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Perceived Variability and Symbol Use: A Common Language-Cognition Interface in Children and Chimpanzees (*Pan Troglodytes*)

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Analysis of two chimpanzees' conversations with their teacher during a tool-use training task demonstrated that chimps use lexigrams, a humanly devised visual symbol system, selectively to encode perceived variability; that is, they generally used their symbols to differentiate alternative possibilities or to represent change or novelty in a situation. In contrast, they tended to leave unsaid what was unchanging, repetitive, or the unique possibility in a situation. Perceived variability influenced not only which symbols were selected but also utterance length: A single dimension of variability in a situation leads to single-lexigram utterances; multiple dimensions are associated with multi-lexigram utterances. This pattern of results indicates that the absence of formal grammatical structure in chimp language does not imply that utterances beyond one word in length are either rote strings or imitations. The chimps' tendency to mention the variable while leaving the constant or redundant unsaid is, moreover, strong support for the position that their use of a humanly devised symbol system is more than a series of conditioned responses.

The goal of this article is to explore the possible commonality between chimp and child in the cognitive determinants of language use through examining the role of perceived variability in the chimpanzee's linguistic communication. Perceived variability is an important factor in the language use of humans, both children and adults. Greenfield and colleagues have shown that even children at the one-word stage (between 1 and 2 years of age) use their single words selectively to refer to the variable aspects of a referential situation; conversely, they leave unsaid those aspects of the situation that are constant or unchanging (Greenfield, 1978b, 1982; Greenfield & Dent, 1979; Greenfield & Smith, 1976; Greenfield & Zukow, 1978).

Uncertainty, as the term is used in semantic information theory (developed by Carnap & Bar-Hillel, 1953), exists to the extent that there are alternatives in a given referential situation. The alternatives may exist across either space or time. In this theoretical framework, a message element is objectively informative to the extent that it resolves uncertainty by selecting from among the possible alternatives. Uncertainty in information theory does not refer directly to an internal state. It refers rather to external, observable variability that may be hypothesized to induce an internal state called uncertainty. Because it is possible to observe and measure external variability but not internal uncertainty, it may be less misleading to substitute the term "variability" in most contexts in which an information theorist might speak of "uncertainty."

The distinction between information (which resolves uncertainty) and certainty is the psychological basis for the distinction between assertion and presupposition in

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language. A presupposition is assumed rather than stated. An assertion is stated. This parallels the situation in the child's single word utterances: What, from the child's point of view, can be assumed is not stated; what cannot be assumed or taken for granted is given verbal expression by the single word. And it is the relatively certain, constant, or old element that is assumed, the relatively uncertain, variable, or new one that is stated. Sometimes information presupposed by one utterance has been stated in a previous utterance. The earlier assertion is termed "old information" (Haviland & Clark, 1974). Rather than repeating old information, later utterances emphasize new information. In this way, the cognitive distinction between constant and variable, between old and new, forms the psychological basis for the linguistic distinction between presupposition and assertion.

Probably the most basic form of variability is change. The orienting reflex is a very basic human response to change. According to the research of Kagan and others, two types of change—contrast and movement—are the prime determinants of visual attention during the first weeks of a child's life (Kagan, 1970b). In visual contrast, the presence of an object against a plain background creates a visual change at the object's edge. In object movement, the change is one of location. Later in the first year, children build up internalized schemata, which form a standard against which change is assessed, and, most important, moderate discrepancy from such schemata attracts the infant's attention (Kagan 1970a). Our hypothesis, tested in a number of studies, has been that human language is from the beginning used selectively when the speaker perceives variability of one sort or another: to mark points of change, deviation from the familiar, choice from among alternatives.

Another way of putting this claim is to say that principles of selective attention become principles of selective word use and that, thus far, the construct encompassing the deployment of attention across the widest range of concrete situations is the concept of variability. Our research has investigated the notion of variability by using naturalistic data and experimental techniques. In general, we have found that, from the one-word stage to adulthood, human beings use their language to express those aspects of a situation in which alternatives exist or there is change over time (Greenfield, 1978b; Greenfield & Dent, 1979, 1982; Greenfield & Smith, 1976; Greenfield & Zukow, 1978).

In our earliest research (Greenfield, 1978b; Greenfield & Smith, 1976), sources of perceived variability were indirectly inferred from an analysis of the naturally occurring referential situation in relation to the child-speaker and his utterance. Such analyses provided a rich source of hypotheses, but we later moved toward more direct tests of our hypotheses—on the one hand, through experimental manipulation of alternatives and change within a potential referential situation and, on the other hand, through observation of the child-speaker's visual attention and behavioral construction of alternatives.

First, an example of experimental manipulation: In a study with mothers, Greenfield and Zukow (1978) created individualized scripts for mothers based on a particular child's own word use and vocabulary, and embodying particular patterns of constancy and variability. In one pattern the mother might tell the child to take off a series of items of clothing, for example, *hat, jacket.* Here action is constant, while object of action varies. Or, in the opposite case, she might tell the child to first put *on* a hat and then take it *off.* Now action is variable, while object remains constant. A prerequisite for such a procedure is that the child have the vocabulary to express either the change of state (*on, off*) or the items of clothing (*hat, jacket*). It was found that children selectively imitate the variable element as the sequence unfolds. When object varies, the child will mention the object name; when action varies, it will be the action that receives linguistic mention. This procedure, although involving experimental manipulation of variability, had the weakness that the variable element in the nonverbal referential situation was also the variable element in the mother's verbal in-

structions. A later study used a similar procedure but eliminated this sort of verbal instruction; it demonstrated that children respond linguistically to perceived variability in the nonverbal situation, not merely to perceived variability in language (Greenfield, 1982). Another study showed experimentally that, in the age range from 6 years to adult, at more advanced stages of language development, the grammatical form and the semantic content of complex linguistic constructions selectively emphasize the variable elements in the stimulus situation which they describe (Greenfield & Dent, 1979, 1982).

Most relevant, however, to the chimpanzee research reported here are the results for young children at the earliest stages of language, particularly the one-word period, for this stage of linguistic development is most similar to that of the chimpanzees. An example of the human focus on variability in the one-word period is the following: A male child names a person who has just come into his field of visual attention but does not, over a period of time, name his caregiver with whom he has been interacting. (The child has both names in his lexicon.) In this example the child uses language to refer to the novel, leaving the old or constant unsaid.

This example is a good one to illustrate how informativeness in language results from a coordination between language and the ontogenetically preexisting perceptual orientation to a new stimulus. Orientation to novelty is also a pervasive and fundamental fact of adult selective attention (e.g., Feigenberg, 1969). This same principle is also widespread in the animal kingdom (Hinde, 1966; Jewell & Loizos, 1966; H. S. Terrace, personal communication, 1981) and is certainly even more notable in chimpanzees (Rumbaugh & Pate, 1984). Selective attention to novelty would, therefore, be a capacity available to chimpanzees being taught a humanly devised symbol system. Indeed, chimps have been observed to make a special noise when they see something strange (Yerkes & Learned, 1925) or new (observations made by second author).

The point of the present research was to determine whether the acquired symbols of Sherman and Austin, two chimpanzees being taught a keyboard-controlled visual symbol system by Savage-Rumbaugh and co-workers (Savage-Rumbaugh & Rumbaugh, 1978; Savage-Rumbaugh, Rumbaugh, & Boysen, 1980) would be used to mark perceived variability, as is the case for human children.

Recently, much doubt has been cast on the ability of chimps to acquire syntax when taught a humanly devised language system (Terrace, 1979). Syntax is the hallmark of the formal side of human language. However, it is far from the center of language's communicative function (e.g., Givon, 1979; Greenfield & Smith, 1976; Ochs, Schieffelin, & Platt, 1979). Up to now no one has systematically examined the parallels between child and chimp in the area of communicative function. The examination of informativeness in chimpanzee language use has implications for the nature of constructed symbolic meaning and for the relation between language and cognition in the chimpanzee. It seems entirely possible that when chimpanzees learn language from human beings, this language learning utilizes the chimp's preexisting cognitive system and enables this system to expand beyond its normal limits.

When the first methods for teaching chimpanzees human language began to achieve some success in the late 1960s and early 1970s, (Gardner & Gardner, 1969, 1971; Premack, 1970; Rumbaugh, 1977), there was much enthusiasm for the linguistic capacity of the chimpanzee in comparison with that of a child. More recently, however, there has been increasing skepticism concerning the chimp's capacity for syntactic language (Savage-Rumbaugh et al., 1980; Terrace, 1979). It may be, however, that syntax is not the place to look for human-chimp parallels. Because of a common evolutionary history before language developed in the human species, it seems more likely that commonalities would be based on an evolutionarily prelinguistic cognitive system and its relation to linguistic communication, rather than on language taken as a formal system in itself. The present study of 2 male chimps, Sherman and Austin, uses the idea of perceived

variability to explore commonalities in the cognition–language interface in child and chimp.

Such an enterprise has relevance not only to the question of human–chimp parallels but also to the nature of meaning in the chimpanzee's use of humanly created languages. Literature that deals with this topic (Brown, 1973; Limber, 1977; Mistler-Lachman & Lachman, 1974; Terrace, 1979) often gives the impression that the only alternative to syntax in chimp language use is the presence of specific conditioned responses. Thus, there is a particular need for a method of analysis that looks systematically at the chimp's use of language to signal meaning. The concept of using language to signal perceived variability provides a conceptual basis for just such an analysis. If our hypothesis that chimps, like children, use their language systematically to signal perceived variability is confirmed by the data, then it is reasonable to conclude that chimp language is more than a conditioned response, even though it has no formal syntax with which to create an internal linguistic structure. In sum, it is suggested that in the evaluation of chimp language, too much attention has been paid to the syntactic aspect of language use and not enough to the pragmatic, the meaningful use of language in context. Recently, an article was published which explored chimpanzees' use of language in relation to its verbal or discourse context (Van Cantfort & Rimpau, 1982). Up to now, however, no one has systematically explored chimpanzee language as it relates to the chimpanzees' perception of nonverbal context. What follows is a first attempt at a pragmatic analysis of chimp language in its nonverbal context.

Method

Selection of the Data

The data selected for the following analysis were collected before the analysis was conceived. The analysis itself was performed primarily by the first author, who was not present at, and played no part in, the teaching of the chimpanzees or the collection of the data. The data themselves were collected by the second author, who provided both the contextual descriptions of the events that co-occurred with word usage and the history of the subjects. During the span of time covered by this analysis, the second author was attempting to expand Sherman's and Austin's tool use skills and vocabulary. The data center around typical training sessions, and no attempt was made, by the second author, during these sessions to encourage the chimpanzees to encode anything other than tool names. The remainder of the encoded events reflect the chimpanzees' own judgments about when to use symbols. In no case was any constraint placed on the chimpanzees' length of symbol strings.

Because the analysis presented here had not been developed at the time the data were collected, trainer bias, a pervasive factor in chimp language research, was, in the present study, totally absent.

The specific days' data used in the analysis of perceived variability were randomly selected according to the following constraints: (a) that the principal teacher-caregiver (the second author) be present, (b) that the data occur within a 6-week time span prior to the date of the analysis, (c) that they center around the tool use task (This criterion was selected because we wanted to assure ourselves that the events of interest were present in the data we chose to focus on). All data in this period included instances of unanticipated spontaneous symbol usage by the chimpanzee, and these occurrences were noted on each day by the principal teacher in the daily records. The competence of the chimpanzees in the specific tool task around which the data centered was about the same throughout the period sampled.

The tool use task was chosen as the focus of this data analysis because it provided a stable situation in which the chimpanzee was free to express virtually anything to the teacher; yet it was structured to the extent that a routine set of events typically occurred which could be anticipated by both the chimpanzee and the teacher. This structure permitted the chimpanzee the freedom *not* to comment on many things if he did not want to, as the routine was known to both chimpanzee and teacher and did not need to be "discussed" at every point. On the other hand, knowledge of the routine also encouraged the chimpanzee to request changes in the routine if he did not want to follow it, because the teacher would otherwise anticipate continuing with the routine. In addition, at many points in the routine, there existed opportunity for the chimpanzee to specify which of a number of alternative things he would prefer to do on that occasion, which thus provided for situational variability.

Description of a Tool Use Cycle

During these training sessions, the teacher and the chimpanzee repeatedly cycled through a routine with the following format:

1. The teacher selects a food unless the chimpanzee specifies a particular food by name. Variants at this point included (a) asking the teacher to tickle, (b) asking the teacher to take the chimpanzee to other locations, and (c) the teacher's offering to get food, perhaps a specific food, for the chimpanzee. (These

variants were encoded at the keyboard by either the chimpanzee or the teacher.)

2. If the chimpanzee requested food, the teacher went to the sink-room to retrieve the food that the chimpanzee had requested. The chimpanzee could either wait by the keyboard or accompany the teacher. At the refrigerator the chimpanzee might be asked to select the food he requested at the keyboard. On some occasions he would help place a portion of the food in a bowl and he might taste the food.

3. The chimpanzee would then accompany the teacher to an area where a number of different tool sites were located and watch as the teacher put the food in a tool site. The teacher carried with her a number of tools that would be used to extract foods from the various sites. The chimpanzee (if he wanted the food) would typically ask for a specific tool. The teacher would find that tool (regardless of whether or not the request was correct) and give it to the chimpanzee. If it was not the correct tool and did not work in the tool site, the chimpanzee would often request another tool. If the chimpanzee did not want the food obtained with the correct tool, he would generally request something else.

4. After obtaining the food, the chimpanzee would return the tool to the tool kit, and the cycle would be repeated as long as the chimpanzee requested foods. When the chimpanzee requested other things, these requests would be granted and the tool use cycle would be interrupted.

Nature of the Data

Sherman and Austin use a visual symbol system. The symbols in the system, lexigrams (geometric symbols composed of one or more of nine different elements), are produced as a visual video display by depressing keys on a vertically mounted keyboard. The keys are linked to a computer which produces a printout of all "verbalization." This record is supplemented by a data-coding device through which the "speaker" is identified and certain other contextual notes are made by the teacher as the utterances occur. In the present study, the records consisted of this computer printout, supplemented by detailed contextual notes made by the teacher.

It should be noted that each chimpanzee had constantly available, on the keyboard, 100 lexigrams. The lexigrams stood for foods, other objects, locations, activities, and people. The chimpanzee could use any lexigram at any time, and the teacher would comply with any request if possible. In addition, the chimpanzee often used nonverbal means of requesting things that were not encoded on the keyboard. The teacher was also sensitive to these requests and would honor them if possible.

The data for purposes of this analysis consist of all utterances that are not complete imitations of the teacher's previous utterance. That is, all partial imitations as well as all spontaneous (nonimitative) utterances were included. The category of imitations, excluded from the analysis, includes partial or rearranged imitations, as long as no "new" lexigram was added. This category comprises a relatively small number of Sherman's and Austin's utterances (see Table 2).

Two transcripts (one for each chimpanzee) were randomly selected from the data generated during the type of training session described in a preceding section. The initial session chosen for Sherman was the 72-min session that occurred on September 18, 1981 (Table 1), and the initial session chosen for Austin was the 49-min session on October 27, 1981 (Appendix). These sessions were not unusual in any way. Many sessions contained far more original utterances than occurred on these particular dates; however, the goal was not to focus on the most exciting sessions, but rather on the average sessions, because it was thought that the capabilities of the chimpanzees were most accurately and conservatively reflected in the average sessions.

Method of Analysis

The analysis began with the identification of the variables that existed in the tool use cycle. Essentially there were three variables in the situation: which food would be baited, which tool would be required to obtain it, and whether the chimp would stay put or change location. These are considered variables because each dimension contains more than one possible value. (Here, value is being used in a qualitative rather than quantitative sense.) Thus, for example, the food variable contains values such as M&M's, sweet potato, orange drink, and peanut butter; the tool dimension contains values such as wrench, key, and straw. These values were intrinsic to the routine itself and were to one extent or another operative for both chimps.

The goal of the analysis was to determine whether the chimps used their lexigrams selectively to choose a particular value in situations in which a given dimension was in fact varying, rather than mentioning a dimension that was constant or redundant. In carrying out this analysis, we considered both variation over time, that is, change, and variation at a single moment, that is, the array of alternatives that existed on a given dimension at a particular point in time.

Our hypothesis was that the chimps would tend to use their lexigrams to mark change or to differentiate alternatives, rather than to mark constant, redundant, or repetitive aspects of situations in which, in terms of their past history and present circumstances, there seemed to be but a single unique possibility.

Thus, during the utterance-by-utterance analysis, each spontaneous statement or request that the chimpanzee made was evaluated in terms of what the chimpanzee actually encoded and of what factors (both objective and subjective) were potentially available for encoding in that situation. It was also noted whether the chimpanzee had encoded any of these items during earlier cycles and thus could now presume that something that had been verbalized earlier (such as a desire to accompany the experimenter to the sink-room) would be inferred by the experimenter and need not be verbally encoded again. With each successive utterance, we asked: Is the chimpanzee encoding the aspects of the situation whose variance is, at this point in time, the most salient? Or does his encoding simply

reflect imitation of the teacher or routinized requests that are not sensitive to the constantly changing aspects of the situation?

In addition to the major variables of tool, food, and location described above, there were also moderating variables relating either to the state of the chimpanzee, unexpected intrusions into the routine, or individual personality predispositions. An example would be the chimpanzee's state of hunger: As a tool use session progressed, the chimpanzee became progressively less hungry. This meant that although a set of alternative foods was present objectively, its subjective presence would gradually be diminished for the chimpanzee across cycles.

Once the utterance-by-utterance analysis was completed for both Sherman and Austin, four more sessions (two for each chimp) were randomly selected for the same 2-month period that the initial sessions were drawn from. The sessions selected for Sherman occurred on October 19 and 22, 1981; for Austin, October 20 and 26 of the same year. The data from these additional sessions were then summarized in order to determine whether they supported the results of conclusions reached during the utterance-by-utterance analysis. Table 2 presents the major quantitative features of the data for initial and later sessions for both chimps. It is discussed when the data from the additional sessions are presented in a later part of the Results section.

Results

Utterance-by-Utterance Analysis

The linguistic data used in the utterance-by-utterance analysis can be found in Table 1 (Sherman) and Appendix (Austin). These list all utterances that occurred, both for the teacher and the chimpanzees. The utterances are laid out cycle by cycle.

The initial food request comprises Part 1 of each cycle, and the initial tool request comprises Part 2 of each cycle, as described above. In Part 1, it is possible for the chimpanzee to also select a location and/or express his desire to accompany the teacher to the sink-room. Thus, what is termed the "initial food request" is often, in reality, a request for both food and change of location.

The analyses are presented separately for each chimpanzee because the animals differed in a number of ways regarding their patterns of symbol selection even though their training histories were virtually identical.

Sherman

Perceived variability influences utterance length. Initially, one of the most striking results of the analysis of the role of perceived variability was that food requests were, on the average, considerably longer than tool requests. Whereas Sherman's spontaneous food requests consisted of combinations of up to four lexigrams, the initial tool requests consisted of a single lexigram in 14 out of 16 cycles (Table 1). This difference reflects the lesser degree of variability inherent in the situation once a tool site has been baited with food. At this point, attention is focused on the site, and the only variable (and therefore uncertain) element is the specific tool which is needed. Note too (Table 1) that food is never mentioned as part of the tool request, even though it is the ultimate goal. By this time in the routine, the food has become "old" information that can be taken for granted.[1] What is still in question is which of the alternative tools can be used to obtain that food, and this is the only information that Sherman (or Austin) verbalizes. However, at the beginning of each cycle, and particularly at the beginning of the first cycles, a number of other things need to be established: (a) Will the chimpanzee accompany the teacher as she leaves the tool site area; (b) once that area is left, will they go to the sink-room or will they go elsewhere, and (c) what food will they get in the sink-room? Thus, the number of sources of variability is greater at the time of the initial food request than at the time of the initial tool request.

The difference in length of request in these two situations suggests that perceived variability affects not only what semantic functions are linguistically realized but also utterance length. Multiple sources of variability thus seem to favor lexigram combinations, whereas the presence of but a single source of variability favors single-lexigram utterances. This line of thinking suggests that "word" combinations may be influenced more by the arrays of behavioral alternatives available to the chimpanzees than by knowledge of grammatical "rules." Indeed, in these data, no evidence was found that combinations are, in any way, related to syntactic rules. Word order, the only syntactic means available to the

[1] The chimps were never trained to refrain from mentioning the food name in this part of the cycle (Savage-Rumbaugh, 1984).

Table 1
Transcript of Tool Use Session: Sherman, 9-18-81

Cycle no.	Cycle part	Speaker	Utterance
1	f	Sherman:	Go sink-room playroom orange-drink.
		Teacher:	No playroom. (Question) go sink-room orange-drink.
		Sherman:	Go sink-room orange-drink.
		Teacher:	Yes.
	t	Sherman:	Lever.
		Teacher:	Yes give Sherman lever.
2	f	Sherman:	Go orange-drink.
		Teacher:	(Question) orange-drink cheese.
		Sherman:	Cheese orange-drink go.
		Teacher:	Cheese orange-drink sink-room.
		Sherman:	Go cheese sink-room [sink-room] orange-drink.
		Teacher:	Yes.
	t	Sherman:	String.
		Teacher:	Yes string.
3		Teacher:	(Question) go sink-room get M&M.
	f	Sherman:	Go M&M.
		Teacher:	Yes M&M sink-room go.
	t	Sherman:	Stick.
		Teacher:	Yes stick.
4	f	Sherman:	Peanut.[a]
		Teacher:	Peanut sink-room (question) go.
		Sherman:	Go peanut.
		Teacher:	Yes.
	t	Sherman:	Wrench.
5	f	Sherman:	Orange-drink.
		Teacher:	No orange-drink. (Question) go sink-room food.
		Sherman:	Go sink-room orange-drink.
		Teacher:	No orange-drink. (Question) go sink-room peanut M&M.
		Sherman:	Sink-room M&M peanut.
		Teacher:	Yes.
	t	Sherman:	Stick. (incorrect choice) Straw (incorrect choice) money.
		Teacher:	Yes money. [Cheese.]
		Sherman:	Money.
		Teacher:	Yes money.
6	f	Sherman:	M&M.
		Teacher:	(Question) go sink-room M&M.
		Sherman:	Sink-room M&M.
		Teacher:	Yes.
	t	Sherman:	Wrench.
		Teacher:	Yes wrench.
7		Teacher:	(Question) go sink-room food.
	f	Sherman:	Go M&M.
		Teacher:	Yes.
	t	Sherman:	String.
		Teacher:	Yes string.
8		Teacher:	(Question) food sink-room.
	f	Sherman:	M&M sink-room food.
		Teacher:	No M&M. Yes go sink-room food.
	t	Sherman:	Lever.
		Teacher:	Yes lever.
9		Teacher:	(Question) go liquid hot liquid sink-room.
	f	Sherman:	Hot M&M.
		Teacher:	No M&M. Yes go sink-room food.
		Sherman:	Go food sweet-potato M&M.
		Teacher:	Yes.
	t	Sherman:	Key give [give].
		Teacher:	Yes give key.
10	f	Sherman:	M&M.
		Teacher:	(Question) go sink-room M&M.
		Sherman:	Sink-room M&M.
		Teacher:	Yes go.
	t	Sherman:	Stick.
		Teacher:	Yes stick.
11	f	Sherman:	Go peanut M&M.
		Teacher:	No peanut M&M. (Question) go sink-room coke.
		Sherman:	Coke sink-room food.
		Teacher:	Yes.
	t	Sherman:	String. (incorrect choice) Sponge.
		Teacher:	Yes. Sponge.
12		Teacher:	Glass get.
	f	Sherman:	M&M food.
		Teacher:	Yes go sink-room food M&M.
	t	Sherman:	Wrench.
		Teacher:	Wrench yes.
13		Teacher:	(Question) go sink-room Milk.
	f	Sherman:	Milk.
		Teacher:	Yes go.
	t	Sherman:	Straw.
		Teacher:	Straw yes.
14	f	Sherman:	M&M.
		Teacher:	M&M gone gone gone.
		Sherman:	Sink-room food M&M.
		Teacher:	M&M gone.
		Sherman:	Food sweet-potato. Peanut.
		Teacher:	Yes peanut sweet-potato food sink-room.
	t	Sherman:	String.
		Teacher:	String yes.
15	f	Sherman:	Sink-room [sink-room] peanut.
		Teacher:	Yes go sink-room peanut.

(*table continued*)

Table 1 (*continued*)

Cycle no.	Cycle part	Speaker	Utterance
	t	Sherman:	Lever.
		Teacher:	Lever yes.
16	f	Sherman:	Orange-drink.
		Teacher:	Yes go sink-room orange-drink.
	t	Sherman:	Sponge give.
		Teacher:	Sponge yes.
17		Sherman:	Sink-room.
		Teacher:	Yes go sink-room.

Note. f = initial food request; t = initial tool request. Periods are used to represent a lexigram that is obligatorily used to signal the end of an utterance. (Question) = question-mark lexigram; hyphenated word = single lexigram. Brackets indicate an accidentally activated symbol.

[a] The peanut lexigram was originally used to refer to peanut butter. In Cycle 11 it is used to modify *M&M* to form *peanut M&M*.

chimps, seems essentially random, whether considered from the point of view of surface structure (subject–predicate), base structure (case relations), or function (topic–comment).

A second major pattern relating to the influence of perceived variability was the progressive shortening of Sherman's initial spontaneous food requests as repetitive aspects of the tool use routine became established within the context of that particular training sessin. Sherman begins with a four-lexigram combination in his first food request (Cycle 1, Table 1), produces a two-lexigram utterance on Cycle 2, and reduces it to a single-lexigram request on Cycles 4–6 and Cycle 10 (Cycles 3, 7, 8, and 9 were not analyzed because the requests were not spontaneous; they were preceded by questions on the part of his teacher).

Looking at this trend in terms of changing semantic content as the utterances get shorter, we find that what drops out is reference to Sherman's own movement and location. What remains is reference to a specific food. (For example, contrast the initial food request of Cycle 1 with that of Cycle 5 in Table 1.) This change in content confirms our hypothesis of a linguistic emphasis on perceived variability, for movement and location patterns have now become repetitive from cycle to cycle whereas food still continues to involve a choice from among an array of alternative possibilities. This choice, moreover, often changes from cycle to cycle.

A lengthening of the food request on Cycle 11 (Table 1), although reversing the above trend toward shorter food requests, nevertheless confirms our general hypothesis by showing the extremely subtle differentiation of alternatives. On the trial before, the teacher's response to Sherman's request for M&M's had been to introduce him to a new food (chocolate-covered peanut M&M's), which she had labeled accordingly as "peanut M&M." On this trial, Sherman signals his desire for this novel food by producing a three-lexigram request *go peanut M&M*. The double-lexigram food label is informationally essential in this situation, for it distinguishes peanut M&M's from two other foods also available and requested in the same session, regular M&M's and peanut butter, each labeled with the individual lexigrams *M&M* and *Peanut*. Here a single-lexigram message would be ambiguous: *Peanut* could mean either peanut butter or peanut M&M; *M&M* could mean either plain or peanut M&M. Sherman's two-lexigram combination *peanut M&M* effectively disambiguates the alternatives that exist in the situation. Here again, an additional source of variability is reflected in a longer utterance: The chimp must take account of two dimensions, type of food and type of M&M, in order to specify exactly what he wants, given the present array of alternative foods.

Why Sherman adds *go* to *peanut M&M* in the utterance being analyzed is less clear. However, it seems likely that the longer utterance is a response to another form of variability, novelty, for peanut M&M's are new to Sherman. If so, novelty or "new information" results in a more explicit linguistic encoding for the chimpanzee, just as it does for the human child or adult.

The superordinate is used to partition relevant alternatives. Another pattern that also confirms our hypothesis is Sherman's use of the superordinate term "food" in contrast with subordinate terms naming specific foods. Indeed, Sherman's usage confirms Brown's (1958) point about human beings: that they tend to use labels at an appropriate level of generality necessary to make distinctions that are functional for the particular activity in which they are engaged. First, "food" is used when it can contrast with "liquid," seeming to indicate that any of several foods would be acceptable, in contrast to liquids. (Indeed, Sherman had learned the lexigram *liquid* by being asked to contrast a number of liquids with a number of foods.) One example occurs in Cycle 9 (Table 1). However, the clearest example is in Cycle 11 (Table 1) in which, after denying a request for peanut M&M's, the teacher verbally offers Sherman a liquid (Coke). He responds *Coke sink-room food* and proceeds to pick out another food to eat with his Coke. The contrast with liquid also seems to be operative in Cycle 12 (Table 1), when liquid is suggested by his teacher's opening statement *Glass get.* At other points it is used to indicate the remainder of the food category after a first-choice food has been denied, as in the example in Cycle 14 (Table 1). The claim that Sherman is selectively using superordinate versus specific terms, according to which alternatives are partitioned in particular situations, is also strongly supported by a dialogue example in which the teacher's general term is replaced by a specific term in Sherman's reply—Teacher: *(Question) Go sink-room get food*; Sherman: *Go M&M.* In terms of the function of selecting from among alternatives that existed in the situation, *food* was an uninformative term because a variety of foods were available. Sherman, acting as though he recognizes this fact, replaces "food" with "M&M" in his own request. Thus, he achieves the level of generality necessary to eliminate uncertainty about which food he is referring to.

In all other cases of nonimitated lexigrams, as can be seen from the transcript (Table 1), Sherman uses a specific food name, reflecting the fact that he must distinguish a particular food choice from an array of alternatives. Thus, his pattern of choice of subordinate over superordinate terminology reflects sensitivity to the possibilities for partitioning alternatives that exist in a particular situation.

The use of location terms reflects the operation of perceived variability. As with the categories of food and tool requests, Sherman's location requests also reflect the influence of perceived variability. Here we analyze Sherman's nonimitated location requests beyond the point at which, as we saw above, locations were verbally specified in order to establish the basic routine of accompanying his teacher to the next room to obtain the requested food. One such request occurs in Cycle 14 (Table 1). Sherman has asked for M&M's. His teacher says *M&M gone gone gone*, showing him the empty bag. His response is *Sink-room food M&M.* Whereas, before, there was but one possible location from which to get more M&M's—the sink-room—the teacher has now created an additional possibility—the M&M bag in the tool room. Hence, location is no longer redundant with food. It is at this point that Sherman spontaneously inserts a location term in a lexigram combination for the first time since Cycle 1, producing *Sink-room food M&M.*

Perhaps most interesting is the last cycle in which Sherman for the first and only time produces *sink-room* without a food name. Although he had drunk a large orange drink, had leftover peanut butter from a previous trial, and had started to eat slowly, his teacher thought he would still like more food and went to the sink-room to get some. However, once in the sink-room, Sherman took her hand to lead her away from the cooler, where the food was kept, toward the outside door. He then gestured to have the door opened and sat down to groom his teacher and watch people and dogs outside. In this example, Sherman specified *Sink-room* because he desired a change of location. Once full, the salient array of alternatives, from his perspective, is no longer foods but locales, and his semantic choice changes accordingly. The only other spontaneous use of *sink-*

room past the initial request confirms this analysis. On the previous cycle, Sherman had started eating slowly as if no longer hungry and, in fact, had peanut butter left over (Cycle 14). On the next cycle (No. 15), he produces *Sink-room* [*sink-room*] *peanut.* Two cycles later, he produces *sink-room* alone. As his hunger decreases, it seems that his intention gradually shifts from possible foods to possible locations, and his verbalization reflects the array of alternatives relevant to this intention.

These examples clearly suggest that Sherman's use of locative terms, like his other uses of symbols, reflects his ability to partition alternatives that are relevant to his intended activity at a particular point in time.

Austin

In order to determine whether Austin's spontaneous use of lexigrams also reflected the perceived variability in the situation, we randomly selected a similar tool use training session for Austin (Appendix). We summarize this record, concentrating on comparison with Sherman. Many similarities as well as differences revolve around the influence of both objective and subjective variability. Sometimes these differences stem from slightly different circumstances that surround their utterances, but more often they reflect differing intentions, traceable to different life histories and resulting personalities. Regardless of these individual differences, the influence of perceived alternatives and desired change runs through even the apparent differences in the lexigrams that both chimpanzees produce and the occasions on which they produce them.

Similarities with Sherman. We begin with major similarities in the patterns of lexigram usage in the tool situation. Austin, like Sherman, tended to produce shorter utterances when requesting tools than when requesting foods on each cycle. This difference held for 10 of 12 tool use cycles. Typically, Austin would simply ask for the tool by name, producing but a single lexigram; in contrast, he tended to produce two or three lexigrams to express a request for food. Thus Austin, like Sherman, was constructing messages that reflect the greater number of sources of variability in the food situation. Unlike the tool situation, the foods move from one room to another, can get used up, can be obtained with or without the chimp's help, and so on These multiple sources of variability are reflected in multi-lexigram messages in contrast to the single-lexigram messages both chimpanzees use to request tools.

A major similarity between Austin and Sherman's communicative responsiveness to perceived variability in their respective tool sessions was manifest in their shifts from using lexigrams to select from a set of foods to using them to select from a set of locations as each chimp became full. This shift is particularly interesting because it was, in each case, internally generated; that is, the external constraints of the situation had not changed. Just as Sherman had begun to add *sink-room* to his food requests as he became full, so Austin began to add the lexigram *out.* Examples are *Yes out orange drink* (Cycle 10, Appendix) and *Austin out melon* (Cycle 12 in Appendix). Thus, as with Sherman's, Austin's changed motivation made an additional set of alternatives relevant. The motivationally salient variable became location, and this change was reflected in his communicative behavior. This production of *out* is particularly interesting because it was totally spontaneous: The teacher had not once used the lexigram *out* in this session. This pattern is confirmed rather strongly for Austin, as it was for Sherman, by the last potential tool cycle (No. 13), in which Austin, now thoroughly stuffed, eliminates food altogether, asking only for a favorite location by means of the lexigram *bathroom.* (Austin is not asking to go to the bathroom in order to urinate or defecate. Stainless steel johns are in all rooms, and both Austin and Sherman use these routinely. He is asking to go to the bathroom because it is a small area where he loves to play "hide and seek" in the shower, to make faces in the mirror, and to turn the lights off and on.)

Use of "yes" when "no" was a definite alternative possibility. Many of Austin's food requests, unlike Sherman's, included the lexigram *yes.* A brief description of Austin's performance on the tool training

task at the time of these sessions is needed in order to better understand his frequent use of *yes* during food requests. Because of recent changes in the physical environment, Austin made frequent errors when requesting tools. He preferred to dawdle in the sink-room and to try to get the teacher to give him as many tastes of the food as possible before returning to the tool room. (Sherman, on the other hand, was always eager to return to the tool toom, made few tool-request errors, and did not dawdle or insist on tasting the food.) Austin responded to these changes and to errors by including in his requests the answer (yes), which he would like his teacher to give; that is, he liked to have the teacher respond *Yes strawberry drink* or *Yes cake* and then give him a taste of that food straightaway, as opposed to putting it in a tool site, which was the expected routine. Austin seemed to use *yes* most frequently in his requests when he wanted to eat the food in the sink-room (instead of having it placed in a site) or when he was uncertain of his teacher's cooperativeness because he had misbehaved or made an error on a previous trial. In all these cases, *yes* is used because Austin's past history indicates that *no* is a reasonably likely response on the part of his teacher.

In this session the use of *yes* during a food request first appeared after a cycle (No. 1, Appendix 1) in which the teacher did not give Austin the tool that he wanted because Austin had used an incorrect lexigram to request that tool. This mistake apparently led Austin to conclude that since the teacher did not give him the tool he wanted, she might also not give him the food that he wanted. Thus on the immediately following request (Cycle 2, Appendix), he explicitly encoded the desired answer to his question by including *yes* as a part of his request. Thus we see that Austin, like Sherman, uses his symbols to encode perceived behavioral alternatives, even though he does not always perceive the same alternatives as Sherman.

Austin's use of his name to differentiate himself from Sherman. Another difference between Austin's multi-lexigram food requests and Sherman's lies in his not infrequent use of his own name (6 out of 13 cycles). Some examples are *Austin peanut* and *Austin lemonade*. Here, we must note that Austin first incorporated his name into a food request on the fourth tool cycle (Appendix). At this point, his teacher was about to leave him in the tool room and go out and obtain food without Austin's company because Austin seemed preoccupied with slowly and carefully consuming the peanut butter that he had just obtained. The teacher had concluded that Austin was not interested in going with her or in using the keyboard to request a specific food. In producing *Austin peanut*, rather than *Peanut* alone, he seemed to be saying "not just teacher, but also Austin" will go to the peanut butter. Thus, through his choice of lexigrams, Austin showed that, in fact, he did want to get a particular food. Hence, he used the lexigram *Austin* to signal another type of variability—change; in this case, it is a desired change in teacher's anticipated behavior toward Austin.

Hence, for Austin, his name functions as "go" functions for Sherman in the same situation. However, because of his relation with Sherman and his general insecurity, he focuses verbally on himself rather than his action in asserting a similar desire to accompany the teacher. In sum, we are hypothesizing that Austin's use of his name is a contrastive one, serving the function of differentiating himself from Sherman.

This view is supported by the fact that whenever Sherman and Austin are mutually attempting to gain their teachers' attention and engage them in a tickling game, Sherman rarely uses the keyboard to specify either himself or the activity. He simply approaches the teacher and begins tickling. Austin, who is much smaller than Sherman, has difficulty gaining attention in such a direct fashion and thus frequently specifies, at the keyboard, *Austin tickle* in order to direct the teacher's attention away from Sherman and toward himself.

An individual difference in the use of location terms. There is one more difference between Sherman and Austin: Austin does not begin his sessions with food–location combinations. Just as Austin does not initially attempt to establish that he can accompany the teacher, he also does not become nearly as upset (on most occasions)

as Sherman when the teacher leaves him alone. Presumably, this is a result of their different rearing histories; Austin was separated from his mother shortly after birth (because she did not care for him) and was housed alone for some time prior to assignment at the language project. Sherman stayed with his mother until he was 1½ years old, at which point he was removed and placed with other chimpanzees.[2] Whereas Sherman fears being left alone, even for short periods, Austin often prefers it. Therefore, he frequently does not bother to specify that he wishes to accompany the teacher to get food in the sink-room, and his initial food requests specify only food.

The analysis of Austin's transcript confirms the generality of the influence of perceived variability and informativeness on chimp language use. In addition, it indicates that life history and personality factors must be added to situationally defined factors in determining exactly what variables will be operative for an animal at a particular moment in time.

Summed Analysis of Additional Sessions

In order to determine whether these analyses were of general value in understanding why and when these chimpanzees chose to encode certain aspects of their environment, we randomly selected and summarized two more sessions for each chimp. We did not subject these additional sessions to an utterance-by-utterance analysis. Instead, we defined a number of basic descriptive principles that we thought applied to the symbol use of each chimp. Then each spontaneous utterance, with emphasis on initial food and tool requests, was examined in these additional sessions in order to determine whether they fit within these principles. We also computed, for these additional sessions, the number of imitative or partially imitative utterances.

The basic hypotheses formulated during the utterance-by-utterance analysis to be tested across additional sessions are outlined below. (Also listed is the name of the chimpanzee to which the hypothesis applies.)

1. More sources of variation are extant in the training situation at the time of food requests that tool requests. Thus, as a general rule, food requests should be longer than tool requests because more variables need to be specified. (Austin and Sherman)
2. Food requests tend to drop out and become replaced by location requests as the session progresses and the chimpanzees become less hungry. (Austin and Sherman)
3. Once a routine of accompanying the teacher to a location is established for a given session, that location tends not to be encoded on later trials. (Sherman only)
4. The use of *yes* occurs during a request when Austin has reason to believe that the teacher might not respond positively to his request. (Austin only)
5. Self-naming occurs, in coordination with a food request, because Austin has reason to believe that attention might be paid to Sherman rather than to himself. (Austin only)

Table 2 contains the results of these two additional sessions for Sherman and Austin. For comparative purposes, the quantitative results from the initial sessions are also presented. The basic purpose of the table is to place the qualitative analysis in a quantitative context in order to confirm that the qualitative results, reported earlier, are not exceptional but are typical of each chimpanzee's behavior.

As this table reveals, the number of spontaneous utterances remained high across these additional sessions, and the number of imitated utterances remained low.

In addition, the tendency of both chimpanzees to produce shorter utterances for tool requests than food requests was confirmed. When one looks at every cycle in which a chimp first requested food (or food plus location) and then requested a tool (36 cycles for Sherman, 20 for Austin), there is not a single instance of a tool request that is longer than a food request. On the other hand, there are 36 instances (19 for Sherman, 17 for Austin) in which a food (or

[2] These separations were both made before these chimpanzees became a part of the language research project. Once they were assigned to the project, every effort was made to provide them with a social group, and neither of them was ever housed alone.

food plus location) request is longer than a tool request. Whereas both chimps uniformly frame their tool requests in single-lexigram utterances, the average length of food (or food plus location) requests is 1.8 per session for Sherman, and 2.6 per session for Austin (Table 2). Hence, there is strong confirmation that each chimp's length of utterance is affected by, and therefore positively correlated with, the number of variables created through the structuring of the experimental situation. From the chimp's point of view, the more aspects of a situation that offer choice, the longer his utterance is likely to be. As was pointed out earlier, because of the way this experimental situation was structured, there are more dimensions of choice in the food-request part of the task than in the tool-request part.

This finding is of theoretical interest because it uncovers a mechanism, apart from syntax, that operates to control utterance length. According to our analysis, variability rather than linguistic structure per se is the primary determinant of the chimps' utterance length.

The individual differences identified in the analysis presented earlier are also strongly confirmed by the additional sessions analyzed. In terms of the initial food requests for each cycle, Austin includes the lexigram *yes* a mean of 4 times per session in the additional two sessions, Sherman not at all (Table 2). As before, we interpret this as stemming from an additional variable or question in the situation for Austin but not Sherman: Will the teacher comply with his request, and will he get to eat some food without having to select and use a tool? This is not a variable for Sherman because he shows behaviorally that he enjoys using the tools and does not care whether their use is prerequisite to getting food. Austin, in contrast, indicates through his behavior that he does not like using the tools, and he uses his language to avoid having to do so.

An alternative explanation for this finding might be that the teacher modeled yes much more frequently for Austin than for Sherman. However, analysis of the verbal input received by the two chimps during the sessions in question revealed that the teacher used yes at least once per cycle with Sherman. The same holds for Austin. Hence the individual difference in the frequency of using the *yes* lexigram cannot be attributed to differential modeling by the teacher in the immediate situation. Basically, both chimps have yes modeled equally often; and in fact any advantage in exposure to yes is in favor of Sherman, the chimp that rarely produces yes himself.

Another individual difference that holds up for the additional sessions analyzed is the tendency for Austin, but not Sherman, to include his own name in food or location requests. Thus we find that Austin uses his own name an average of seven times per session in the two additional sessions whereas Sherman does not do so even one time (Table 2). As before, the interpretation is that Austin defines himself in contrast to Sherman, by whom he is generally dominated. Another way of thinking of this is that Sherman generally dominates in the allocation of resources, and therefore it is necessary for Austin to specify not only the desired resource (food or location) but to specify himself—not Sherman—as possessor of the resource.

In the additional sessions we again found a tendency in Sherman's data for food requests to get shorter as the basic situation repeats itself from cycle to cycle. Because of its repetitive nature, location can be presumed after the initial cycles, and verbal specification of location drops out. In Sherman's session of 10-19-81, the first nonimitated food request has three lexigrams and includes a location term, his second has two but still includes a location term, and his third has but one, a food term. Thus, this session confirms the tendency to produce increasingly short utterances as a referential situation repeats itself. Essentially the same pattern is observed for Sherman's other analyzed session, 10-22-81. Sherman's first three food requests consist of three lexigrams, including a location term (*sink-room*). His fourth, in contrast, contains but one lexigram, a food term (*cake*).

This analysis confirms the general idea that a location term is not uttered simply when Sherman wishes to take a particular

Table 2
Quantitative Results

Session	Total no. utterances		Session length (in min)		No. spontaneous utterances[a]		No. imitated utterances[b]		No. expanded imitations[b]		*M* length of spontaneous initial: Food request		Tool request	
	Sh	As	Sh	As	Sh	As	Sh	As	Sh	As	Sh	As	Sh	As
Initial	49	38	72	49	32	34	9	2	8	2	1.7	2.2	1.1	1.0
Additional	60.5	33.5	73	56	53	30	2	2	5.5	1.5	1.8	2.6	1.0	1.0

[a] This category is based on Sanders (1980). For Sanders, *spontaneous* is defined as utterances that do not immediately follow another's turn in the conversation. However, he has an additional category, termed *novel*, that comprises nonimitated utterances that do immediately follow another's turn in the conversation. Because

travel pattern or to go to a particular location. Instead, and crucial to our argument, it is used only in that subset of location or travel-pattern requests in which it would not be redundant. Specifically, *sink-room* is not used in those circumstances in which a request for food automatically entails movement to the sink-room because of a repetitive routine that has been set up. It is, however, used when needed to signal a change desired by the animal. This includes early food requests when it is not yet established that choosing a food entails going to the sink-room to get it. It also includes requests for a change of location to the sink-room independently of a desire to obtain food there.

The latter is illustrated by looking for uses of *sink-room* outside of the early food requests. This is particularly noticeable in Sherman's session of 10-19-81, when a worker was cleaning up, first in an adjacent room, later outdoors. Sherman got very distracted and kept wanting to go to see what was happening. This was reflected in Sherman's utterances *Sink-room out* (three times) and *Sink-room outdoors* (once) in which he uses the lexigram *sink-room* to indicate a travel pattern to get to the outdoors where the worker is making noise. Here *sink-room* is not redundant because no food is involved and there are alternative routes to the outdoors.

There are also a number of instances in which Sherman combines a food name with *sink-room* after the initial cycles during which the routine is established. Although this appears to go against the hypothesized pattern, in fact, it does not, as Sherman is actually in a conflict situation. His teacher is attempting to get him to participate in the tool-request procedure, and he is hungry; but he also wants to go out and investigate and display toward the person bustling around outside the laboratory. In this particular situation of conflict, requests such as *sink-room M&M* may represent the operation of two conflicting variables, food—part of the tool procedure— and location—part of Sherman's desire to explore what is happening outside. Such food–location combinations occurred seven times after the basic routine had been established, and the location terms always occurred when the worker was nearby. Thus, the location–food combinations reflect two sources of variability in the situation from the animal's point of view.

This analysis is only partially confirmed by Sherman's other session, at 10-22-81. In this session, two instances of location–food combinations occur that do not seem motivated by the circumstances that would create sources of variability. These two utterances constitute the only data in all six sessions that do not fit into the patterns identified in this article.

When one looks at Austin's records for the shortening of food requests over time, one sees, as before, that there is an individual difference. In both sessions Austin, unlike Sherman, starts his food requests as single-lexigram utterances. However, as was mentioned earlier, this difference does not seem to reflect the nonoperation of the principle of informativeness so much as it reflects a personality difference between Austin and Sherman. These consistent dif-

Table 2 (*continued*)

Use of location term								Use of *yes*		Use of own name	
During early cycles		During middle cycles		When full		When outside disturbances					
Sh	As	Sh	As	Sh	As	Sh	As	Sh	As	Sh	As
2	0	0	0	3	5	—	—	0	7	0	6
2.0	1	1.0	0.5	1.5	3.5	5.0	—	0	4	0	7

there were so few of these in our data (a mean of 1 per session), we included Sherman's and Austin's novel utterances in our category of spontaneous. [b] Criterion for this is also based on Sanders. Imitations across cycle boundaries were not counted.

ferences between Austin and Sherman illustrate the point that the analysis of behavioral alternatives partitioned by language is not a mechanical operation but must be based on knowledge of a particular animal's behavioral repertoire and preferences.

As with Sherman's, Austin's location–food combinations again appear to be guided by the principle of perceived variability. At 10-26-81, he produces this type of utterance when the food he wants (orange drink) is gone and he loses interest in the task. At this point he produces utterances that combine food and location (as well as his name), such as *Austin out orange-drink strawberry-drink cake*. Finally, the foods drop out, and we find *Austin out*. This development parallels what we observed happen to the chimps during their initial sessions when they got full: A change of location, rather than a change in food came to be paramount, and this was reflected in their verbalizations. Austin manifests a similar pattern in his other session, 10-26-81. The only difference is that he ends with food–location combinations rather than with location alone.

This pattern of use of location lexigrams is revealed in Table 2, where it can be seen that location terms appear mainly in the early cycles before the routine of going to the sink-room has been established (for Sherman only), in the last cycles during which the chimps are full, and at times when there are outside disturbances. Location terms are used least in the middle cycles during which none of these special conditions obtained.

To summarize, the additional sessions analyzed for Sherman and Austin confirmed the hypotheses generated during the first sessions selected for utterance-by-utterance analysis in almost every respect. When a new situation comes into play in the additional sessions (specifically, the additional person working around Sherman during his tool session), different usage patterns emerge. However, these patterns also support the view that lexigram usage is a function of perceived variability.

Conclusions

These data strongly indicate that the two chimpanzees, Sherman and Austin, are constantly and consistently formulating verbal messages that encode perceived variability. In almost all cases, variability consists of an array of alternatives relative to the chimp's intention. In this respect, the chimpanzees manifest the same pattern as human children (e.g., Greenfield, 1982). Indeed, they give the appearance of conforming even more strongly to the principle of encoding perceived variability than children do. This is probably because the chimps' real alternatives are so much more limited than are children's. To a great extent this is due to the fact that restriction and classification of alternatives were built into the chimps' training situation by design.

The chimps' tendency to mention the variable while leaving the constant or redundant unsaid is a strong support for the position that they are using their humanly devised language in a meaningful rather than rote fashion (Savage-Rumbaugh, 1981). Although there is some overlap between the phenomena reported here and conditioned responses, the chimpanzees go

well beyond the limits of conditioning in their communicative performance. For example, the shortening of requests seen in Sherman's data as the session proceeds is similar to the dropping out of response elements that the animal learns are unnecessary for reinforcement in a behavioristic analysis. However, such an analysis can not explain why, in certain later trials, Sherman's requests lengthen. The longer utterances are still unnecessary for reinforcement. They are, however, necessary for information: to differentiate the new alternatives of food and location that have arisen in the situation. At this point, the informational account succeeds where the behavioral one fails. In using language to partition alternatives, Sherman and Austin are performing a function that Olson (1970) placed at the very heart of reference in human language. Thus, our results speak against the argument that chimpanzee use of humanly taught languages is mainly a function of complex conditioning.

Indeed, we can go further than saying that they are using language in a meaningful manner to claim that they are maximizing effective and efficient communication: Avoiding mention of the constant or repetitive amounts to avoiding mention of the obvious, an important principle of normal human conversation (Grice, 1975).

An unexpected finding was that the chimps' utterance length was controlled by the number of dimensions of perceived variability in a particular situation. In this they resemble children at the two-word stage (Leonard & Schwartz, 1978; Miller, 1979; Weisenberger, 1976) and even human adults (Rommetveit, 1968; Vygotsky, 1934/1962). Unlike in the case of humans, however, this phenomenon occurred in the absence of any tendency to use consistent word order either syntactically or pragmatically. From a theoretical perspective, such a result indicates that the absence of formal grammatical structure in chimp language does not imply, contrary to Terrace's claim, that utterances beyond one word in length are either rote strings (Straub, Seidenberg, Bever, & Terrace, 1979) or imitations (Terrace, 1979). In this connection, it is important to recall how few of the chimps' utterances were imitations of the immediately preceding utterance. In sum, our conclusion is that Sherman's and Austin's multi-lexigram utterances are used to encode variability, just as their single-lexigram utterances are.

In conclusion, our results confirm the idea that chimpanzee use of a humanly taught language builds on the apes' perceptual tendency to attend to variability. In this regard, the chimpanzee resembles the human child, who also coordinates language with a preexisting perceptual system. This finding is particularly interesting in the context of so many differences in the language learning of child and chimp, particularly the common chimp's lesser ability with and proclivity for symbolization per se (e.g., Greenfield, 1978a; Savage-Rumbaugh, in press).

Our findings are of a preliminary nature, based as they are on ad hoc analyses of data collected for other purposes. Certainly they need to be followed up by further systematic research. However, the evidence thus far clearly suggests that chimpanzee use of humanly taught languages may build upon the same cognitive substrate that guides a child's language use from a very early stage of ontogeny. Indeed, it is possible that this is the same cognitive substrate out of which human language evolved in the first place.

References

Brown, R. (1958). *Words and things.* Glencoe, IL: Free Press.

Brown, R. (1973). The first sentences of child and chimp. In C. A. Ferguson & D. J. Slobin (Eds.), *Studies of child language development* (pp. 445–462). New York: Holt, Rinehart & Winston.

Carnap, R., & Bar-Hillel, Y. (1953). *An outline of a theory of semantic information* (Technical Report No. 247). Cambridge, MA: Research Laboratory for Electronics, Massachusetts Institute of Technology.

Feigenberg, I. M. (1969). Probabilistic prognosis and its significance in normal and pathological subjects. In M. Cole & I. Maltzman (Eds.), *A handbook of contemporary Soviet psychology* (pp. 354–369). New York: Basic Books.

Gardner, B. T., & Gardner, R. A. (1971). Two-way communication with an infant chimpanzee. In A. M. Schrier & F. Stollnitz (Eds.), *Behavior of nonhuman primates* (Vol. 4, pp. 117–183). New York: Academic Press.

Gardner, R. A., & Gardner, B. T. (1969). Teaching

sign language to a chimpanzee. *Science, 165,* 664–672.

Givon, T. (1979). *On understanding grammar.* New York: Academic press.

Greenfield, P. M. (1978a). Developmental processes in the language learning of child and chimp. *Behavioral and Brain Sciences, 4,* 573–574.

Greenfield, P. M. (1978b). Informativeness, presupposition, and semantic choice in single-word utterances. In N. Waterson & C. Snow (Eds.), *Development of communication: Social and pragmatic factors in language acquisition* (pp. 443–452). London: Wiley.

Greenfield, P. M. (1982). The role of perceived variability in the transition to language. *Journal of Child Language, 9,* 1–12.

Greenfield, P. M., & Dent, C. (1979). A developmental study of the communication of meaning: The role of uncertainty and information. In K. Nelson (Ed.), *Children's language* (Vol. 2, pp. 563–598). New York: Gardner Press.

Greenfield, P. M. & Dent, C. H. (1982). Pragmatic factors in children's phrasal coordination. *Journal of Child Language, 9,* 425–443.

Greenfield, P. M., & Smith, J. H. (1976). *The structure of communication in early language development.* New York: Academic Press.

Greenfield, P. M., & Zukow, P. G. (1978). Why do children say what they say when they say it? An experimental approach to the psychogenesis of presupposition. In K. Nelson (Ed.), *Children's language* (Vol, 1, pp. 287–336). New York: Gardner Press.

Grice, H. P. (1975). Logic and conversation. In P. Cole & J. L. Morgan (Eds.), *Syntax and semantics: Vol. 3. Speech acts* (pp. 41–58). New York: Academic Press.

Haviland, S. E., & Clark, H. H. (1974). What's new? Acquiring new information as a process in comprehension. *Journal of Verbal Learning and Verbal Behavior, 13,* 512–521.

Hinde, R. A. (1966). *Animal behaviour: A synthesis of ethology and comparative psychology.* New York: McGraw-Hill.

Jewell, P. A., & Loizos, C. (1966). Play, exploration, and territory in mammals [Symposia of the Zoological Society of London, No. 18]. London: Academic Press.

Kagan, J. (1970a). Attention and psychological change in the young child. *Science, 170,* 826–832.

Kagan, J. (1970b). The determinants of attention in the infant. *American Scientist, 58,* 298–306.

Leonard, L. B., & Schwartz, R. G. (1978). Focus characteristics of single-word utterances after syntax. *Journal of Child Language, 5,* 151–158.

Limber, J. (1977). Language in child and chimp? *American Psychologist, 32,* 280–295.

Miller, M. H. (1979). *The logic of language development in early childhood* (R. T. King, Trans.). New York: Springer.

Mistler-Lachman, J. L., & Lachman, R. (1974). Language in man, monkeys, and machines. *Science, 186,* 871–872.

Ochs, E., Schieffelin, B. B., & Platt, M. L. (1979). Propositions across utterances and speakers. In E. Ochs & B. B. Schieffelin (Eds.), *Developmental pragmatics* (pp. 251–268). New York: Academic Press.

Olson, D. R. (1970). Language and thought: Aspects of a cognitive theory of semantics. *Psychological Review, 77,* 257–273.

Premack, D. A. (1970). A functional analysis of language. *Journal of the Experimental Analysis of Behavior, 14,* 107–125.

Rommetveit, R. (1968). *Words, meaning, and messages.* New York: Academic Press.

Rumbaugh, D. M. (1977). *Language learning by a chimpanzee: The Lana project.* New York: Academic Press.

Rumbaugh, D. M., & Pate, J. L. (1984). Evolution of primate cognition. In H. L. Roitblat, T. G. Bever, & H. S. Harris (Eds.), *Animal cognition* (pp. 569–587). Hillsdale, NJ: Erlbaum.

Sanders, R. (1980). *The influence of verbal and nonverbal content on the sign language conversation of a chimpanzee.* Unpublished doctoral dissertation, Columbia University.

Savage-Rumbaugh, E. S. (1981). Can apes use symbols to represent their world? *Annals of the New York Academy of Sciences, 364,* 35–59.

Savage-Rumbaugh, E. S. (1984). Verbal behavior at a procedural level in the chimpanzee. *Journal of the Experimental Analysis of Behavior, 41,* 223–250.

Savage-Rumbaugh, E. S. (in press). Levels of communicative symbol use: Prerepresentational and representational. In G. Greenberg & E. Tobach (Eds.), *T. C. Schneirla conference on levels of integration and evolultion of behavior.* Hillsdale, NJ:Erlbaum.

Savage-Rumbaugh, S., & Rumbaugh, D. M. (1978). Initial acquisition of symbolic skills via the Yerkes computerized language analogue system. In R. Schieffelbusch & J. Hollis (Eds.), *Language and communication: Primate to child* (pp. 277–294). Baltimore, MD: University Park Press.

Savage-Rumbaugh, E. S., Rumbaugh, D. M., & Boysen, S. (1980). Do apes use language? *American Scientist, 68,* 49–61.

Straub, R. O., Seidenberg, M. S., Bever, T. G., & Terrace, H. S. (1979). Serial learning in the pigeon. *Journal of the Experimental Analysis of Behavior, 32,* 137–148.

Terrace, H. S. (1979). *Nim.* New York: Knopf.

Van Cantfort, T. E., & Rimpau, J. B. (1982). Sign language studies with children and chimpanzees. *Sign Language Studies, 34,* 15–72.

Vygotsky, L. S. (1962). *Thought and language* (E. Hanfmann & G. Vakar, Eds. and Transls.). (Original work published 1934)

Weisenberger, J. L. (1976). A choice of words: Two-year-old speech from a situational point of view. *Journal of Child Language, 3,* 282–286.

Yerkes, R. M., & Learned, B. W. (1925). *Chimpanzee intelligence and its vocal expressions.* Baltimore: Williams & Wilkins.

Appendix

Transcript of Tool Use Session: Austin, 10-27-81

Cycle no.	Cycle Part	Speaker	Utterance
1	f	Austin:	Peanut.
		Teacher:	Yes go sink-room get peanut.
	t	Austin:	Wrench. (incorrect choice)
		Teacher:	Yes wrench.
		Austin:	Key.
		Teacher:	Yes key.
2	f	Austin:	Yes peanut.
		Teacher:	Yes go get peanut.
	t	Austin:	Lever.
		Teacher:	Yes give lever.
3	f	Austin:	Yes peanut.
		Teacher:	Yes sink-room go get peanut.
	t	Austin:	Key.
		Teacher:	Yes give key.
4	f	Austin:	Austin peanut.
		Teacher:	Yes Austin peanut go sink-room Sue.
	t	Austin:	String.
		Teacher:	Yes give string.
5	f	Austin:	Yes peanut.
		Teacher:	Yes go sink-room get peanut.
	t	Austin:	Wrench.
		Teacher:	Yes give wrench.
6	f	Austin:	Yes peanut.
		Teacher:	Yes go sink-room get peanut.
		Austin:	Orange-drink.
		Teacher:	Orange-drink gone no. (Question) strawberry-drink.
		Austin:	Strawberry-drink.
		Teacher:	Yes strawberry-drink peanut sink-room.
	t	Austin:	String. (incorrect choice)
		Teacher:	Yes string.
		Austin:	Sponge.
		Teacher:	Sponge give.
7	f	Austin:	Yes Austin strawberry-drink.
		Teacher:	Yes.
	t	Austin:	Key.
		Teacher:	Yes key.
8	f	Austin:	Orange-drink.
		Teacher:	Orange-drink [sore] gone. Orange-drink gone.
	. .		Coke. Coke. Lemonade.
		Austin:	Austin lemonade.
		Teacher:	Yes sink-room go get lemonade.
	t	Austin:	Wrench. (incorrect choice.)
		Teacher:	Groom.
		Austin:	Groom. Groom. Groom. Lever.
9	f	Austin:	Yes strawberry-drink.
		Teacher:	Strawberry-drink sink-room go.
	t	Austin:	Wrench. (incorrect choice) String. String.
		Teacher:	Yes string.
10	f	Austin:	Yes out orange-drink.
		Teacher:	Orange-drink gone. M&M cheese pudding jelly milk. Liquid.
		Austin	Out liquid banana.
		Teacher:	Yes.
	t	Austin:	Wrench.
		Teacher:	Give wrench.
11	f	Austin:	Austin out lemonade.
		Teacher:	Yes.
	t	Austin:	String. Straw.
12	f	Austin:	Austin out melon.
		Teacher:	Yes.
	t	Austin:	Lever.
		Teacher:	Lever give.
13		Austin:	Austin bathroom.
		Teacher:	Yes Austin bathroom.

Note. f = initial food request; t = initial tool request. Periods are used to represent a lexigram that is obligatorily used to signal the end of an utterance. Brackets are used to indicate a probable "slip of the hand" on the keyboard. In this transcript, the peanut lexigram is used to refer only to peanut butter. (Question) = question-mark lexigram; hypenated word = single lexigram.

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WHAT ARE OTHER ASYMMETRIES BETWEEN FOOD & TOOL PHASES
→ FOOD IS REWARD
TOOL IS INSTRUMENT NOT REWARD