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IS PROBLEM-SOLVING LANGUAGE?[1]

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Opinion has shifted during the last decade about the ability of chimpanzees to learn language. Recent projects have reversed earlier failures to establish communication between man and chimpanzee by bypassing the troublesome (for chimpanzees) vocal medium of language. Nevertheless, just what a chimpanzee can learn about language remains controversial. Through the media of American Sign Language (*e.g.*, Gardner and Gardner, 1969) and the artificial visual languages invented by Premack (1970) and by Rumbaugh and von Glasserfeld (1973), chimpanzees have been taught to produce and comprehend far greater vocabularies than were thought possible following the unsuccessful attempts of the Hayeses (1951), the Kelloggs (1933, 1968), and others to communicate with chimpanzees via vocal languages. What is at issue is whether a chimpanzee can master relationships between words; in particular, relationships as expressed in sentences.

Premack's ambitious book, *Intelligence in Apes and Man*,[2] adds an important new dimension to the controversy about a chimpanzee's linguistic ability. On the one hand, Premack continues to ask the question he has posed in numerous research papers: what kinds of evidence show that a chimpanzee can learn certain rudiments of human language? But as the title of his book reveals, Premack is not content to limit himself to that rather complex question. Having accepted his own data as evidence that a chimpanzee can master many aspects of language, Premack speculates about the intellectual skills implied by the linguistic performance of the chimpanzees he has studied over a 10-yr period. Why, Premack asks, is a chimpanzee more successful at learning language skills than a rat or a pigeon?

Premack addresses this question with both empirical and conceptual arguments. First, he cites evidence that chimpanzees have learned something about language. From his interpretation of those data, he derives a conceptual framework for relating language to more general intellectual functions. *Intelligence in Apes and Man* provides the most comprehensive presentation to date of training techniques and data on language learning by chimpanzees. It also provides the most comprehensive set of hypotheses about what a chimpanzee might or might not be doing when it uses language.

In many ways, the most interesting and readable sections of *Intelligence in Apes and Man* are Premack's conclusions about the intellectual bases of language. These conclusions, however, are only as valid as the data on which they are based. For that reason alone, it is appropriate to begin our evaluation of Premack's hypotheses about intelligence and language by examining their empirical foundations.

Teaching the Language

Premack's basic training procedures have been described extensively in earlier papers, as well as in *Intelligence in Apes and Man*. In this review, it should suffice to summarize a few representative examples of some of the "atomic constituents" of language that Premack has selected for study. The "words" of Premack's artificial language were plastic chips of different colors and shapes. Only those few chips that signified individual chimpanzees or trainers resembled their referents. The other chips provided no information about what they signified. An obvious advantage of a lan-

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[2]David Premack. *Intelligence in Apes and Man*. Hillsdale, New Jersey: Erlbaum, 1976.

guage consisting of tangible words is that performance is not limited by the chimpanzee's ability to remember words that are not physically present. Instead, performance would appear to be limited only by the subject's ability to grasp the semantic and syntactic complexities of a particular problem.

Premack not only invented a vocabulary of plastic words, he also provided an exact set of rules for using these words. In devising these rules, Premack

> made no attempt to simulate the "natural approach," mainly because the natural approach is far from well-defined and it is difficult to simulate an ill-defined condition. Instead, . . . [he] . . . attempted to devise the most efficient training procedure possible, without regard to whether it did or did not simulate the human one (p. 20).

Some of these training procedures are illustrated in the following examples.

(1) *Production of four-word sentences.* All communication took place on a "language board" placed between the chimpanzee and the trainer. Words were placed on the board either by the trainer or by the chimpanzee. The trainer could also place various incentives on the board. In teaching a sequence such as *Mary give apple Sarah,* training began with an exchange of the word *apple* for a real apple. A plastic blue triangle (the word *apple*) was placed within easy reach of Sarah, Premack's star student. The apple itself was out of reach. When Sarah picked up the blue triangle and handed that word to the trainer, she was given the apple. Later, Sarah had to discriminate between two pieces of plastic, one the word apple, the other a word for a less desired incentive. Variations of this procedure were used to train a vocabulary describing different incentives.

The next step was to train Sarah to "write" the words *give apple,* in that order. That did not prove very difficult. However, attempts to teach Sarah to differentiate between the consequences of writing *give apple versus insert apple* proved unsuccessful. During the next stage of training, Sarah had to write *give apple Sarah* in order to obtain an apple. As an aid to learning her name, Sarah was given a necklace from which was suspended the plastic word signifying *Sarah.* Trainers and other chimpanzees were likewise identified. In an earlier paper, but not in *Intelligence in Apes and Man,* Premack (1971) described a procedure in which Sarah had to choose between the names of two recipients, when another chimpanzee (Gussie) was present. If Sarah wrote *give apple Gussie,* the apple was given to Gussie (and not to Sarah). Through contrasts of this type, Sarah presumably learned the difference between *Sarah* and *Gussie.*

The addition of the donor's name completed the sequence, *Mary give apple Sarah.* It is difficult to determine from the information provided in *Intelligence in Apes and Man* just how well Sarah performed at this stage of training. Premack writes that the "use of the donor name was optional at this early stage. . . . Later, when several agents were present in the same session, use of the donor's name was made obligatory" (p. 102). However, no data were presented concerning Sarah's performance when the donor's name was obligatory. Premack does report that two other juvenile female subjects, Peony and Elizabeth, were required to produce sequences of the variety *Donor give X recipient.* Neither subject performed well when offered choices of different words for donors, objects, and recipients. They also balked at performing four-word sequences. For that reason, they were returned to two-word sequences of the type *give X.*

(2) *Comprehension of the hierarchical structure of a sentence.* Hierarchical structure is one of the hallmarks of human sentences. The clear advantage of arranging words according to a hierarchical, as opposed to a linear rule, is that certain words can dominate other words. For example, in the instruction *Sarah apple pail banana dish insert, insert* dominates two phrases, *apple pail* and *banana dish.* Premack argued that Sarah demonstrated comprehension of the hierarchical structure of a sentence by carrying out instructions of this type.

Compliance with these and similar instructions was trained as follows. First, Sarah was required to perform the actions called for by sentences of the following variety.

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

In each case, Sarah was given two empty receptacles (a pail and a dish) and two fruits (an

apple and a banana). From these basic sequences, the instructions were changed progressively until the target sentence was reached. First, two sentences were simply linked together, for example:

Sarah banana pail insert Sarah cracker dish insert.

Then, the agent's name was omitted:

Sarah banana pail insert cracker dish insert.

Finally, the target instruction was achieved by deleting the first *insert:*

Sarah banana pail cracker dish insert.

After learning to carry out the instruction *insert,* Sarah was given sequences requesting her to *take* (remove) the contents of the receptacles in front of her. Having learned to follow the instruction *take,* Sarah was given a series of instructions in the presence of two pairs of receptacles. One pair was empty. Each member of the other pair contained a banana and an apple. An apple and a banana were also placed between the two pairs of receptacles. On some trials, Sarah was instructed to *insert;* on others, she was asked to *take.* Sarah made only one error on the 10 trials in which the action required of her changed from trial to trial.

(3) *Prepositions.* Sarah, Elizabeth, and Peony were trained on comprehension and production problems that used the word *on.* In a typical comprehension problem, Sarah was given red and green cards. The trainer wrote instructions such as *red on green* or *green on red.* Reward was provided when Sarah arranged the cards as described in the instructions. At a later stage of training, Sarah was given production problems in which she was required to write *red on green, yellow on red,* and so on, in accordance with the configuration of colored cards arranged by the trainer. On these trials, Sarah was provided with the words *on, red, yellow,* and *green.* Peony and Elizabeth were given similar problems in which object names (*keys, clay, shoes,* and so on) were used instead of colors names. Peony and Elizabeth were subsequently required to choose among three alternatives (a sponge, clay, and monkey chow) in executing an instruction such as *sponge on clay.* This type of problem forced the subject to attend both to the object names and to the order of the object names in the trainer's instructions.

If only two choices were provided in a comprehension problem, the subject need pay attention only to the first word. That word identifies which object is to be placed in the top position. With three choices, the topmost object can be identified in the same way. However, identification of the bottom object requires the subject to match the name of the bottom object with one of the two remaining choices.

(4) *Mapping of predicates onto various arguments.* Premack considered problems dealing with *same-different* judgements, properties of objects, and causal inference as problems in which the subject was asked to apply a particular predicate to different arguments. For example, the predicates *same, name of, color of, if then,* derive their meanings only to the extent that they can be applied to various arguments and to the extent that these predicates are perceived as descriptive relational terms:

> To acquire these predicates in a generalized sense that is indispensable for language, the subject must in each case respond to a relation between relations. For example, to acquire "same-different" the subject must first recognize that the relation between, say, apple and apple is $same_1$; likewise that the relationship between, say, banana and banana is $same_2$; and finally that $same_1$ is the same as $same_2$. It must make a comparable judgement in the case of other predicates:
>
> 1) The relation between, say, "apple" and apple is the same as that between say, "banana" and banana, i.e., name of_1 is the same as name of_2.
>
> 2) The relation between, say, red and apple is the same as that between, say, yellow and banana, i.e., color of_1 is the same as color of_2.
>
> 3) The relation between, say, dropping a glass and the glass breaking is the same as that between, say, tipping the glass and the water spilling, i.e., $\supset_1$ is the same as $\supset_2$. (p. 133).

(*a*) *Same-different.* Before teaching the words *same* and *different,* Premack verified that his subjects could sort familiar objects in simple matching and oddity tasks involving cups, spoons, keys, paper clips, and so on. *Same-dif-*

ferent training was introduced once a subject could match novel items (or select the odd item from a set of two similar items and one dissimilar item). When like items were presented, the response of putting the word *same* near, or between, them was reinforced. When dissimilar objects were presented, the word *different* was reinforced.

At a later stage of training, a symbol meaning ? was placed between two objects. If the objects were the same, the required response was to replace ? with *same*. If the objects were dissimilar, *different* was the correct answer. This paradigm was used in a number of ways. In some instances, the problem was posed as a question in the following formats: object, *same*, ?, or object, *different*, ?. The correct solution of the problem was to replace ? with the appropriate object. The choices were an object identical to the object presented in the question or a dissimilar object. In another variation, problems of the following variety were presented:

Object A *same* Object A ?
Object A *different* Object A ?
Object A *same* Object B ?
Object A *different* Object B ?

In each case, the subject's choices were the words, *yes* and *no*.

(*b*) *Property names.* After Sarah learned the words for *red, yellow, round, square, large* and *small,* along with the names of various objects, she was taught to use plastic chips meaning *color of, shape of, size of,* and *name of.* This was accomplished through training on frames of the following variety:

? color of apple *? color of banana* *? not color of apple* *? not color of banana,* etc.	where the alternatives are *red* and *yellow*
Red color of ? *Yellow color of ?,* etc.	where the alternatives are *apple* and *banana*
? red color of apple *? orange color of apple*	where the alternatives are *yes* and *no*
round ? ball *round ? square,* etc.	where the alternatives are *shape of* and *not shape of*

After *color of, shape of, size of,* and *name of* were taught separately, a series of problems was presented in which questions concerning the *name of, shape of,* and *color of* different objects were given in the same session. The range of Sarah's performance was 83 to 100% correct.

(*c*) *Causal inference.* Premack offered two types of evidence that a chimpanzee can perceive causal relationships between various events. In one type of problem, the trainer presented the subject with a pair of objects in two different states, for example, a whole apple and a piece of an apple. The task was to place between the two objects the instrument that was responsible for causing it to change from one state to the other. As was the case with other types of problems, the first stage of training consisted of errorless trials. A knife was placed on the training table within easy reach. All Sarah had to do was to move the knife between the whole and the cut apple. When the array consisted of a blank piece of paper and a paper with scribbles on it, Sarah was required to place a crayon (the only other object on the training table) between the marked and unmarked pieces of paper. During the next phase of training, two instruments were present on each trial. For example, when the chimpanzee was shown a dry sponge and a wet sponge, it had to select between a crayon and a container of water and place one of those objects between the two test objects. On transfer tests, novel pairs of objects were presented, for example, a sponge marked with a crayon and an unmarked sponge. The choices on this trial might consist of a container of water and a crayon. Sarah, Peony, and Elizabeth performed at typical levels of accuracy on these tests (75 to 95% correct).

Causal inference was also studied in problem sets made up of conditional sentences. In one type of problem, Sarah was shown a pair of sentences providing instructions as to how she might obtain a piece of chocolate. For example:

Sarah take apple if then Mary give Sarah chocolate.
Sarah take banana if then Mary no give Sarah chocolate.

Sarah preferred chocolate to both apples and bananas. In order to obtain a piece of chocolate, Sarah had to choose the alternative stipulated by the instructions. An English paraphrase of these instructions would read: when

presented with a choice between an apple and a banana, Sarah will be given a piece of chocolate if she takes an apple. If she chooses the banana, she is given nothing.

In a more complicated version of this type of problem, Sarah was confronted with sentences such as:

Mary give cracker Debby if then Sarah eat yellow fruit.
Debby give cracker Mary if then Sarah eat red fruit.

On each trial, Sarah had to choose between an unnamed yellow (cantaloupe) and a red (strawberry) fruit. Though not stated explicitly in the text, it seems reasonable to assume that Sarah was allowed to eat the fruit only if she followed the instructions.

Premack recognized that Sarah did not have to attend to the verbal argument in this last type of problem (*e.g., Mary give cracker Debby*). In the first place, the antecedent was always carried out. Thus, the verbal specification was redundant with the action. In actual fact, Sarah could solve the problem without paying any attention to either the antecedent or to the action. All she had to do was to discriminate the piece of plastic describing the color of the fruit she was allowed to eat.

To determine whether Sarah could relate the action of one of her trainers, as specified by a particular verbal argument, with the action specified in the consequence, Sarah was shown simultaneously a set of six conditional sentences. These sentences referred to possible exchanges between two of the three trainers present. The exchange could go either way, for example, *Mary give X Debby; Debby give X Mary; John give X Debby; Debby give X John,* and so on. Following each of these types of argument was a conditional instruction, such as *if then Sarah take red* or *if then Sarah take green.* The sight of an array of six long conditional sentences caused Sarah to leap away from the language board to the other side of her cage, where she remained until the board was erased.

A simpler version of the same problem was tried with only two trainers. Depending on whether Mary gave green or red to Debby, or *vice versa,* Sarah was supposed to choose a candy or a cracker. On each trial, she was shown only two sentences. One stated when she was supposed to choose the candy, the other when she should choose the cracker. Sarah made two errors on eight trials of this type of conditional problem.

Language or Discrimination Learning?

The validity of these and related examples of problem solving as exemplars of language invites careful scrutiny. One issue is the general procedure used to train and test each exemplar. With but few exceptions, all of the problems presented during each training session were of the same nature. Also, within a session, the number of answers was quite limited. In most cases, only two alternatives were available, and these alternatives were restricted to a small subset of contrasts, for example *same* versus *different, yes* versus *no, red* versus *blue* (or *yellow* or *green*), and so on.

The homogeneous nature of the questions posed during any one sessions, along with the restricted range of possible answers, increases the likelihood that nonlinguistic contextual cues contributed to the performance of Premack's subjects. In at least one instance, it was possible to solve a problem without paying any attention to the critical word. Consider, for example, training designed to convey the meaning of the preposition *on.* In these problems, *on* was never contrasted with any other preposition. The format of each trial was the same: either the trainer placed one object on top of another or Sarah was required to do so. The only contribution of language to the solution of this problem was a lexical one: to identify which object was to be placed on top of the other object (red on green, clay on key, and so on). In fairness to Premack, I should mention an earlier article in which he did refer to Sarah's use of the prepositional term *in front of* (Premack, 1971). But even this fact was presented in a footnote that provided no information about whether *in front of* was contrasted with other prepositions or about how well Sarah performed.

Another factor to keep in mind is the chimpanzee's motivation for solving the problems posed by Premack and his trainers. In each case, some tidbit of food is provided following each correct response or at the end of a run of correct responses. Premack does not seem terribly concerned about this state of affairs. He argues that reinforcement is a performance variable and not necessary for learning *per se.* Premack also asserts that he could have ob-

tained the same results using social reinforcement. As far as I could tell, however, no evidence was presented to support this conjecture.

In view of the many training procedures Premack describes, it is often frustrating not to be able to learn from the text just what took place and when. No mention is made of the actual sequence of problems given to each chimpanzee. Only in a few cases is it possible to infer which problems were presented earlier and which problems were presented later in the course of each subject's training. This problem could have been obviated by presenting a table describing the sequence and the number of each type of session, as experienced by each subject.

Also lacking are lists of the actual words mastered by Sarah, Elizabeth, and Peony. In the legend of Figure 3.3, Premack states that what is shown is "a major portion of a lexicon of 130 words" (p. 75). However, a count of the words shown in Figure 3.3 reveals only 48 words, at least two of which are repeated. Nor does it help to read on page 156 that Figure 3.3 shows how "the negative particle was appended to the head of one of the instruction". None of the symbols shown in Figure 3.3 was identified.

What is at issue, though, is the contents of Sarah's, Peony's, and Elizabeth's vocabularies, and not their actual size. It would be of interest to compare the nature of their vocabularies with that of chimpanzees from other contemporary studies. It would also be of interest to know whether each word was mastered in both the production and the comprehension modes. It does not suffice to assert parenthetically at the end of the book that "after sufficient training, every word taught the chimpanzees in either production or comprehension transferred to the other mode" (p. 354). For example, after the unsuccessful attempt to teach *insert* productively, it is stated that this verb was taught in the comprehension mode. However, no information is provided as to when and how *insert* was taught productively. Here again it would have been helpful to look at a simple table, showing when each word was learned and in what mode.

The ambiguous nature of some of Premack's data gives rise to yet another type of frustration. For example, in Table 4.1, performance is characterized by reference to the number of incorrect responses that occurred in a set of problems. In Tables 6.1 and 12.1, performance is characterized by the number of correct responses. However, neither the neighboring text nor the title of Table 15.1 specifies what Table 15.1 (a three-page table!) shows: correct or incorrect responses? Given the marginal nature of the performance shown by many of the entries of Table 15.1, it is especially unsettling not to be sure what kind of data it presents.

Sentences or Rotely Learned Sequences?

The most serious drawback of *Intelligence in Apes and Man* is to be found in Premack's interpretations of his data, rather than in their fragmentary nature. The basic problem is whether Premack has correctly interpreted how his subjects perceived the symbols and sequences of symbols they were required to use.

(1) *Is "Mary give apple Sarah" a sentence?* As far as one can tell from Premack's description of the procedures used to train four-symbol sequences, the trainer's name was never contrasted with the names of other trainers during the same session. While *Mary, Amy, Debbie,* were alternated as choices between sessions, they were never contrasted with one another within the same session. Furthermore, since each trainer wore his or her name symbol on a necklace, all that the subject had to do in order to solve this type of problem was to start the sequence by matching the symbol on the language board with that worn by the trainer. Even though, as Premack observed, the subject could have learned to associate the symbols worn by the trainers with the trainers themselves, there is no evidence that they did so. From the chimpanzee's point of view, the symbols referring to each teacher's name could well have been nonsense words.

As mentioned earlier, the meaning of *give* was not distinguished from that of other verbs. As such, it could have amounted to another nonsense word that had to be placed after the first nonsense word. On some trials, two recipient names were provided. Throughout each of these problem sets, however, only one recipient was present. From the subject's point of view then, one alternative was consistently correct. The subject need not have used the fourth symbol of the sequence to refer to itself. Of the symbols used in training four-symbol sequences, Sarah, Elizabeth, and Peony appear to have learned the meanings of only those sym-

bols that referred to the objects they requested. But even in the case of objects, only two choices of object names were provided on each trial.

These considerations suggest that the sequences glossed by Premack, in general form, as *trainer give X recipient* (p. 81), could just as well be described as the rotely-learned sequence ABXD in which substitutions of the meaning of *X* varied with the object on hand. Premack is clearly aware that only

> the object class was explicitly mapped. . . . Action, recipient, and donor classes were not mapped in the same explicit fashion, although the training session did provide information that an appropriately inferential subject might have used to arrive at the referents of the other particles (p. 82).

Premack recognizes that only the meaning of the symbols for objects was learned. Yet, throughout *Intelligence in Apes and Man,* he refers to the symbols of the three remaining elements of the sequence *trainer give X recipient* as if Sarah, Elizabeth, and Peony had in fact learned their meanings.

Premack's poetic licence in attributing meanings to each of the symbols glossed as *trainer give X donor* is clearly revealed by considering the performance of another organism on a similar problem. If a pigeon performed a sequence ABXC, where *X* referred to different incentives, it would seem far-fetched to refer to that sequence as *trainer give grain R-42.* That type of performance is easy to obtain. Pigeons were trained to peck the sequence A→B→C→D, where A,B,C, and D were different colors, at levels of accuracy comparable to that reported by Premack in the case of "four-word sentences" (Straub, Seidenberg, Terrace, Bever, 1978). On each trial, A,B,C, and D were presented simultaneously in different physical arrays. We have yet to try to extend this performance to ABXC problems (where X_1 could refer to one type of grain, X_2 to a different type of grain, X_3 to water, X_4 to the opportunity to attack another pigeon, and so on). If a pigeon could learn such a sequence (a not unlikely outcome), one wonders what is to be gained by assigning names to each member of that sequence.

Similar problems of interpretation arise in connection with Sarah's performance on comprehension problems in which a single verb refers to actions that are to be repeated (*e.g., Sarah apple pail banana dish insert*). Premack asks, "Did syntax play any role or were the compound sentences processed on an exclusively semantic basis?" (p. 329).

After rejecting a semantic interpretation of his instructions, Premack concluded that Sarah did use a syntactic rule:

> . . . in processing such sentences . . . the functional effect of the rules, although not necessarily the rules themselves, can be described by grouping the words in a sentence by parentheses and brackets. . . . The bracketing emphasizes the following features of her performance.
>
> She recognized the word "Sarah" applied to the whole sentence and not just to the first clause; that is, she did not confine her behavior to the first clause but carried out the whole instruction. By the same token, she must have recognized that the word "insert" applied across the sentence to all appropriate items mentioned in the sentence, and not just to the second clause. Additionally she divided the food and container words appropriately, using a container word as a break and grouping together all food words that occur above any container word (p. 330).

In these tests, Sarah was the only chimpanzee present. That context, along with a long history of working with problems that required the execution of all aspects of an instruction, is sufficient to ensure the result that "she . . . recognized (that) the word 'Sarah' applied to the whole sentence and not just to the first clause." To conclude otherwise would imply that Sarah would not have performed in the same manner if *Sarah* was omitted. No evidence of that unlikely outcome was presented.

Even the most difficult instruction put to Sarah required only one kind of action (*insert* or *take*). In view of the progression from compound to condensed instructions, it would be surprising if she had *not* recognized that the verb ". . . applied across the sentence, to all appropriate items mentioned in the sentence, and not just to the second clause."

What Sarah appears to have learned in this type of problem is what Premack rejected as a "semantic" rule: operate on all of the objects listed before the name of a container in the

manner specified by the verb at the end of the sequence. Unless Sarah could decode an instruction in which she had to perform two actions, where at least one of the actions had to be repeated, it seems gratuitous to conclude that Sarah had learned a hierarchical rule of syntax.

Prepositions

The major difficulty in concluding that Premack's chimpanzees learned the meaning of *on,* is that *on* does not appear to have been contrasted with other prepositions. Since there is no evidence that a chimpanzee can learn the meaning of a preposition from its context, there is no basis for concluding that Sarah, Elizabeth, and Peony interpreted *on* as a preposition. These considerations apply to both comprehension and production tasks. Accordingly, Premack's conclusion that Sarah, Elizabeth, and Peony showed "successful transfer of 'on' from comprehension to production" (p. 128) seems unwarranted.

Predicates

The evidence that chimpanzees master predicates is most convincing in the case of *same* and *different* and least convincing in the case of causal relationships. More so than any other set of words of the vocabularies of Sarah, Elizabeth, and Peony, *same* and *different* appear to have been used in a wide variety of situations. But even in this instance, evaluation is difficult. Consider, for example, Peony's performance with *same* and *different* when she worked with them in a new format. Instead of having Peony put *same* or *different* between a pair of similar or dissimilar objects, she was invited to use these symbols without configurational constraints. She was simply presented with three objects (two similar and one different) and two words (*same* and *different*). Premack noted that Peony's performance on the first such test was "profoundly reassuring as to the nontrivial character of pongid intelligence."

> 1) She puts spoons together (did nothing with the word "same," as though it was redundant) and put the word "different" on top of the piece of clay.
>
> 2) She put clay next to the word "different," the two spoons together and the word "same" on top of them.
>
> 3) She put two pieces of clay together and the word "same" on top of them (and did nothing with "different" and the spoon).
>
> 4) She wrote out in a linear fashion "clay same clay different spoon," that is, *A* same *A* different *B*.
>
> On subsequent lessons, she was given a large variety of objects in the same configurationless way. Most of the forms that appeared in the first lesson disappeared, including, regrettably, her linear format: *A* same *A* different *B*. By and large, she settled on only one of the several forms that had appeared on her first lesson; she superimposed the two like objects in so far as possible and placed the word "same" on top of them; then she placed the word "different" either on or alongside the odd object. One form she did not use was to bring together the two unlike objects and place the word "different" on them, perhaps because to have done so would have left no way to deal with the remaining object and the word "same". Peony's behavior suggested that to her "same" meant an object with a twin, whereas "different" meant the condition in which an object did not have a twin; this was a construction altogether compatible with the terms of her training (p. 145).

Without question, Peony, Sarah, and Elizabeth mastered the use of *same* and *different* in the standard configuration in a variety of problem sets. What is not clear is the reliability of Peony's use of *same* and *different* in novel configurations.

Performance on problems with the more difficult *if-then* predicate provided little evidence to justify Premack's conclusion that his subject's understood the conditional relationship expressed in the instructions. With but one exception, the subject could discover what to do by attending only to the consequence of the conditional sentence (the second clause). It was unnecessary to understand the contents of the argument (the first clause). In the one test in which it was necessary to attend to the argument, Sarah made two mistakes in a set of eight problems. With such meager information, it is not possible to decide if that was a reliable result.

More reliable data were obtained with problem sets on causal inference. On these problems, the subject had to place the appropriate instrument between an object in two different states and thereby indicate what caused the object to change from one state to another. Performance was reliably accurate when novel objects and instruments were presented. Accordingly, Premack concluded that his subjects expressed an understanding of how the instrument caused a particular consequence (for example, how a crayon, as opposed to a glass of water, caused an unmarked sponge to become a marked sponge).

About this performance, Premack remarked:

> Simple as this outcome is, it can be given a stronger interpretation than may first meet the eye, The visual sequences are infinitely ambiguous: each can be coded in indefinitely many ways, such as red-blank-red, one-blank-two, round-blank-flat, large-blank-small. Not only the test items but also the three alternatives are subject to indeterminately many codings. Knife, for instance, need not be read as knife (instrument that cuts) but can be coded as sharp, metal, long, shiny, etc., and the same holds for the other alternatives. The subjects evidently did not code the sequences or alternatives in this way, for they consistently chose alternatives compatible with only one coding, viz.: how do you change the object from the intact to the terminal stage? With what instrument do you produce the change? Because the subjects read the sequences in a specific and consistent way—finding the same question in each of the sequences—I infer that they have a schema, a structure that assigns an interpretation to an other wise infinitely ambiguous sequence (p. 337).

Adult educated human observers will probably agree with Premack that a "knife . . . need not be read as a knife (instrument that cuts) but can be coded as sharp, metal, long, shiny, etc." However, the critical question is, can a *chimpanzee* code the knife and other so-called instruments in the manner described by Premack? Without any training to code objects according to sharpness, shininess, and so on, there is no reason to expect the chimpanzee to do so. In suggesting that his subjects refrained from coding instruments in these irrelevant manners, Premack appears to have taken for granted a competence on the part of chimpanzees for which there is no evidence.

How Premack's subjects solved these problems is suggested by the following thought experiment. Suppose that the set of causal inference problems was given without each object in its original state. That is, the subject would see only identical pairs of objects such as two damp sponges, two apples, each showing a crayon mark, and so on. It would not be at all surprising if the chimpanzee performed as well under this condition as it did when the object was presented in its original state. Without such tests, it is not clear whether Premack's data support his conclusion that the chimpanzee inferred a *causal* relationship between an instrument and a particular state. A more parsimonious interpretation is that, as a result of extensive drill, the subjects learned to associate certain so-called instruments with various states, *e.g.*, crayons with crayon marks, wet objects with water, pieces of objects with knives, and so on.

Syntax

One of the most perplexing chapters of *Intelligence in Apes and Man* is the chapter entitled "Syntax", a chapter in which Premack concluded that a chimpanzee can learn some rudimentary rules of grammar. Premack recognized that his method did not encourage his subjects to generate new sentences by combining separately learned phrases. However, in evaluating Sarah's performance, Premack observed that ". . . there are at least five different cases sifted through her record in which Sarah comprehended (and in a few cases produced) sentences formed by a process more demanding than that of combining phrases" (p. 319). We have already considered one of these five cases: "hierarchical organization". Let us consider briefly a few of the other examples of Sarah's purported syntactical competence.

Attribution

The instructions in this instance were in the form *Sarah take X*. Initially, *X* was a property, for example *red*. Thus, when Sarah was instructed *Sarah take red,* where the choices were a red and a green dish, she was rewarded for taking the red dish. In the same series, it appears as if Sarah was also given instructions of the type: *Sarah take dish* where the choices

were a dish and a pail. For Premack, the critical test was Sarah's performance following the instructions: *Sarah take red dish,* where the alternatives were red and green dishes and red and green pails. No details of this test are provided nor are any data presented. Nor is there any entry in the index under "attribution" that would help the reader to dig out the relevant information from other sections of the book. Let us assume that Sarah did perform reliably on this test and ask, would it be valid to conclude that:

> In taking the red dish, instead of either the green dish or the red/green pail, [Sarah] demonstrated comprehension of the attribute form. Her accomplishment went beyond that of a child, for although she had been taught "Sarah take dish" and "Sarah take red," she had never been taught "red dish." Unlike the sentence a child produces at stage II, Sarah comprehended a sentence involving a unit that had no history of independent occurrence (p. 320).

The question at issue is whether Sarah regarded *red* as an attribute of *dish* or whether she solved the problem by matching *red* and *dish* to the objects on hand in two separate operations. Her correct performance when instructed *Sarah take red/green,* and confronted with red and green dishes or pails, clearly suggests that she could match the symbols *red* and *green* to the objects on hand. In following the instructions *Sarah take red dish,* one must assume that Sarah was encouraged to choose only one object from the set of four objects with which she was confronted (red and green pails, and red and green dishes).

Sarah could have followed one of two strategies that would have enabled her to solve this problem without any understanding of the attributional relation between *red* and *pail.* All she had to do was first to attend to the dishes and then to the red object, or first to the red object and then the dish. So long as this type of problem can be solved by relating symbols to the objects on hand, one at a time, the interpretation that Sarah spontaneously exhibited attribution seems gratuitous.

The further interpretation that this type of performance shows evidence of understanding an "actor-action-attribute-object form" (p. 320) seems even more far-fetched. The evidence that Sarah encoded *Sarah* as an exemplar of a class of symbols meaning "actor" is virtually nil. Since *take* appears to be the only verb in this series of problems, it seems foolhardy to interpret *take* as an action. And, as mentioned earlier, it seems doubtful that Sarah truly distinguished between an object and its attribute in this set of problems.

From Demonstrative Pronoun to Demonstrative Adjective

Sarah was taught the so-called demonstrative pronouns *this* and *that* in situations in which she was instructed to take a near (*this*) or a far (*that*) object. She was also taught to produce sequences of the form *Give Sarah this* in order to request a near object and *Give Sarah that* in order to request a far object. Premack observed that

> . . . when required to produce "Give Sarah this cookie" vs. ". . . that cookie," she made only three errors in fifteen trials, with none on the first five trials. She wrote the incorrect "give Sarah cookie this" almost as often as ". . . this cookie" but there was no reason why her word order should have been correct. Sentences of that kind have never been modeled for her. Her own production of the demonstrative adjective form on that occasion was her first experience with the form (pp. 320-321).

Here again the details of training are scanty. In this instance, however, one can refer back to a slightly more elaborate description of the procedure (p. 282):

> Two cookies were placed on the table, one notably larger than the other, with the larger one closer to Sarah on some trials and closer to the trainer on other trials. She was given the words "give," "Sarah," "cookie," "this," and "that." Without further training she was required to write either "give Sarah this cookie" or "give Sarah that cookie" depending on the location of the desired cookie.

Having just been trained on a series of problems in which she was required to produce sequences of the form *Give Sarah this* and *Give Sarah that,* it is not surprising that Sarah added the additional symbol for the incentive when that symbol was provided. The interpretation of this performance pivots on just what

Premack meant by saying that Sarah ". . . without further training was required to write either *give Sarah this cookie* or *give Sarah that cookie* . . .". Just how did Sarah know what was required? Though Premack successfully rebutted Clever Hans' interpretations of performance on other types of problems, in this instance the trainer could have cued Sarah's performance. Did the trainer end a trial and code Sarah's performance as an error if she wrote *give Sarah cookie*? If he did not, and instead encouraged Sarah to choose another symbol, the sequences *give Sarah cookie this* or *give Sarah cookie that* are not surprising, especially in view of her training to write *give Sarah this* or *give Sarah that* in the preceding problem set. Since *this* and *that* had just been used to refer to objects, it seems premature to refer to them as demonstrative adjectives.

Conjunction

In arguing that Sarah learned the "major recursive form" of conjunction, Premack states

> in the beginning she requested separate fruits with separate sentences, say, "Mary give Sarah apple" and "Mary give Sarah banana," but subsequently requested separate fruits with a single sentence "Mary give Sarah apple banana". . . . [The] use of conjunction was impressive . . . because it was invented. . . . no aspect of conjunction was taught Sarah or the other subjects (p. 321).

The reader is invited to judge the validity of Premack's claim that Sarah (and Elizabeth and Peony as well) "invented" the conjunctive form by reading Sarah's training on "conjunction reduction".

> Before we taught Sarah an explicit marker for "and," we invited her to engage in an implicit form of conjunction reduction on her own. In previous drills on simple sentence reduction, a piece of food had been placed in front of her along with a small set of words, her task being simply to request the food—for instance, to write "Mary give apple Sarah" when the food was apple and "Mary give banana Sarah" when it was banana, etc. After many such drills, we invited Sarah to behave conjunctively, by placing before her pieces of two different fruits and giving her the usual set of words, including names for both fruits. On the first eight trials, she responded in keeping with her previous training, writing "Give apple Sarah," and "Give banana Sarah," her usual individual sentences. On the ninth trial, however, she changed her approach and wrote, "Mary give Sarah apple orange," for the first time requesting both items in one sentence. On a subsequent lesson when given three items per trial, she requested all three of them, writing for example, "Give banana apple orange Sarah" (p. 243).

The initial conjunction of *apple* and *orange* could well have occurred by chance, then been strengthened by virtue of a dual reward. It is also the case that putting together a sequence in which it is possible to use all of the object names is an easier task than one that requires the subject to choose only one object name.

Intellectual Foundations of Language or Problem Solving?

Particularly in the last chapter of *Intelligence in Apes and Man* (entitled Mechanisms of Intelligence: Preconditions for language), Premack's mixture of creative hypotheses, scanty data, and overly rich interpretations of that data detract from the soundness of his conclusions about the intellectual basis of language. The longest section of this chapter considers the ability of an organism to engage in casual inference. For the sake of brevity, I will focus on this section (though similar problems arise in Premack's discussion of intentionality, representational capacity, map reading, multiple internal representation, mnemonic capacity, and second-order relations).

The evidence of causal inference to which Premack seems to assign the most weight is the data on $\text{object}_{\text{state 1}}$-$\text{object}_{\text{state 2}}$-instrument matching that was described earlier. Premack remarks that "Because the subjects read the sequences in a specific and consistent way—finding the same question in each of the sequences —I infer that they have a schema, a structure that assigns an interpretation to an otherwise infinitely ambiguous sequence" (p. 337). Recall that the problems posed by such sequences could have been solved by symbolic matching. Knives could be matched with multiple portions of an object, crayons with crayon marks, and so on. Given the existence of convincing

data on symbolic matching in pigeons, it seems doubtful that this kind of problem solving is unique to chimpanzees and man.

Premack acknowledges that another line of evidence supporting the chimpanzee's ability to communicate about causal inference is indirect. The data come from problem sets in which Sarah was required to write sequences of the type *trainer give X Sarah.*

> At an early stage of training, when first being taught word order, Sarah wrote 409 three- or four-word sentences requesting that one of several fruits be given her. Although she made 76 errors of word order (and many more errors of word choice) in doing so, only three times did she begin a sentence with the name of an object, mistakenly putting the object in the agent's role, as in for example, "orange give Sarah apple." The infrequency of this kind of error is compatible with the view that she divides the word as we do, assigning different functions to objects and agents (p. 338).

The problem with Premack's interpretation is not that the data regarding Sarah's perception of objects and agents was indirect but that a simpler explanation is readily available. The sheer number of trials in simpler forms of this problem, in which the object name was always required to appear last, would seem to account for Premack's observation equally well. Before three- and four-word sequences were trained, two sequences of the type *give X* were trained. Unfortunately, no data are provided in *Intelligence in Apes and Man* regarding the number of *give X* trials to which Sarah was subjected, nor are any data provided on the number of *give Sarah X* trials that Sarah experienced before being trained on four-symbol sequences (where *give Sarah X* sequences were also acceptable). It is at this stage of training that Premack reports only three instances in 409 sequences in which the object was placed first.

Having exhausted his own data on causal inference, Premack turns to data from a natural situation in which chimpanzees were observed to hunt termites by first selecting straws from nearby plants, then inserting them in the termite mound and finally "fishing out" the termites.

> One finds in the chimpanzee's technology evidence of at least three aspects of its intelligence: planning, memory, and inference.
>
> 1. In selecting the straw at a distance from the mound, the chimpanzee appears to be able to plan. If planning is correctly said to depend on the ability to hold in mind a representation of one's objective, then there is no question but that the chimpanzee should be able to plan. Its ability to generate and use—in highly determinate ways—internal representations has been amply demonstrated in the present research.
>
> 2. The individual chimpanzee is said to collect from over 25 different mounds. Its ability to remember the locations of the mounds, and the orifices concealed in each of them, testifies to the ape's long-term memory. Our own evidence confirms this capacity most dramatically in the animal's ability to identify the "anatomy" of various fruits.
>
> 3. I have not been in a position to interrogate the field chimpanzee, but if I were, I would ask it whether or not it knows what goes on in a termite mound. Can it infer what happens between the time when it inserts an empty straw into the mound and withdraws it full of termites? Fishing is after all a cognitively special activity, a kind of black-box technology in which input is related to output by a hidden middle. We could use the visual causality tests described earlier to interrogate the chimpanzee, and find out whether or not it knows the content of the hidden middle. The three pictures would consist of a chimp fishing, a blank frame, and a chimp holding a laden straw, about to eat the termites. The chimp's task would be the usual one of selecting the missing picture. The alternatives could include: (1) termites with their feet or antenna caught in cracks in the straw; (2) termites caught while using the straw essentially as a bridge to cross little streams inside the mound; (3) termites either attacking the straw or trapped by their own curiosity, and carried out even while exploring the straw, etc. Let us assume that the third alternative is the correct one. Whether it is or not, if the chimpanzee chose it consistently, this would demonstrate that it

> could identify the fishing situation as one that induced curiosity, and could picture another species responding to the situation in the same way it would. But perhaps this exceeds pongid intelligence (pp. 340-341).

This and other passages of *Intelligence in Apes and Man* illustrate how Premack's creative imagination can isolate instances in the chimpanzee's environment that *may* reveal important aspects of intelligence. Just what does this example say about the uniqueness of this performance in chimpanzees and how does it contribute to language? There is sufficient evidence available from lower forms that could just as readily serve as a basis for arguing that those forms have representations of their worlds. Humming birds can remember where they last gathered food from a comparable number of alternative food sites. The hypothetical experiment Premack poses is an interesting one, but, as we have seen earlier, it is not clear what it would demonstrate about causal inference as opposed to symbolic matching.

In opting for an artificial, as opposed to a natural language, the reader will recall that Premack "attempted to devise the most efficient training procedure possible, without regard to whether it did or did not simulate the human one". By claiming indifference to the degree to which his language simulated human language, Premack may have hoped to discourage comparison between the linguistic achievements of his subjects and those of a human child. Yet the very title of Premack's book, and the numerous comparisons drawn between chimpanzee and human language, invite the reader to ask just what did Sarah and her companions learn about language?

Despite Premack's frequent claims to the contrary, a careful reading of *Intelligence in Apes and Man* reveals that Premack himself is aware that many exemplars of language in the chimpanzee fall considerably short of simulating human language. These contradictions weaken the impact of this provocative book. We have already seen that Premack's own analysis of the semantic limitations of the four-symbol sequences he tried to teach Sarah, Elizabeth, and Peony did not stand in the way of referring to such sequences as sentences and to referring to the elements of these sequences by their English glosses.

Premack also seems to be aware of the limitations of his teaching procedures. In discussing Sarah's ability to ignore irrelevant words during one phase of her training, he writes:

> Lessons were typically devoted to a small well-defined topic. A search of extensive data reveals perhaps a dozen lessons that pick up several topics and shifted freely from one to the other, but most lessons dealt with only one topic. . . . Always the lesson concerned a well-defined set of alternatives. The words and even the sentence to each lesson also made up a well-defined set. The boundedness of the lesson, in both its verbal and non-verbal alternatives, could not but have helped Sarah discover the topic of the lesson (p. 127).

Unfortunately, Premack did not pursue the implications of training his subjects on homogeneous sets of problems whose solutions were selected from a minimal set of alternatives. Were he to do so, he would have to recognize fundamental differences between Sarah's use of language and that of a child's. In learning a natural language, a child experiences a large variety of utterances, as expressed by its parents and siblings. That variety of linguistic input is matched by the variety of words the child has available in responding to another person's utterance or in generating spontaneous utterances. When a child says, *ball red* upon picking up a ball, its use of language differs fundamentally from that of Sarah who may have produced the corresponding sequence in response to a question such as *ball?*. The issue here is not simply a question of the spontaneity of the child's utterance. Of equal importance are three other factors: the range of alternative words available to the child and the chimpanzee, the kind of training needed to produce the utterance in question, and the motivation for making that utterance.

One can anticipate Premack's reaction to the concern that Sarah's use of language was rather limited from his reaction to the objection that sequences containing the symbol ? were not really questions. One answer to this objection is especially telling.

> She answered but did not ask questions. This would be a serious objection if she failed to ask questions when given an opportunity to do so. The omission was in

> the training program, however, not in the subject. In the beginning we could not find a simple condition in which to make the test; then we were diverted from the matter by other issues and ended up by (conveniently) forgetting it. Moreover, on more than one occasion, apparently bored by excessive drill, she stole all the words before her—retired to the floor where her position was less vulnerable—and wrote out and then answered all the questions taught her. Hunching over the plastic pieces, passionately arraying them in sequences taught her, she offered one of the few displays not only of her ability to learn but of her ardent desire to use what she had learned. The display also bespeaks one of our main failures, a failure to interdigitate the motivational pressures that make language valuable with the cognitive program teaching it. In fact, we did not locate Sarah or the other objects in a world, such as the child's, where increasing command of language provided increased command of the world (p. 153).

Here again, Premack recognized the limitations of his program. At the same time, he nonchalantly ducks the issue by noting that his subjects were not provided with the opportunity to ask questions, or the motivation to use language to increase their command of the world. Premack seems to assume that by simply arranging the appropriate training sequences and by somehow changing the motivation, Sarah would ask a question and would advance beyond the rote learning that gave rise to the dubious behavior of stealing the words from the language board and then writing out and answering all of the questions put to her by her trainer.

Morgan's Canon Revisited

The attitude that anything is possible, if one uses the appropriate training procedure, is expressed all too frequently in *Intelligence in Apes and Man*. Regrettably, it begs the questions that Premack set out to answer in the first place. If Premack wants to study language in the chimpanzee, its performance on his exemplars must be compared with some sort of reference performance. In order to go beyond the interpretations given to the solutions of animal problem tasks, the burden of proof is on Premack to show that those interpretations are inadequate. A chimpanzee's closeness to man does not exempt it from C. Lloyd Morgan's observation that an animal's behavior should be interpreted at the simplest level, unless there is compelling evidence that an explanation involving higher processes is needed. Such evidence cannot be obtained gratuitously by assigning to Sarah's symbols whatever meanings might be appropriate in English or by arguing that Sarah would exhibit different features of language if she were exposed to certain untried protocols.

An optimistic assessment of Premack's approach to language is that it is incomplete but viable, so long as the problems he posed are presented in a more elaborate form. Specifically, one would want to see how performance fares when:

(1) the heterogeneity of the questions posed to a chimpanzee is increased so that, within a single problem set, a subject might encounter *same-different* questions, *name-of* questions, causal inference questions, instructions thorough enough to test for an understanding of syntax, and so on;

(2) the available answers span many categories of words;

(3) each word used by the trainer and by Sarah is contrasted with at least one other word from that word category; and,

(4) the referents of each of those words are not present.

In short, one would want to see even a modest attempt at synthesizing, within a single session, some of the so-called "atomic constituents" that Premack had identified in his analysis of language.

Whether problem solving, no matter how elaborate, can ever simulate language is, of course, an empirical question. *Intelligence in Apes and Man* provides a stimulating sketch as to how one might undertake such an approach. In view of the creative effort that went into this research and its interpretation, it is unfortunate that it falls short of providing clear answers to the many stimulating questions it poses, both about language and intelligence.

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