the imperative mood; *e.g.,* "Mary give banana Sarah," "Sarah take banana pail orange dish," *etc.* There have been no questions and no metalinguistic propositions. By the latter I have in mind the use of language to teach language, as in the case of "X is the name of Y," where a so-far unnamed object is given a name, or "X is a synonym for Y," where an object with one name is given another one.

We will treat the interrogative first. It can be introduced in several ways, of course, though we found highly effective a procedure that exploited the concept of sameness or identity. Thus, some of the very first questions we asked the chimp were, in English paraphrase, "What is the relation between those objects, identity or non-identity?" Identity or sameness is a concept for which the chimp can readily distinguish between positive and negative instances. It is therefore an ideal subject matter for questions, since in the beginning at least there is no point in asking the chimp questions she cannot answer. Also, the procedure leads naturally from the wh- form of the question to the yes/no form. Hence, the advantage of the procedure is that the chimp is asked questions she can answer and the several forms of the question develop in a natural succession from a common situation.

What are the concepts that the chimp knows? Fortunately, we need not guess but can answer that question directly through matching-to-sample procedures. For example, if given a cup and a spoon, and another cup set somewhat apart from the other two objects, the subject will indicate by whatever gesture we choose, that the cups go together or participate in a relation which the cup and spoon do not. This procedure, which does not depend upon language and which can be applied broadly, is a boon to the teaching of language. With it we can determine what it is that the subject already knows and thus can avoid wasting time attempting to teach the subject names for concepts it does not know. Only with rare exceptions—of a kind I will deal with in the section on metalinguistics—does language teach the subject new concepts. Mostly it merely teaches names for concepts the subject already knows.

The matching procedure is not restricted to object identity but can be used to inventory the overall conceptual knowledge of the subject. For example, the subject can be given objects that match on no other basis than that of color, or shape, or size; or sets of objects that match on no other basis than that of area, volume or number. Similarly, it can be used to assess the capacities for perceptual transformations. The subject can be required to match (three-dimensional) objects to their (two-dimensional pictures), or *vice versa*—something that Sarah does nicely—as well as match one orientation of an object or picture to another orientation. Whenever it is shown that the subject can distinguish between positive and negative instances of the concept in question, it is reasonable to attempt to introduce a name for the concept. For the procedure by which a name is taught for the most abstract concept is no different from the one by which a name is taught for the most mundane object.

Having established that the subject is capable of matching like objects, a name is established for the fact of sameness or identity—as well as a name for non-identity—in the same way names were previously established for objects, actions and agents. We establish a consistent relation between positive instances of the concept and one language element and negative instances and a second language element. In the actual training, two objects, say two cups, were placed before her at a small distance from one another. She was given a piece of plastic, intended to mean same or identical, and required to place it between the two like objects. On other trials she was given objects that were not the same and required to place a different language element between them, one intended to mean non-identical or different. (Notice how an exactly analogous procedure can be used to map the concept of equality and inequality. For example, three

marbles are set slightly apart from three sticks, and the subject is required to place an equality sign between them. On other trials, two marbles are set apart from five sticks, and the subject is required to place an inequality sign between them. Both the schema for identity and for equality are so far hybrid, *i.e.*, contain elements from the world and from the system mapping the world. For example, XXX = YYY, or stick, stick, stick = marble, marble, marble, rather than 3 = 3. To convert the hybrid sentence into a pure form requires naming the objects so that the relation can be stated between names of objects rather than objects themselves. Likewise, converting the hybrid equation into a pure form requires naming the number of the objects so that the relation can be stated between numbers rather than number of objects. The traditional question about the arithmetic ability of infrahuman primates has been misformulated. Can chimps be taught to count or to do arithmetic? That is a misleading way to put the question. A better way is: do chimps recognize numerosity? That is, can they match sets of objects that have nothing in common except the fact of their equal number? That question can be answered, in a matter of hours, with matching-to-sample procedures. If the answer is positive, there would be little doubt but that they could be taught to count. But if the answer is negative and the chimp cannot recognize numerosity, though some might remain sanguine I would not wish to be the instructor. Teaching a concept and mapping one that already exists are different enterprises.)

Were the proper associations formed between the language elements on the one hand and cases of identity and non-identity on the other? That was established in the usual manner. She was given both the words for same and different in the presence of a case of, say, identity on one trial and non-identity on the next, and required to match the word to the case. She was also given generalization tests to determine whether she had merely memorized the training cases. We tried her on a variety of new cases, including new combinations of old items, entirely new items, and new items for which names had and had not been previously taught. But these experimental niceties proved to be in vain, for she made so few overall errors that one condition could not be differentiated from another. Also, she made no more errors on non-identity than on identity. Thus, in principle, the subject could go about the cage, picking up pairs of objects, and labeling them identical or non-identical. Any instance of this kind, which she could previously recognize, she could now label as such. That is what the language training contributed. The matching-to-sample procedure established that she could distinguish between positive and negative instances of identity; the language training simply provided her with a name for a concept that already existed.

Interrogative

In the identity exercise above the chimp is already being asked a question. If you were to instruct an English-speaking subject in the same task as the chimp's, you would say something along these lines: "What is the relation between the two objects, are they the same or different?" The chimp is asked the same question but without benefit of an explicit interrogative marker. The only marker she has so far is the implicit one of the space between the objects—into which she is to insert her answer—along with the fact that the trial does not end until she completes the schema by adding the third item.

The question can be made explicit by any one of the three standard linguistic devices: inflection, word order, or an interrogative particle. We chose the latter as the simplest both in the sense of involving the least change for the subject and of being most compatible with the present physical system. So we simply added a question marker to the schema she was already receiving. For example, where we previously wrote:

A A
"identical" "non-identical"

we henceforth wrote

A ? A
"identical" "non-identical"

We are now in a position to look at examples of all there types of questions which the identity exercise generates. The first two are wh- types—what or which—while the last one is of the yes/no form. Examples of two versions of a wh- type question are shown in the upper panel of Fig. 2; they can be paraphrased as "X is what to X?" and "X is what to Y?". The alternatives for both versions are "identi-

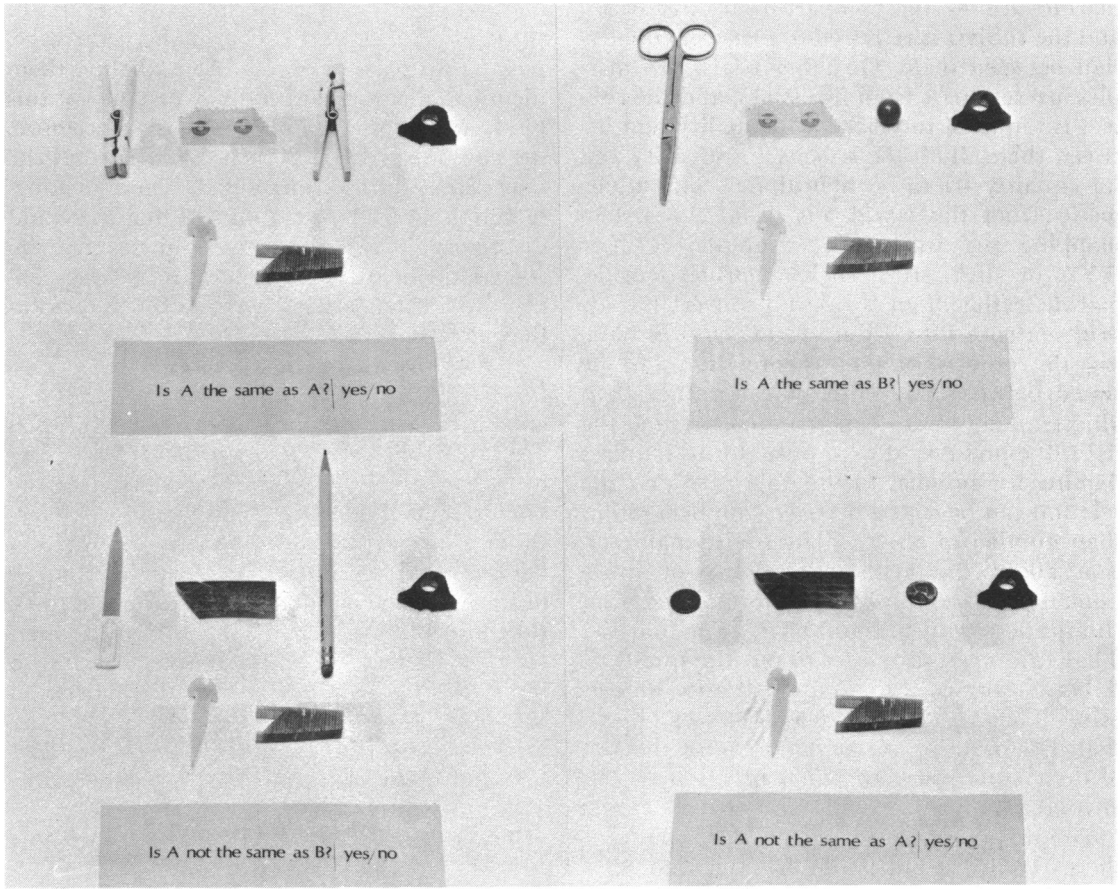


Fig. 2. Four Wh-type questions, with English paraphrases.

cal" or "non-identical" and the subject's task in both cases is to replace the interrogative marker with the word appropriate to the case.

Two versions of a second type of wh- question are shown in the lower panel of Fig. 2; they can be paraphrased as "X is the same as what?" and "X is not the same as what?" The alternatives are no longer the words "identical" or "non-identical" but the objects themselves. The subject's task remains essentially the same, however: to replace the interrogative particle with the appropriate object.

The yes/no question, which is shown in Fig. 3, has four forms rather than two as in the wh- questions, and these can be paraphrased as (i) "Is X the same as X?", (ii) "Is X not the same as X?", (iii) "Is X not the same as Y?", and (iv) "Is X the same as Y?". Her alternatives now are neither the words "identical" or "non-identical" nor the object X and Y, but the words "yes" and "no". Her task remains the same: to replace the question mark with either "yes" or "no".

The chimp is capable of answering correctly all the question types shown, for an essentially unlimited variety of items, words as well as objects. In this case, too, the generalization tests, requiring that she recognize the concept when applied to items not used in training, proved that she had not merely memorized the training cases but could apply the concept broadly. Indeed, the subject has never failed a generalization test. Though often trained on no more than two positive and two negative instances of the concept, she has always been able to apply the words to cases not used in training. How shall we explain this? If we adopt the position that in teaching a new word we are at the same time teaching a new concept, generalization emerges as a mystery. But if we recognize that concepts antedate the language training, there is then little mystery in

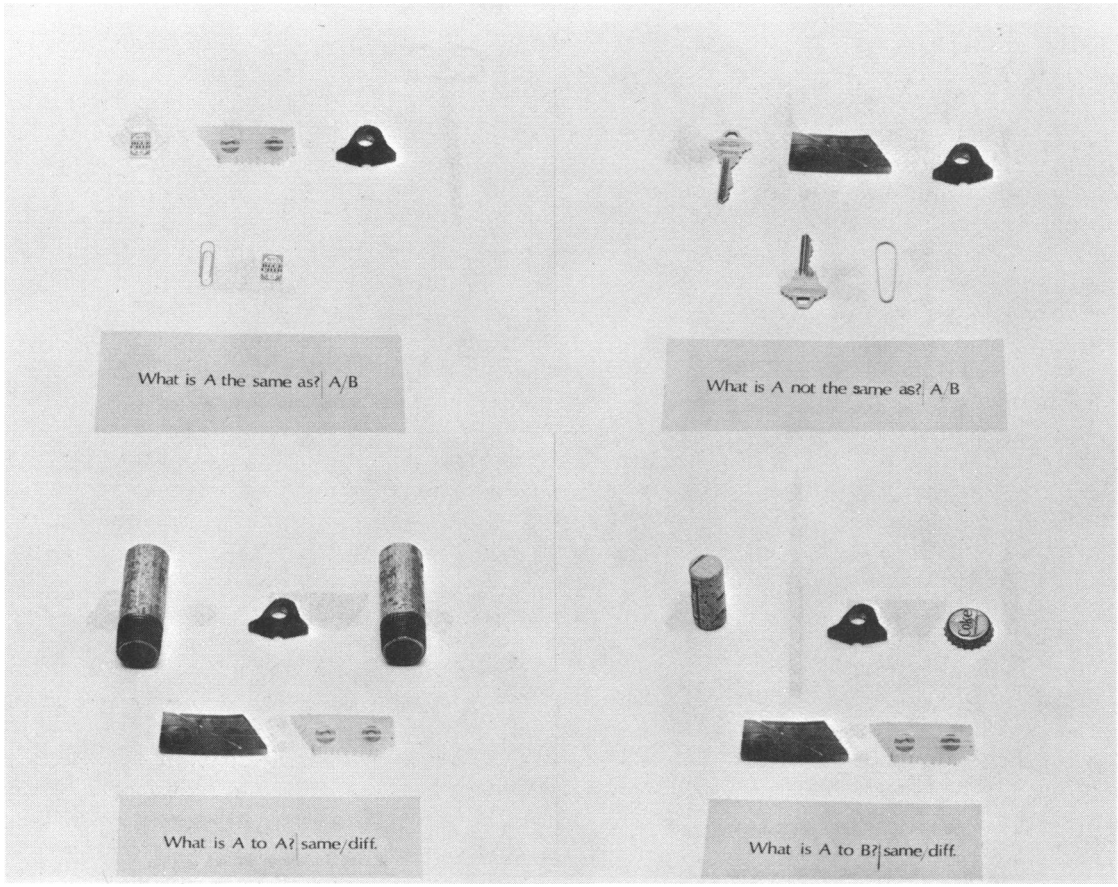


Fig. 3. Four yes/no type questions, with English paraphrases. Notice how one of the objects shares dimensional values with the language elements and, though not a word, is easily confused with the words.

the subject's ability to apply words beyond the training cases. Only failures in generalization would speak against the existence of concepts that antedated the language training.

Consider three objections to calling the above expressions questions. First, each case has the form of a one-to-one substitution: The interrogative particle is removed and replaced by a single item. Human interrogation does not suffer from this limitation since answers may be of any length.[2] But in fact, the present system is not restricted to one-word answers either. The answers considered have been short because the language is simple; in addition, there are already counter-examples in which answers consist of more than one word. For example, if we give her as alternatives, "no" and "identical"—rather than "identical" and "non-identical"—when the question asked of her is "A ? B," *i.e.*, what is the relation between A and B?, she will answer "no identical," which though laconic is nonetheless a two-word answer and is thus no longer a case of one-to-one substitution. (Her ability to use the negative particle in this fashion is of considerable interest in its own right, though not to the present discussion.)

Second, she has answered but never asked any questions. This would be a serious objection if she failed to ask questions when given an opportunity to do so. But so far the omission is in the training program, not the subject. Our failure to have tested her ability to produce questions is a failure to have found a simple condition in which to make the test. (On one occasion the chimp offered her own solution to this problem. She stole the test materials for the lesson, as she does from time to time, and went on both first to produce and

[2] I am indebted to E. Klima for this interesting observation.

then to answer many of the questions we had taught her.)

Third, a quite different kind of objection might be made on the grounds that the questions are not themselves genuine. In human affairs, a question is often taken as evidence of (i) the speaker's ignorance and (ii) his assumption that the listener is less ignorant. Thus, a person may ask, "What time is it?" because (i) he does not know and (ii) he believes his listener does know. It is clear that the questions asked the chimp do not belong to this paradigm.

But it is equally clear what paradigm they do fit and also that the paradigm above is only one of several that figure in human interrogative behavior. Another strong paradigm is based on exactly the opposite assumption about the distribution of knowledge; it is the mainstay of the teacher's business and is the paradigm that is applicable here. The teacher knows the answer to the question and therefore asks it of the student to find out whether he too knows the answer. Thus, a father may ask his son, "What time is it?" thereby determining whether or not the boy can tell time. Although the distribution of knowledge is now the opposite of that in the first case, the utterance is no less a question.

Metalinguistics

The relation that now concerns us can be paraphrased as "X is the name of Y." In the relation just dealt with, *viz.*, "X is identical with X," the items instancing the relation were both objects. But the items instancing the present relation are a word and an object, a word which in positive instances of the concept is the name of the object, and a word which in negative instances is not the name of the object. The training procedure for establishing a name for this concept is nonetheless the same as for all the cases already described. In brief, positive instances of the concept are associated with one language element, negative instances with another.

The well-established words for apple and banana along with the corresponding objects were the training materials used. Thus, positive instances consisted of the pairs, "apple"-apple and "banana"-banana, and negative instances of the pairs, "apple"-banana and "banana"-apple. That is, positive instances consisted of a word and the object named by the word, negative instances of a word and an object not named by the word.

The subject was given a word-object pair set slightly apart and required to place between them the language element intended to mean "is the name of". Parallel trials were given on negative instances, *i.e.*, a pair such as "banana"-apple was set before her and she was required to place between them the language element intended to mean "is not the name of". Should we proliferate the vocabulary by introducing an independent word for the negative case, or should we economize and require her to form the name for the negative ("is not name of") by applying the negative particles to the name for the positive case? We compromised by introducing an independent name for the negative case which consisted, however, of the negative particle attached as a single unit to the name for the positive case (see Fig. 4).

Following the training in which the words "name of" and "not-name of" were associated with the negative and positive cases respectively, her associations were tested in a manner that took advantage of her competence in the interrogative. First, she was asked a wh- type question, in effect, "What is the relation between 'apple' and apple?" Her alternatives were "name of" and not-name of" and her task was to replace the interrogative marker with the word of her choosing. Next, her associations were tested with yes/no questions. For example, she was asked in effect, " 'banana' is the name of apple?" and required to choose between the alternatives "yes" and "no". She was tested on both versions of the wh- question as shown in Fig. 2, and all four versions of the yes/no question as shown in Fig. 3. The questions were confined at first to the four word-object pairs on which she had been trained, but once it was clear that she had mastered the training cases, this restriction was lifted and the same kinds of questions were asked of a number of word-object pairs that had not been used in training, some of them the names of fruits like those used in training and some of them not, *e.g.*, "dish" and "pail". Once again her performance on the generalization test did not differ materially from her performance on the training materials, indicating that she was able to apply the names beyond those few cases on which she had been trained.

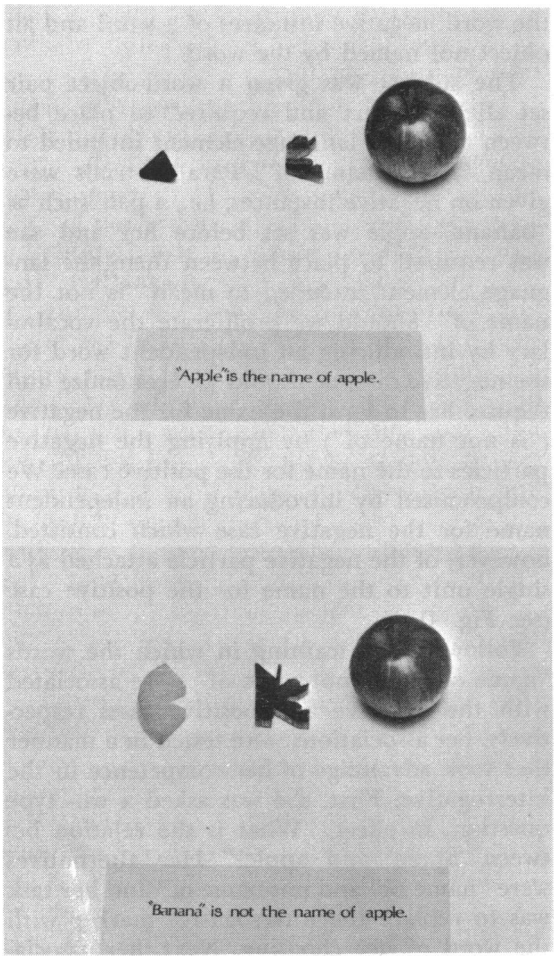


Fig. 4. Examples of the relation "X is the name of Y" and "X is not the name of Y". Note that the name for the negative relation amounts to the negative particle built onto the name for the positive relation.

Productive vs. Recognitional Use of a Concept

I have emphasized all along that language training is primarily a mapping of existing knowledge; it gives the subject names for distinctions that he or she could draw in advance of the language training. In the concept "name of" we have an important exception. This concept was inculcated by the language training and would not have existed otherwise. An interesting and powerful consequence of this fact is that this kind of concept can be used to generate new instances of itself.

In the standard generalization test, the subject may recognize instances of the concept that were not used in training, but this is not the same thing as using a concept to generate new instances of itself. In the generalization test, the cases called "new" are so only in the limited sense that they were not used in the training of the word in question. They are otherwise old, established cases. For example, when we found that the chimp could apply "name of" to "apricot"-apricot (and "not-name of" to "apricot"-raisin), we proved that she could apply the words to cases other than those used in training. But the pair "apricot"-apricot was not a new pair. It was an old pair with a history of use in sentences that the chimp had both produced and comprehended, some part of which history—exactly which part we do not yet know—enabled the chimp to identify the pair as an instance of "name of". This is quite different from introducing new words by telling the subject that this piece of plastic is the name of this object; and then finding that the piece of plastic is henceforth used appropriately in sentences dealing with the object in question. We will call the application of a word to new cases in a generalization test *recognitional,* to distinguish it from this second and more powerful use which we will call *productive.*

Fig and crackerjacks were objects that interested the subject but which had never been given names. We used them as the first objects to name with the use of the concept "name of" rather than the more laborious procedure of rotating a class through a range of values while at the same time changing the corresponding language elements (which, however, is the only procedure that can be used to teach a naive subject its first words. See above for a description of this more laborious procedure). A three-step procedure was used to introduce the new words, as well as test the effectiveness of the introduction by subsequently requiring her to use the word in a sentence.

First, a piece of plastic (potential word) and a fig were placed slightly apart and the word "name of" set between them; next a second piece of plastic was placed slightly apart from a fig and the word "not-name of" was placed between them. Had the subject paid attention to the lesson or had her attention wandered like that of students in classrooms everywhere? In order to answer this question we resorted to the interrogative, as teachers do everywhere, giving the subject both the wh- and yes/no forms of the question. In effect, she was asked,

"What is the relation between the piece of plastic and fig?" for which the alternatives were "name of" or "not-name of" and "Is this piece of plastic the name of fig?" where the alternatives were "yes" and "no". Her generally correct answers permit us to move to the last step, which required that she use the appropriate word in a sentence.

The materials set before the subject were a fig and a number of words; "fig", the piece of plastic she had been told was not the name of fig, the names of two other fruits, "give", "Sarah", and "Mary". The subject was given the fig when she produced the sentence "Mary give fig Sarah", which she did correctly on eight of the first 10 trials, never using the incorrect form for fig but twice using other established fruit names, perhaps as a request for these fruits (a methodological problem noted earlier). She was equally proficient when later exactly the same training procedure was applied to crackerjacks. Notice that the negative trials—on which she is told that X is not the name of Y—serve to rule out the possibility that the name is conferred simply by the geometry, by the physical contiguity between the language element and the object. Both when it is asserted that X is the name of Y, and when it is denied, the spatio-temporal relation between the language element and the object are identical. Yet only in the case of assertion does the subject go on to use the language element as the name of the designated referent.

Internal Representation: When Is a Piece of Plastic a Word?

When does a piece of plastic cease to be a piece of plastic and become a word? We might answer by saying, when it is used as a word: when it occurs along with other words of appropriate grammatical class in sentences, and when it occurs as the answer or part of the answer to questions. For example, we consider a small piece of blue plastic to be the name for apple because (i) it is the word used when, for example, the subject requests apple, and (ii) it is the answer given when the subject is asked, "What is the name of apple?" This is a standard treatment, and we cannot improve upon it, though we may be able to add to it. We might say in addition that the piece of plastic is a word when the properties ascribed to it are not those of the plastic but are those of the object designated by the piece of plastic. By what means can we determine whether this condition obtains?

This can be done quite directly by using match-to-sample procedures to obtain independent-features analyses of both the word and its referent. For example, to obtain a features analysis of apple the subject was given a series of trials on which an actual apple was presented along with two alternatives. Her task was to indicate which of the two alternatives was more like the apple than the other. The most explicit version of this test would make use of such words as "similar" or "more like than" but these words were not a part of her vocabulary at the time, and we did not find it necessary to instill them before doing the present tests. The subject's disposition to match-to-sample was strong enough so that the three items had only to be set before her in the established geometrical arrangement; this was sufficient to assure that she would select one of the alternatives. The alternatives used in the present tests were: a red plaque *vs* a green one; a square plaque *vs* a round one; a square plaque with a stem-like protruberance *vs* a plain square one; and a square plaque with protruberance *vs* a plain round one. The alternatives could be words, rather than objects instancing the properties named by the words. That is, the subject could be required to decide whether the apple was more like the words "red" and "green" rather than the red and green plaques. We did not use words because of limitations in Sarah's vocabulary.

After obtaining a features analysis of apple, we repeated the test exactly except for replacing the object apple with the name for apple. Once again the subject was requird to indicate whether the sample—now a piece of blue plastic—was, for example, red or green, round or square, *etc.* Although the sample was no longer a shiny red apple but a piece of blue plastic, the subject assigned to the plastic the same properties she earlier assigned to the apple (see Table 1). Surely if we did not know that the plastic stood for apple, we would be confused by her analysis of it; we might reasonably conclude that she did not understand matching-to-sample. But this is ruled out by her analysis of the object apple, which accords nicely with the human analysis. The properties she assigns to the word are

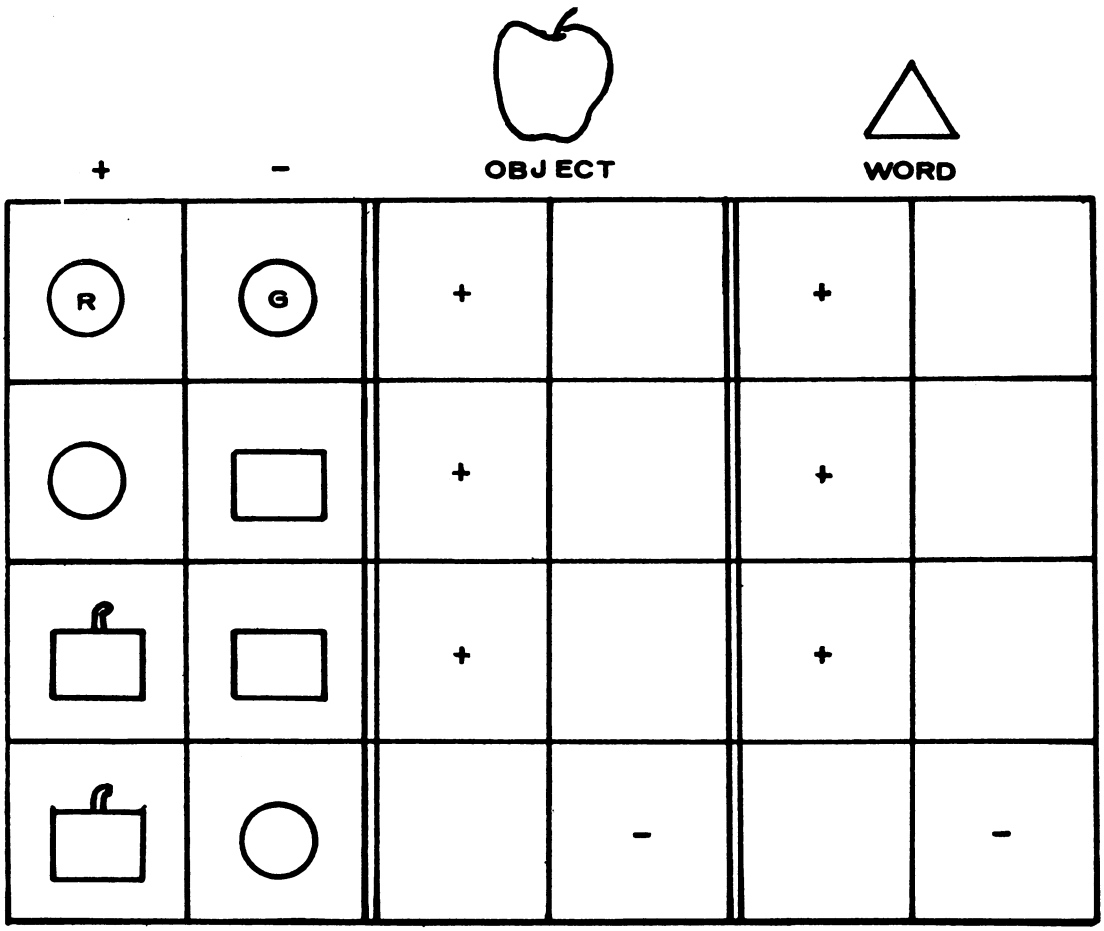
immediately sensible if we consider that her analysis of the word is not of its physical form but of that which the form represents.

Bertrand Russell in an early work (1940) noted that uttering a word is like jumping in that both the word and the jump are responses, but that the word differs from the jump in that it has meaning. Skinner (1957) commended the first part of Russell's observation, but rejected the second part on the grounds that a behavioral analysis of language should eschew or at least does not need the concept of meaning. Since I can think of no philosopher more admirable than Russell, nor any psychologist whose reputation is more enviable than Skinner's, I am pleased to suggest that they are both wrong: Skinner in holding that we do not need meaning, and Russell in suggesting that the distinction between responses with and without meaning is a radical one. On the other hand, there is a sense in which both men are right, and their correct judgments lead more surely to the points that need attention now than their more fallible judgments.

Russell is correct in arguing that a response may represent something other than itself. The identical-features analysis which the chimp ascribes to apple on the one hand and to the name of apple on the other supports that conclusion directly. But Skinner is correct in urging that the process by which a response becomes a word is not a unique one, not a process different in principle from the one by which a pigeon learns to peck a key when it is lighted. Words do not require special train-

TABLE 1

FEATURES ANALYSES OF APPLE AND "APPLE"



ing methods. The procedures that train animals will also produce words.

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