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ON THE DEVELOPMENT OF PERCEPTUAL STRATEGIES IN CHILDREN: A CASE STUDY ON THE JAPANESE CHILD'S COMPREHENSION OF THE RELATIVE CLAUSE CONSTRUCTIONS*

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1. Background

1.1. Early Views on the Relationship between Grammar and Performance

As is well known, current linguistic theory makes a distinction between linguistic competence and linguistic performance. While the study of linguistic competence has been carried out with considerable concentration, the study of linguistic performance on the other hand has not entertained a comparable intensity. This situation is in fact quite understandable: on the one hand, linguistic performance involves far more intricate factors than does linguistic competence; moreover, the study of linguistic performance depends crucially on the development of an adequate account of linguistic competence.

Early works in psycholinguistics--a new discipline purported to study the psychological mechanisms underlying human lingustic behavior--were often marred by numerous misunderstandings on the part of the researchers. Some established scholars even ventured to propose what is usually known as the "derivational theory of complexity," according to which the hearer follows the path of transformational derivation backwards in the comprehension of a sentence. These scholars succeeded in devising several types of experiments to verify their theory and found the results satisfying for their contention. Later works, however, nullified the validity of the arguments for the derivational theory of complexity based on those early experimental results. It was pointed out, first of all, that the early studies made an unwarranted assumption that the experimental methods employed would elicit complexities originating in the decoding process of a sentence, even though these complexities might derive from some other mental work, e. g., verification of the given statements or identification of an exact match. Moreover, the early psycholinguists reduced, again without warrant, the elementary factor that contributes to the complexity accumulatively to the number of processes involved in the decoding task; they did not consider the inherent complexity of each such process. It is no wonder, then, that subsequent experiments revealed the existence of sentences whose derivational complexity contradicts the degree of perceptual complexity predicted by the derivational theory of complexity. The derivational theory of complexity received a final fatal blow from grammatical theory when theoretical linguists decided to make significant modifications in their technical apparatus; the derivational paths which the early psycholinguists had assumed and used to measure derivational complexity were sentenced void by their fellow linguists.

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1.2. The Theory of Perceptual Strategy

Late in the nineteen-sixties there appeared a second extreme view of the interaction of grammar and performance principles which had a strong impact on subsequent researches. This is the theory of "perceptual strategy" expounded by T. G. Bever and his colleagues. This theory claims that the mechanism for sentence comprehension is not in the rules of grammar but in a totally different system of procedures which the proponents of the theory call "perceptual strategies," which associate properties of surface structure with pieces of semantic information in a rather direct manner.

There has been an impressive amount of work done on the alleged power of the theory of perceptual strategy to explain phenomena which are grammatically aberrant and hence beyond the explanation of grammatical theory, though there is a peculiar lack of sufficient experimental evidence for the claim. According to this theory, the only contribution of a grammar to performance principles is to provide basic categories for the perceptual and other strategies to operate with: categorial notions like sentence, noun phrase, verb; functional notions like subject, object, head, modifier; and other notions such as preposition, case marker, etc. [1)]

The theory of perceptual strategy is, of course, not without critics, especially among theoretical linguists. Kiparsky (1975), for instance, stating that this theory is not "very convincing," proposes an alternative view on the relation between grammar and performance: "The most straightforward assumption would be that speech utilizes the grammar and a set of heuristic procedures for accessing the rules in an effective way. On this interpretation the production and comprehension of a sentence would involve constructing its derivation by means of the appropriate grammatical rules, though the rules need not at all be 'run through' in the order in which they figure in the grammar." In actual fact, this view has been reiterated by theoretical linguists as far back as Katz and Postal (1964).

While it appears that Kiparsky's remark is sound and cogent, it may not be readily obvious just how his view would conflict with the theory of perceptual strategy. Probably the conflict results from Bever's unduly strong diminution of the role of a grammar in performance. Bever has gone so far as to claim that "the relationship between linguistic grammar based on intuition and that based on the description of other kinds of explicit language performance may not just be 'abstract'... but may be nonexistent [emphasis original] in some cases." (Bever 1970a)

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1) Cf. the following passage from Bever (1970b:8). "The basic claim... is that there is a set of perceptual rules which map surface sequences onto the corresponding internal relations. ...[P]erceptual rules... apply without reference to the full grammar. Rather than using the grammar in an analysis-by-synthesis recognition routine... or using an ordered series of 'inverse transformations' each corresponding to a transformation to 'detransform' the surface tree back to the underlying tree [reference omitted], many perceptual rules appear to provide direct mappings of the surface sequences onto the underlying syntactic relations."

1.3. Modification of the Theory of Perceptual Strategy

It seems, however, that Bever has gone too far afield. The mere fact that the perceptual strategies make reference to notions defined by grammatical theory (which Bever himself recognizes) is sufficient to show that linguistic grammar does indeed play a fundamental role in speech perception. The lack of direct behavioral reflection of intermediate structures or of transformational operations is no evidence that grammar is irrelevant to performance, since the "processes" in the grammatical derivations are abstract processes and are not run on a real time basis. Indeed, they can be "run through" as real time processes only by students in the introductory linguistics course who are learning a smattering of the history of modern theoretical linguistics.

In a sense, each speaker merely retains in his mind the set of pairs of sound and meaning, and in a performance situation he finds the most appropriate pair by means of perceptual strategies, i.e., by Kiparsky's "heuristic procedures." In fact, the output of the perceptual strategies, even in Bever's version, must be a semantic representation endorsed by linguistic grammar. If grammar were totally irrelevant for speech perception, it would be a mere coincidence that perceptual strategies bring about representations that are in perfect consistency with the stipulations of grammatical rules.

It thus seems reasonable to assume that speech perception is essentially a heuristic process, a search for the semantic representation whose relation to the input surface form is grammatically endorsed according to the following sorts of grammatical information: (i) lexical information; (ii) notions of constituent categories; and (iii) the structure of linguistically significant levels, e.g., surface structure and semantic representation. Given this framework, we can see that the central role of the heuristic procedures in speech perception, i.e., perceptual strategies, is the reconstruction of surface structure configuration; once it has been reconstructed, the search for the corresponding semantic representation is instantaneous or even "timeless."

Our task, then, was to determine what particular properties of the input form function as cues for the reconstruction of surface structure, and to what extent. Along this line of investigation, our research group conducted several series of experiments on the perception of syntactic structure by Japanese speakers. [2] It was discovered that the linear order of constituents affected the subject's perception to a greater extent than had been anticipated. Moreover, the results strongly suggested that the hearer has a certain pre-designated format for the organization of the constituents of a sentence, i.e., what we called the "canonical form" of a sentence, and he rearranges the segments of the input form into this format in the perception of sentence structure. [3]

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2) The description and major results of those experiments are found in Uyeno and Harada (1975).

3) In the case of Japanese, the canonical form of a simple sentence is: subject-adverbial-object-predicate.

It follows, then, that perception of syntactic structures involves not only the reconstruction of the surface structure of the given sentence but also the reduction of this structure to a canonized structure.

1.4. Perceptual Strategies in Child Language Development

If the adult's linguistic performance makes use of heuristic procedures such as perceptual strategies, these procedures must be either innate or learned in childhood, and in either case they must emerge at some distinct points during language development. It is, then, a very profitable enterprise to study language development from the standpoint of perceptual strategy, since it is possible to isolate individual perceptual strategies by observing the linguistic behavior of children lacking one or more perceptual strategies employed by adults. Direct studies of adult perceptual strategies are often difficult and indeed fruitless, even if one devises a rather ingenious new experiment technique (such as the click detection technique of Ladefoged and Broadbent). This is because the strategies form such a tightly organized system (to make the search of meaning truly effective) that one strategy can hardly be separated from another on the basis of adult behavioral data.

The study of child linguistic performance is also of great importance to the study of the development of grammar, since whatever grammatical system the child may have internalized is based on the linguistic data he has experienced through the heuristic procedures he has acquired, immature as they may be.

Notions equivalent to "perceptual strategy" have in fact long been pertinent in developmental psycholinguistics, though in different guises. To quote just one example from one of the earliest works in generative grammar-oriented developmental psycholinguistics, Carol Chomsky (1969) discovered a developmental trend in children from five to ten years of age that infinitival complement constructions obeying a "general principle in English" that the superficially null subject of the infinitive is understood to be the same NP as the NP closest to the infinitive, elicit correct comprehension earlier than those constructions which are exceptions to that principle. Thus, for example, sentences such as those in (A), which can be correctly interpreted in terms of this principle, are also correctly interpreted earlier in childhood than those in (B), which, at an early stage, are consistently given the wrong interpretation, viz., that the underscored NP is the subject of the infinitive.

(A) The doll is able to see.

John told Bill to come.

(B) The doll is hard to see.

John promised Bill to come.

This principle, which Chomsky misleadingly refers to as the "minimal distance principle" (MDP), [after Rosenbaum (1967)], is not to be regarded as a grammatical principle (as Chomsky appears to claim) but rather as a perceptual principle. If it were a grammatical principle, it would have to give a general account of a broad range of phenomena, and its exceptions would have to be confined to a very limited set of idiosyncratic

irregularities. In the given case of the interpretation of the missing subject of an infinitive, however, not only do the exceptions to the MDP comprise a substantially large group, but they moreover possess a common semantic property, thus nullifying their categorization as irregularities.

The above caveats notwithstanding, Chomsky's results are nevertheless quite significant and bear much implication for future avenues of investigation. Under the strategist reinterpretation, her results unmistakably show that general perceptual strategies like the MDP are acquired earlier than less general ones, such as those responsible for the interpretation of sentences containing verbs like promise. [4)]

1.5. Hypotheses on Children's Comprehension of English Relative Clause Constructions

The earliest known study in developmental psycholinguistics to explicitly explore the problem of the role of perceptual strategies in child language development is Sheldon's (1974) work on relative clause constructions. Relative clause constructions are sentences in which one or more NP's consist of a modified, or head, NP and a modifying clause whose semantic representation contains an NP identical to the head NP. In English, the modifying relative clause follows the head, and the identical NP in the relative clause is converted to an appropriate WH-word and fronted to the beginning of the clause. (See Fig. 1.)

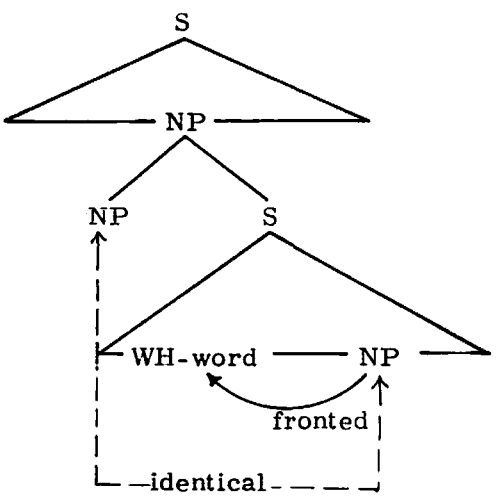


Fig. 1

4) There are other cases in which the strategist reinterpretation is not only feasible but also plausible, but we shall not document them there.

Depending on the grammatical relation of the head and the relativized NP's, we can distinguish at least four types of relative clause constructions:

SS: The boy who liked the girl kicked the bully.

SO: The girl who the boy liked hated the bully.

OS: The boy liked the girl who hated the bully.

OO: The boy kicked the bully who the girl hated.

The captions indicate the grammatical relations of the head and the relativized NP, in this order: SS marks the sentences in which the head is the subject of the matrix clause and the relativized NP is the subject of the relative clause; SO marks those in which the head is the sublect of the matrix clause and the relativized NP is the object of the relative clause; and so on.

In a pioneering non-strategist study on child comprehension of relative clause constructions, Brown (1971) found that the only statistically significant difference in the response behavior of his 96 subjects (youngest 3:0, oldest 5:9 years: months) for the referent identification task was observed between stimulus types SS and OS on the one hand and types SO and OO on the other, the former pair eliciting more correct responses than the latter. Brown suggested several plausible explanations for this discrepancy. Firstly, the SO and OO types might be harder to comprehend because they are not readily analyzable into two contiguous NVN clauses, while the other two types are so analyzable. (Incidentally, in order for this explanation to apply to the SS type, it must be assumed that the relative pronoun who or that is perceived by the child as a meaningless expletive just like interjections eh, uh, etc.) In other words, the SO and OO types are perceptually complex due to the interruption of one clause by another clause. This has been called the "Interruption Hypothesis." Secondly, the SS type might be easier because it can be correctly interpreted even if the child lacks the capacity to handle relative clause constructions correctly but applies the strategy for conjoined sentences instead. In other words, this type can be correctly interpreted even if the child incorrectly takes it to be a mere stylistic variant of the conjoined sentence:

(C) The boy liked the girl and kicked the bully.

Let us call this the "Juxtaposition Hypothesis."

Sheldon examined Brown's hypotheses against the experimental data gathered from act-outs by 33 subjects from 3:8 to 5:5 years:months old. According to her results, the SS type sentence elicited the highest percentage of correct responses, significantly more than the OO type; the OO type in turn elicited substantially more correct responses than the OS and SO types. Obviously the Interruption Hypothesis cannot account for these results, and this circumstance led Sheldon to propose yet a third alternative, dubbed the "Parallel Function Hypothesis," whereby constructions in which the head and the relativized NP have the same grammatical function are easier than those in which they have distinct functions. Though this hypothesis accounts for the disparity between the SS and OO types on the one hand and the SO and OS types on the other, it nevertheless does not obviate the need for the Juxtaposition Hypothesis, which would still be necessary to account for the rather outstanding optimality of the SS type.

Sheldon's conclusions were seriously challenged by Smith (1974), who reported that the developmental trend figuring in his own results is OS-SS-OO-SO, with OS the easiest and SO the most difficult. This was based on his elicited imitation experiment on ten children from 2:5 to 3:0, using stimuli whose nouns and verbs are nonsense syllables. Smith claims that the trend is accounted for by the Interruption Hypothesis (or, equivalently, by means of the so-called NVN strategy underlying this hypothesis) in conjunction with what he calls the "minimal distance principle." While his experiment and its results are indeed very interesting, his arguments are nevertheless not well articulated, and there are places where his assumptions appear unwarranted. For example, he uses a technique demanding that his very young subjects listen to a complex sentence containing three nonsense words, requiring them to respond with a "paraphrase" in the form of a conjunction sentence. This procedure appears too artificial to warrant a straightforward interpretation of his results.

1.6. Motivation for the Study of Japanese Children

Although the conflicts among the results of the three works reviewed above may in part be resolved as arising from differences in their respective research methods, the ultimate resolution is likely to come from the study of languages other than English. It must be remembered that English is a rigid SVO language and that the types of relative clause constructions testable (in experiments) are thus quite limited in number, specifically four. In order to determine the principal factor in child comprehension of relative clause constructions, we must look for evidence from other languages with more flexible sentence structure. Japanese is one such language. It is an SOV language with optional inversion of subject and object. Though its word order is rigid in that the verb must end a sentence and a relative clause always precedes the head, the flexibility of the S-O order grants us a sufficiently broader range of stimulus sentences than in the case of English. In fact, we now have twice as many types of relative clause constructions as in English.

What follows, then, is a report on the research our group carried out in 1975 on the development of the Japanese child's comprehension of relative clause constructions through two series of experiments modeled in large part after those of Sheldon.

2. Experiment I

2.1. Materials

The test-items consisted of fifteen sentences, twelve of which belonged to the relative clause construction: three sentences for each of the four types of relative clause construction (SS, SO, OS, and OO). Three extra sentences of the conjunction sentence construction were included as a control. The sentences were constructed exclusively with three nouns and two verbs chosen from the following set of nouns and verbs:

Nouns: kirin (giraffe), kuma (bear), sika (deer)
uma (horse), usagi (rabbit), and zoo (elephant)

Verbs: naderu (pat), taosu (knock down), and tobikoeru (jump over)

Each of the five sentence types is illustrated in Table 1 below: The entire set of stimuli will be given in the Appendix.

Table I

SS: [zoo ga kirin o taosita] zoo ga sika o nadeta
R(S) H(S)
elephant giraffe knocked elephant deer patted
'The elephant that knocked down the giraffe patted the deer.'

SC: [zoo ga kirin o taosita] kirin ga sika o nadeta
R(O) H(S)
elephant giraffe knocked giraffe deer patted
'The giraffe that the elephant knocked down patted the deer.'

OS: zoo ga [sika ga kirin o taosita] sika o nadeta
R(S) H(O)
elephant deer giraffe knocked down deer patted
'The elephant patted the deer that knocked down the giraffe.'

OO: zoo ga [kirin ga sika o taosita] sika o nadeta
R(O) H(O)
elephant giraffe deer knocked down deer patted
'The elephant patted the deer that the giraffe knocked down.'

C: [zoo ga kirin o taosite][zoo ga sika o nadeta]
(S)
elephant giraffe knocked down elephant deer patted
"The elephant knocked down the giraffe and patted the deer.'

where H stands for the head and R for the relativized NP. The symbols S and O enclosed in parentheses stand for subject and object, respectively. The boxed elements are deleted by transformations and are thus absent from surface structure.

Reversibility of the sentences was fully taken into account so that no sentence in the set of test-items could be interpreted without assessment of the syntactic features of word order or particle choice.

The order of stimuli was first randomized and then controlled so that no sentence would follow another of the same construction type.

The sentences were then recorded on tape by a female native speaker. Each sentence was used twice in succession. The stimuli were presented in one order to half of the subjects and in the opposite order to the other half.

2.2. Subjects

The subjects were 98 monolingual children, 54 boys and 44 girls. All attended nursery schools, kindergartens, or grade schools in the Tokyo area and were judged as normal by their teachers. The children were divided into fifteen age groups: each group had an age span of six months and consisted of six or more children, in approximately equal numbers of boys and girls. The total age range was from 3:6 to 10:11 years:months.

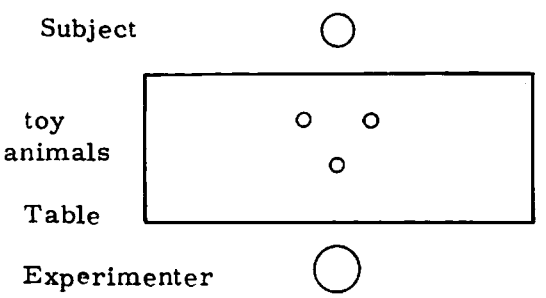
2.3. Method

The subject's task was to act out the actions expressed by the stimulus sentence he or she hears. Six plastic toy animals of approximately equal size were used for the performance.

Each subject was interviewed individually. The six animals were placed on the table in front of the subject and he was first asked to identify the animals. The child was then asked to perform six pre-session practice sentences to verify that he understood the procedure and could act out sentences. Those who were unable to do so were excluded.

Following the performance of the pre-session practice sentences, the child was instructed to respond in the same way to the recorded test sentences. The three animals that would appear in the test sentence were then placed before the subject about 20 cm. apart from each other, in the shape of a triangle, with the base downward. (See Fig. 2.) In order to avoid a

Fig. 2. Experimental Set-out



response bias arising from the linear order positions of the animals in a sentence and the actual positions of the toy animals, the arrangement of toy animals was controlled so as not to coincide with their order of appearance in the given sentence.

2.4. Scoring

In each session, at least two observers (including the experimenter) witnessed the subject's performance. The results were recorded on a previously prepared scoring sheet using specially devised shorthand-like notations, e.g., EH-EG* (Elephant jumps over Horse, and then Elephant knocks down Giraffe).

In order to analyze the results, the subjects were regrouped into eight age groups, each with an age span of one year, rather than six months. Only those responses that consisted of the correct sequence of actions with

appropriate choice of agents and patients were counted as correct responses.

2.5. Results and Discussion

Figure 3 presents a graph of the percentage of correct responses against total stimuli for the relative clause constructions (R) and for the conjunction construction (C). As expected, it shows a tendency for the percentage of correct act-outs to increase monotonously along age for both constructions. There is, however, a remarkable difference between R and C, which demands further analysis.

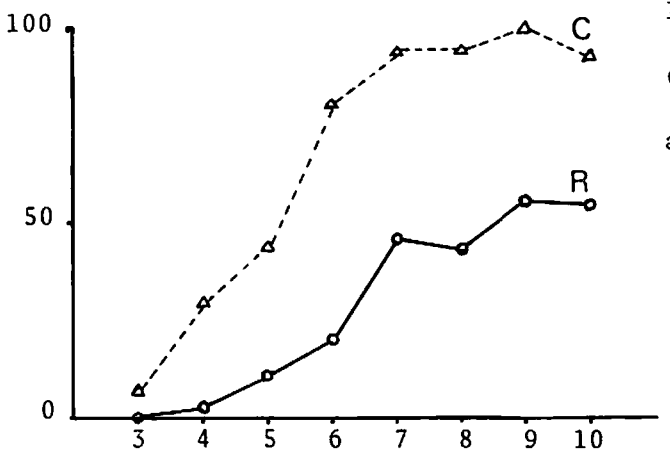


Fig. 3. Percentage of Correct Responses against Total Stimuli

Figure 4 shows the development of correct responses to each stimulus type. We can immediately detect at least the following three developmental phases:

Phase I: below age 5

No difference in performance is observed among the four stimulus types.

Phase II; age 5-7

There is a difference between types SS and SO (type SX) on the one hand, and types OS and OO (type OX) on the other. Specifically, type SX elicits more correct responses than type OX.

Phase III: age 8 and above

As in Phase II, type SX elicits more correct act-outs than type OX; there is, however, a mysterious deterioration or performance for type SO.

If we are correct in assuming that children come to establish perceptual strategies as they develop their linguistic performance capacities, the

above developmental phases should correspond to the predominant perceptual strategies employed at the respective stages.

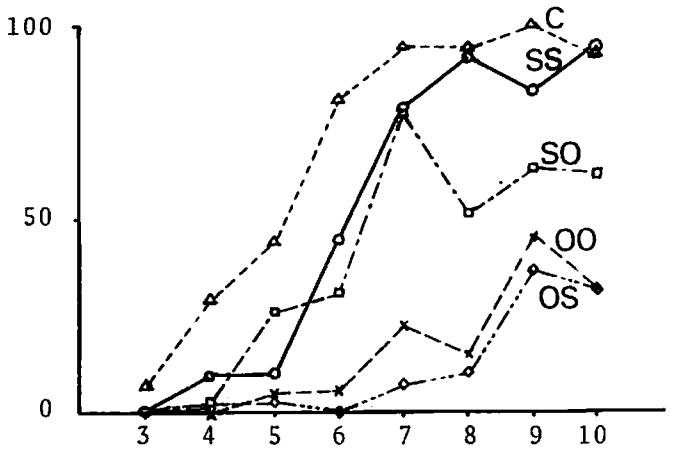


Fig. 4. Percentage of Correct Responses to Each Stimulus Type

In Phase I, however, children do not seem to obey strategies of the sort we are considering here, for they do not exhibit a consistent performance in the experiment. As has been indicated in independent work such as that of Watanabe (1975), children in this phase do display a fairly good comprehension of so-called "irreversible" sentences (sentences whose interpretation is uniquely determinable from semantic constraints holding between the words comprising them), and thereby we may reasonably conclude that children in Phase I do not use syntactic perceptual strategies and instead, appeal exclusively to whatever semantic constraints they have internalized.

In Phase II, the striking difference between type SX and type OX strongly suggests that children in this phase have established a strategy sensitive to the syntactic difference between SX and OX. Notice that SX differs from OX in word order pattern:

SX: N-p V N-p N-p V

OX: N-p N-p V N-p V

(where N stands for a noun, V a verb, and p a particle.)
We can then hypothesize that children in Phase II follow a perceptual strategy which makes crucial use of the input word order. We thus might imagine an "SOV" strategy, which would segment the sequence of two nouns followed by a transitive verb as a clause and assign the grammatical relations "subject" and "object" to the initial and the second nouns respectively. This strategy would give the correct interpretation to type C stimuli but the wrong interpretation to type OS and OO (cf. below).

Stimulus type	Word order pattern	Interpretation by SOV strategy	Correct interpretation
C	1-ga 2-o V 3-o V	12 13	12 13
OS	1-ga 2-o V 3-o V	12 13	32 13
OO	1-ga 2-ga V 3-o V	12 13	23 13

If the above account is correct, it will predict that Phase II children should make a proportionally large number of errors in which OX sentences are interpreted as though they were conjunction sentences. Let us refer to such erros as "C-errors." Figure 5 shows the percentages of C-errors for OS and OO stimuli, together with the percentage of correct responses to type C. Clearly the percentage of C-errors is significantly high in children from 6 to 8, i.e., approximately in Phase II.

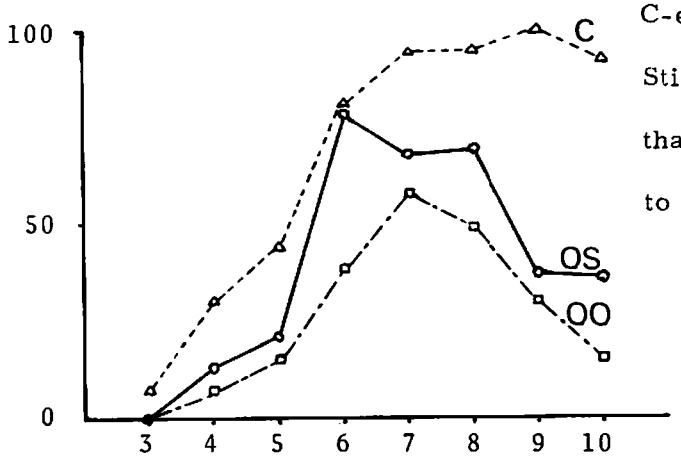


Fig. 5. Percentage of C-errors to OS and OO Stimuli, Compared with that of Correct Responses to C.

It should be noted in passing that type OS stimuli elicited significantly more C-errors than type OO stimuli. This asymmetry is quite natural in view of the independently elicited fact that Japanese children generally come to use particles as cues for interpretation by the time they enter elementary school. Since OS resembles C not only in word order pattern but also in the order of particle appearance (ga-o-o), it seems reasonable to assume that application of the SOV strategy is reinforced by a supplementary strategy in terms of particles.

In Phase III, we notice a steady improvement of the performance on OX and, in contrast, an abrupt deterioration of performance on type SO. Analysis has revealed that the most frequent error types are (1) one in which the sentence is misconstrued as type SS, i.e., in which the initial NP is taken to be an object of the relative clause, and (2) one in which the initial NP is misconstrued as the subject of the matrix clause, thus rendering the true matrix subject into an object.

Frequent Error Types for SO

type SO:	1-ga V	2-ga 3-o V
Correct Interpretation:	12	23
Error Type (1):	21	23
Error Type (2):	12	13

It appears, then, that Phase III children tend to force a parallel subject interpretation: if a certain NP is identified as a subject, that NP is assumed to function as the subject for both clauses. Let us call this the "Parallel Subject Strategy." While the Parallel Subject Strategy yields correct interpretation in the case of SS and C, it results in the wrong interpretation in the other cases, particularly in the case of SO. [5]

The results of Experiment I provide no conclusion, however, as to whether the observed dominance of type SX over type OX is due to a structural difference between left-branching (LB) constructions and center-embedding (CE) constructions, or due to a functional difference of the head NP. In order to decide between these possibilities, we have devised an additional experiment in which some of the stimuli have an inverted word order. (Because of the restriction that the predicate be the last constituent of a clause, inversion is possible only between the matrix subject and object of our stimuli; this nevertheless still provides a sufficient range of structural variation to test the validity of the above-mentioned possibilities.) If the perceptual complexity of type OX sentences is due to the structural property of center-embedding, inversion of word order would result in improvement of performance for type OX and deterioration for type SX. If, on the other hand, the complexity is due to the status of the head as an object, inversion would have no effect on the performance of the children.

3. Experiment II

3.1. Materials

The materials for Experiment II consisted of the same set of nouns and verbs as used in Experiment I. For this experiment, however, two out of the three sentences representing each construction type had inverted word order. In the case of relative clause constructions, the matrix subject and object were inverted. In the case of conjunction sentences, not only were the subject and object of the first conjunct clause inverted but also the noun that appeared in the second conjunct clause was made a subject, so as to make the sentence-initial noun the common object for both clauses. [6]

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5) Note in this connection that the Parallel Subject Strategy is a special case of the Parallel Function Strategy proposed by Sheldon (1974). In Sheldon's version, the strategy selects one NP as a subject or an object for both the matrix and embedded clauses. We have not followed her, however, because we do not find a tendency for children to force a parallel object interpretation to our stimuli.

6) The small letters n and r suffixed to the captions for construction types indicate normal and reversed word order, respectively.

3.2. Subjects

The subjects were 83 monolingual, normal children, 42 boys and 41 girls, who attended grade schools in the Tokyo area. The children were divided into twelve groups. Each group had an age span of six months and consisted of six or more children made up of approximately equal numbers of boys and girls. The total age range was from 6:9 to 12:5 years:months.

3.3. Method

The method employed in Experiment II was identical to that used in Experiment I.

3.4. Scoring

As in Experiment I.

3.5. Results

Figure 6 shows the development of the average percentage of correct responses for LB and CE. It unmistakably demonstrates that the structural property of CE is the primary factor affecting comprehension difficulty. On the other hand, Figure 7, where the average percentages of correct responses are shown for type SX and OX, reveals the rather surprising tencency that type OX elicits far better comprehension than does

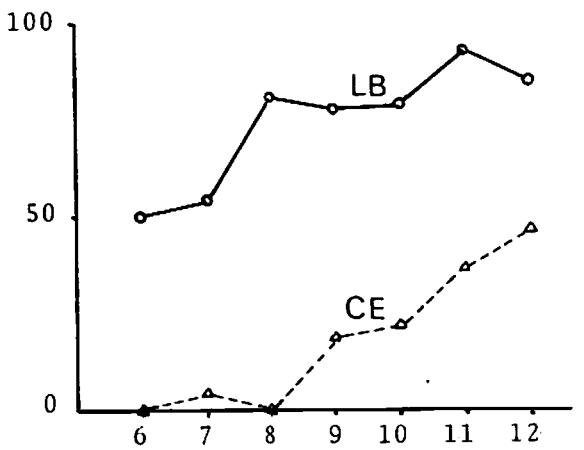

Fig. 6. Percentage of Correct Responses to LB and CE Constructions

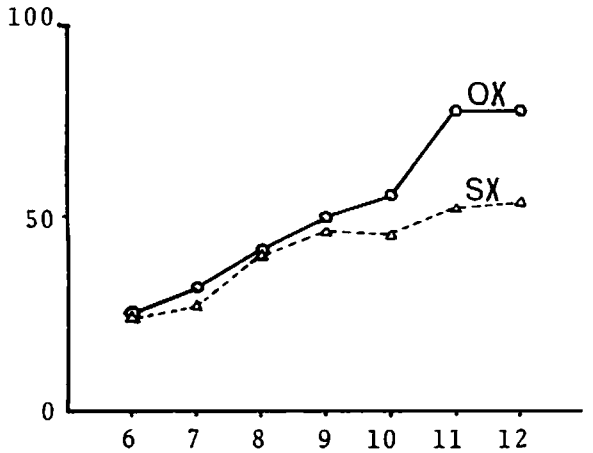

Fig. 7. Percentage of Correct Responses to SX and OX Constructions

type SX. Analysis has revealed that this asymmetry is due primarily to the poor performance on type SOr stimuli. What is crucial to our discussion is that type SX does not elicit good performance as would be predicted by a functional theory of speech perception like that proposed by Sheldon.

Major error types in Experiments I and II are summarized in Table 2. From this table we can see that the interpretation errors overwhelmingly involve failure to recognize a clause boundary between the first and second NP in CE constructions. In contrast, the grammatical function of the third NP is without exception correctly identified, probably because of the particle attached to it. [7]

7) Several colleagues have pointed out to us that one of our test-items specifically item No. 3 (see Appendix II), refers to a semantically unnatural situation in which the horse knocked down by the giraffe was supposed to pat the elephant, and this unnaturalness might have been the reason of the child's poor performance on SOr. Upon examination, however, 64 out of 83 (77% of the) responses to this stimulus correctly identified the horse as the agent of patting, and there was no statistically significant difference between this stimulus and the other SOr stimulus, No. 14, with respect to the percentage of those responses that correctly identified the third noun as the agent of the second action.

Table 2. Frequent Response Patterns Arranged in the Order of Frequency
(The figures in parentheses indicate percentage.)

	Experiment Number	Construction Type	Correct responses are underscored			
LB	I	SSn 1-o V 2-ga 3-o V	21 23 (79.9)	12 23 (7.9)		
	I	SOn 1-ga V 2-g 3-o V	12 23 (56.9)	21 23 (14.4)	12 13 (9.8)	
	II	OSr 1-o V 2-o 3-ga V	21 32 (75.9)	21 23 (6.0)	21 31 (6.0)	
	II	OOr 1-ga V 2-o 3-ga V	12 32 (69.9)	12 32 (16.9)		
CE	I	OSn 1-ga 2-o V 3-o V	12 13 (58.6)	32 13 (20.1)		
	I	OOn 1-ga 2-ga V 3-o V	12 13 (36.2)	23 13 (19.5)	12 23 (9.8)	
	II	SSr 1-o 2-o V 3-ga V	12 31 (22.3)	12 32 (16.9)	32 31 (15.7)	
	II	SOr* 1-o 2-ga V 3-ga V	21 32 (28.3)	12 31 (18.7)	21 31 (14.5)	12 32 (11.45)
C	II	Cr 1-o 2-g V 3-g V	21 32 (28.3)	21 32 (25.9)	12 31 (22.3)	12 32 (13.3)

* Correct Response: 23 31

4. Implications

Our study has succeeded in revealing a number of interesting facts concerning the acquisition of relative clause constructions in particular and about language development in general. Here we shall discuss certain implications of our study, as well as problems that remain open for future research.

4.1. Implications for the Theory of Relative Clause Acquisition

As we reviewed in section 1, several hypotheses have previously been proposed to account for the imbalance among the four realization types of relative clause construction with regard to perceptual complexity and developmental tendency. The most plausible are Slobin's Interruption Hypothesis (IH), Sheldon's Parallel Function Hypothesis (PFH), and Smith's hypothesis in terms of NVN strategy and the Minimal Distance Principle (MDP). Our own findings show that of these hypotheses only Slobin's possesses the possibility of being a universally valid account of the development of relative clause constructions, though modifications are of course necessary.

IH predicts that center-embedding structures will be more difficult to perceive than right- or left-embedding structures and hence will be correctly understood much later than these other structures. This prediction is fully borne out by our findings reported in section 3.5. The hypothesis, however, appears to make an invalid prediction that the English SS construction will be difficult to perceive, a fact contradicted by Sheldon's data. How can we resolve this contradiction?

We would like to point out that actually no contradiction is involved here. Notice that there is no evidence that a majority of pre-school children tested in Sheldon's and other experiments actually understood complex sentences as such. Rather, the reported results strongly suggest that the children analyzed complex sentences as a mere juxtaposition of two clauses with a shared subject. This is what we have named the "Juxtaposition Hypothesis" (JH). [8] JH predicts that the English SS construction will be perceptually optimal because it can be correctly understood if the relative pronouns are ignored. For instance, the sentence

(1) The dog that jumps over the pig bumps into the lion. (SS)

would sound, to the pre-school child's ears, as

(2) The dog ... jumps over the pig, bumps into the lion.

where '...' might be interpreted by the child as a meaningless interjection.

The validity of JH can be demonstrated by the performance on type OX stimuli in our Phase II children (see section 2.5 above). What is relevant in the present context is that JH frees IH from the burden of accounting for all facts concerning English relative clause acquisition. SS can be an exception to IH simply because it is not conceived of as an interruption by children at that age.

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8) The original insight is due to Brown (1971), which we reviewed in section 1.4 of the present paper.

JH also accounts for the majority of errors observed in Sheldon's experiment. Sheldon observes that OS is understood poorly by her subjects. and that the most frequent errors are those which impose "extraposition and parallel function" interpretation.

(3) The pig bumps into the horse that jumps over the giraffe. (OS)
1 2 3

Correct: 23 12
Extraposition and PF: 12 13

Her account of such errors sounds very strange, to say the least: "We can explain this type of response," she says, "if we assume that children are over-relying on an Extraposition rule." In other words, young children "interpret the relative clause at the end of the main clause as if it had been part of the subject NP in deep structure and had been transported by the Extraposition rule to sentence final position." It seems more to the point, however, to consider that the children simply fail to grasp the function of the relative pronoun "that", and thus sentence (3) is received by them in the form of (5),

(4) The pig bumps into the horse ... jumps over the giraffe.

where '...' is again a meaningless epithet for the children. The misinterpretation in (3) will then be precisely accounted for in terms of JH.

Sheldon even speaks of a "widespread and systematic behavior of avoiding continuous constituents and favoring discontinuous constituents" and claims that "it falsifies the claim that children will use strategies of speech perception and production which prohibit interruptions or rearrangement of linguistic units." But this argument is invalid in two respects. On the one hand, the data she quotes as evidence for the alleged behavior of "favoring discontinuous constituents" can be given an entirely different and more reasonable account, as we have just shown. On the other hand, it is undeniable that there is a perceptual complexity due to "interruptions" and/or "rearrangement of linguistic units": Normal order OX and inverted order SX sentences in Japanese. These sentences share the same surface pattern,

(5) N_1-p N_2-p V_1 N_3-p V_2

where there is one clause boundary between N_1-p and N_2-p, and another between V_1 and N_3-p. In order to understand the given sentence correctly, the hearer must make use of a strategy such as:

(6) Relative Clause Strategy
If there is a defective finite clause immediately in front of a noun, it is a relative clause modifying the latter, and the gap in that clause should be filled in by the same noun as the modified (head) noun.

where a "defective clause" is a clause one or more of whose arguments are unrealized in surface form.

Suppose the hearer somehow failed to establish the initial boundary of the relative clause. Occurrence of a finite verb is an unmistakable sign of a clause-final boundary in Japanese, so that the hearer will immediately

recognize the end of a clause when he hears V_1. At this point he has two nouns and one verb, and if he is a child in our Phase II he will most likely take this set of words to compose a clause and impose an interpretation according to the SOV strategy (cf. section 2.5). If he has furthermore acquired the Relative Clause Strategy, he will immediately face a problem when he goes on to the next word, because although the next word is a noun, the preceding clause is finite but not defective. If he fails to recognize the finiteness of the verb, he will merely continue to process the rest of the sentence and will conclude with a juxtaposition interpretation. On the other hand, if he does recognize the finiteness of the verb, he will have to go back and eject the initial NP to make the finite clause immediately preceding N_3-p defective, so that the Relative Clause Strategy can apply. In short, the correct interpretation of sentences following pattern (5) crucially depends on a chain of intricate strategies, and failure at any point in this chain means that the hearer must go back to the beginning of the given sentence to make a fresh start.

If this is the correct account of what takes place in the subject's mind, as we believe it is, then Sheldon's theory will be completely refuted. There is no denying, however, that Sheldon is correct in pointing out the tendency toward looking for common function. This tendency holds systematically, however, only for subjects and not for objects. Thus, in our findings there is no similarity observed between SS and OO. The percentage of correct performance on OO stimuli is in no way comparable to that on SS; furthermore, the developmental trends are so different that no attempt seems justifiable to group them together.

Lastly, let us turn to Smith's version of MDP. According to Smith, this principle (or strategy, in our terminology), when applied to relative clause constructions, "predicts that the NP which immediately precedes an embedded clause will be interpreted as subject of the embedded clause beginning with a relative pronoun." Little imagination is necessary to realize that in the case of Japanese, MDP will impose an object interpretation on the head N P, since it follows rather than precedes the relative clause. This implies that type XO should be better than type XS in perception. This prediction is easily falsified by our findings reported in sections 2.5 and 3.5. Both in normal and inverted word order, SS was understood as well as SO (in Phases I and II) or even better (in Phase III). OO was no better understood than OS. We must thus conclude that MDP is impossible to evoke as a crucial factor in children's comprehension of relative clauses.

4.2. Implications for the Theory of Language Acquisition

For the theoretical linguist, "knowledge of language results form the interplay of initially given structures of mind, maturational processes, and interaction with the environment." (Chomsky, 1974:123) Every child is born with a genetically predetermined ability to learn human languages which is absent in the other species and which therefore provides a characterization of human beings. This ability -- or the "language faculty," to follow Chomsky's terminology consists of a rather rich body of information about the general, or universal, properties of language which restricts the range of possible variations in the grammatical system to be acquired to a sufficiently narrow class. When the child reaches some appropriate maturational stage, he begins to exploit this language faculty to construct the

grammar of the language to which he is exposed, and this continues until he goes beyond the critical period, when the language faculty ceases to function.

Within theoretical linguistics, special emphasis has been laid on the investigation of the "initially given structures of mind," or the language faculty, i.e., the innate characterization of human language. This emphasis is fully justified because the innate language faculty is the factor of language acquisition which had long been belittled or indeed completely ignored until the theory of generative grammar reminded us of its importance.

In the present paper we have focused our attention on the role and development of performance principles, with particular reference to perceptual strategies. A question will naturally be raised as to how such strategies are formed, and what relevance the language faculty has for the development of perceptual strategies.

To answer the latter question first, it seems to us that knowledge of the universal properties of language plays an important role in the development of perceptual strategies as well. Recall that we detected three phases in a child's comprehension of relative clause constructions. The first phase was characterized by the absence of systematic syntactic strategy, though other studies have demonstrated that children in this phase have established semantic constraints. The second phase was characterized by excessive reliance on a strategy in terms of word order, especially the precedence of a subject over an object. And the third phase might be characterized by the Relative Clause Strategy. Comparison of the three phases suggests that strategies which enter the child's perceptual mechanism earlier employ less language-particular properties. In fact, the developmental trend from strategies in terms of universal features to those in terms of particular features of the language being learned is found in a number of stuides on child comprehension. Thus, Hayashibe's (1975) findings that the cues for interpretation of simple sentences shift from semantic constraints to particles via word order is in perfect conformity with this observation. The development of comprehension of English passives discussed by Bever (1970a) also provides another confirming piece of evidence.

Suppose that we are correct in asserting that strategies employing a more universal property are acquired earlier than those employing a less universal property. This will then provide a very strong argument for the thesis that innately given knowledge of language is fundamental even to the formation of performance principles. Most children are monolingual, and even bilingual or multilingual children learn one language at a time. Thus the child has no way to learn whether a given feature of the language he is exposed to is a universal or an accidental property of that language. Despite this disadvantage, however, children somehow manage to pick up universal properties and begin to employ them as perceptual cues in the earlier period of acquisition. Notice that no explanation is available in terms of frequency or familiarity, because language-specific features are often among the most frequent features of the language. The only logical conclusion would be that children know what is universal and what is not in advance, without learning: in other words, such information must be given innately.

Given this much consideration, we may now return to our first question: how are the strategies formed? There is some plausibility in viewing strategy formation as essentially a sort of associative learning: strategies are formed through association of regularities in form with regularities in the structure of concepts. Such association is easiest in the case of irreversible sentences, since there can be only one well-formed concept structure consisting of the given atomic concepts (each corresponding to a morpheme). Through the experience with irreversible sentences, the language-learning child might recognize the systematicity of concept-form correspondence and shape this into some appropriate strategy. In the case of reversible sentences, he would face several possibilities and he might make a selection by applying the strategy formed in the earlier period of acquisition. If this gives him a suitable interpretation, the strategy, applied tentatively to reversible sentences, will be confirmed (or "reinforced"). If the strategy does not yield a proper result, the child might seek a new, usually more sophisticated, strategy to cope with the situation.

This account receives some strong support from our results, where it was revealed that a child's systematic errors arise from a generalized application of a strategy established in earlier periods for more straightforward cases.

With reference to the framework set up by Chomsky (1975), we may characterize the above account as a non-instantaneous and intensional approach to language acquisition, where the latter term means that the input to the learning theory of a child at each stage of development consists not of the set of all data given to them, but rather of the system of linguistic principles theretofore acquired and an additional new set of data. We depart from Chomsky's framework, however, in that we take the system of linguistic principles to be that of performance principles, instead of grammatical rules.

What then is the role played by grammatical rules in language acquisition? It has been proposed by Bever (1975) that the reason that a grammar (or "psychogrammar" in his terminology) exists is because it plays a vital role in language acquisition as an equilibrator of conflicting capacities of the two systems of speech behavior (i.e., the system of perception and of production) developing independently from each other. This view appears quite plausible, although we do not necessarily agree with Bever that this role provides the sole motivation for man's possession of a (psycho) grammar. We would like to suggest that a grammar equilibrates not only the capacities of perception and production, but also the conflicting capacities of perceptual strategies.

Consider the transition between Phase II and Phase III in the performance of our subjects. Performance of Phase II children does not suggest that those children have internalized the following grammatical rules, needed to generate relative clause constructions:

(7) a. Phrase structure rule: A noun phrase may consist of a sentence followed by a noun phrase.

b. Transformational rule: Delete a noun phrase in the relative clause that is identical to the modified head noun phrase.

Rather, the systematic juxtaposition interpretation of type OX strongly suggests that these rules are absent in the grammar of such children. Children

in Phase III, however, show a remarkable improvement in the performance on type OX; which implies that these children are in the process of establishing the Relative Clause Strategy. But in order to establish this strategy, these children must first internalize the rules for relative clause formation. Once these rules are established, they then serve to reinforce the Relative Clause Strategy. Thus, the grammatical rules for relative clause formation equilibrate the imbalance in perceptual capacities between type SX and type OX.

To summarize, it seems to us that language acquisition primarily relates to the development of performance strategies, both of perception and production, which is endorsed by universal and developing particular grammars. Universal grammar provides the initial state of language acquisition, and the developing particular grammar integrates the development of different sections of performance mechanism.

4.3. Problems and Prospects

Several problems remain, however. First, it remains to be settled whether the terms "perception," "comprehension," "understanding," and "interpretation," which we have used interchangeably, should be differentiated and applied to distinct portions of the entire process of associating form and meaning. Refinement of terminology is vitally necessary, because confusions in this area often result in futile disputes.

We have also neglected the role of intonation in language acquisition. It is well known that very young children on the verge of uttering their first word are often observed to utter jargon with perfectly natural intonation imposed. This implies that intonation (or, more generally, prosody) is among the first linguistic features a child acquires. We should then expect that a child would exploit prosodic information when trying to analyze the given input phonetic information into surface syntactic structure. To see if this is the case, and if so, what role the prosodic features play in language acquisition, are problems whose investigation would demand a far more refined experimental technique than we have thus far been able to avail ourselves of.

The most important question left unexplored in our study is the relation between perception and production. We have been speaking only of perceptual strategies, as has most of the work in this field. But if there are perceptual strategies, then it is almost a logical necessity that there should also be production strategies. What, then, are the contents of production strategies, and how are they related to perceptual strategies? These are problems that cannot seriously be answered until we develop a substantive and empirical theory of speech production, but at least some suggestions are in order.

According to Bellugi (1968), there are several distinct stages in the formation of interrogative sentences by her subject. At one stage, the child carried out the subject-auxiliary inversion only in yes/no questions, giving a paradigm like the following:

(8) Can he ride in a bus?
What he can ride in?

At a later stage, the same child became capable of inverting an auxiliary

in affirmative wh-questions but not in negative wh-questions:

(9) Why can he go out?
Why he can't go out?

Let us refer to these stages as Stage I and II, respectively, and to the stage attained in the end as Stage III. The basic distinction between these stages relates primarily to the number of operations that can be carried out; at Stage I, only one operation can be carried out; at Stage II, maximally two operations can be carried out; and so on. This is ultimately a matter of expansion of the processing span, but the point relevant to our investigation is that the "operation" involved here refers to a production strategy, rather than to a grammatical rule. The grammatical rules relevant for question formation are the following:

(10) a. Wh-fronting: A wh-phrase is fronted to the beginning of the clause that contains it.

b. Subject-aux Inversion: Interchange the positions of a subject and an auxiliary verb in certain environments.

Notice that both rules appear in Stage I; hence, the development cannot be that of acquiring new rules. The development should instead be accounted for as an accumulation of the following production strategies:

(11) a. Question Formation Strategy
Put the element that characterizes a question sentence in the sentence-initial position.

b. Negative Formation Stragegy
Put not or n't immediately after the first auxiliary verb.

c. Inversion Strategy
Interchange subject and the first auxiliary in certain environments.

At Stage I, where only one operation can be carried out, Question Formation alone is applicable. This strategy will front an auxiliary in a yes/no question, since the sentence-initial auxiliary characterizes a yes/no-question. In the case of wh-questions, the wh-word is what characterizes the question; thus it is fronted, and no further operation may take place. At Stage II, where two operations may take place, affirmative wh-questions undergo Subject-Auxiliary Inversion, but negative wh-questions cannot. This is because wh-fronting and negative placement are indispensable for negative wh-questions, but inversion in not necessary. At Stage III, the limitation on the possible number of operations is relaxed, and all these strategies may be applied.

That production strategies may differ from perceptual strategies is indicated by the findings of K. I. Harada (1976). She had her two-year-old subject repeat relative clause constructions and then checked the child's comprehension by verbal questions. She found out that CO sentences were understood poorly but repeated fairly faithfully; Type SS was nearly perfect both in comprehension and in repetition. Harada thus conjectured that Sheldon's Parallel Function Hypothesis may account for children's production capacity. Though we need more experimental results to verify or disclaim her conjecture, it is clear, at least, that

production strategies are in principle subject to different restrictions from perceptual strategies.

Appendix

The Test-Sentences Used

I. Experiment I.

1. (S) zoo-san ga nadeta kuma-san ga sika-san o taosita
elephant patted bear deer knocked down
'The bear the elephant patted knocked down the deer.'

2. (C) kirin-san ga usagi-san o tobikoete uma-san o taosita
giraffe rabbit jump over horse knocked down
'The giraffe jumped over the rabbit and knocked down the horse.'

3. (OO) zoo-san ga kuma-san ga nadeta sikasan o tobikoeta
elephant bear patted deer jumped over
'The elephant jumped over the deer the bear patted.'

4. (SS) kirin-san o nadeta uma-san ga zoo-san o taosita
giraffe patted horse elephant knocked down
'The horse that patted the giraffe knocked down the elephant.'

5. (OO) kuma-san ga zoo-san ga tobikoeta usagi-san o nadeta
bear elephant jumped over rabbit patted
'The bear patted the rabbit the elephant jumped over.'

6. (SO) uma-san ga tobikoeta usagi-san o nadeta
horse jumped over rabbit patted.
'The deer the horse jumped over patted the giraffe.'

7. (C) usagi-san ga sika-san o taosite kuma-san o tobikoeta
rabbit deer knock down bear jumped over.
'The rabbit knocked down the deer and jumped over the bear.'

8. (OS) usagi-san ga kirin-san o taosita uma-san o tobikoeta
rabbit giraffe knocked down horse jumped over
'The rabbit jumped over the horse that knocked down the giraffe.'

9. (SO) kuma-san ga taosita zoo ga usagi-san o tobikoeta
knocked down elephant rabbit jumped over
'The elephant the bear knocked down jumped over the rabbit.'

10. (OS) uma-san ga sika-san o nadeta kirin-san o taosita
horse deer patted giraffe jumped over
'The horse knocked down the giraffe that patted the deer.'

11. (C) sika-san ga uma-san o taosita kirin-san o nadeta
deer horse knock down giraffe patted
'The deer knocked down the horse and patted the giraffe.'

12. (SS) zoo-san o tobikoeta kuma-san ga sika-san o nadeta
elephant jumped over bear deer patted
'The bear that jumped over the elephant patted the deer.'

13. (OS) sika-san ga usagi-san o nadeta kuma-san o tobikoeta
deer rabbit patted bear jumped over
'The deer jumped over the bear that patted the rabbit.'

14. (OO) kirin-san ga uma-san ga nadeta zoo-san o taosita
giraffe horse patted elephant jump

15. (SS) usagi-san o tobikoeta kirin-san ga uma-san o taosita
rabbit jumped over giraffe horse knocked down
'The giraffe that knocked down the horse jumped over the rabbit.'

II. Experiment II

1. (SOn) usagi-san ga nadeta kirin-san ga uma-san o tobikoeta
rabbit patted giraffe horse jumped over
'The giraffe the rabbit patted jumped over the horse.'
2. (Cr) kuma-san o zoo san ga tobikoete sika-san ga nadeta
bear elephant jumped over deer patted
'The elephant jumped over the bear and the deer patted (it).'
3. (SOr) zoo-san o kirin-san ga taosita uma-san ga nadeta
elephant giraffe knocked down horse patted
'The horse the giraffe knocked down patted the elephant.'
4. (OOr) sika-san ga taosita kirin-san o uma-san ga tobikoeta
deer knocked down giraffe horse jumped over
'The horse jumped over the giraffe the deer knocked down.'
5. (OSn) zoo-san ga kuma-san o taosita sika-san o nadeta
elephant bear knocked down deer patted
'The elephant patted the deer that knocked down the bear.'
6. (SSr) kuma-san o sika-san o taosita usagi-san ga tobikoeta
bear deer knocked down rabbit jumped over.
'The rabbit that knocked down the deer jumped over the bear.'
7. (OSr) zoo-san o tobikoeta usagi-san o kuma-san ga taosita
elephant jumped over rabbit bear knocked down
'The bear knocked down the rabbit that jumped over the elephant.'
8. (OOn) usagi-san ga kirin-san ga tobikoeta uma-san o taosita
rabbit giraffe jumped over horse knocked down
'The rabbit knocked down the horse the giraffe jumped over.'
9. (OSr) uma-san o tobikoeta zoo-san o kirin-san ga nadeta
horse jumped over elephant giraffe patted
'The giraffe patted the elephant that jumped over the horse.'
10. (Cn) uma-san ga kirin-san o nadeta zoo-san o taosita
horse giraffe patted elephant knocked down
'The horse patted the giraffe and knocked down the elephant.'
11. (OOr) zoo-san ga taosita kuma-san o sika-san ga nadeta
elephant knocked down bear deer patted
'The deer patted the bear the rabbit knocked down.'
12. (Cr) zoo-san o kuma-san ga nadete usagi-san ga taosita
elephant bear pat rabbit knocked down
'The bear patted the elephant and the rabbit jumped over (it).'
13. (SSn) kuma-san o nadeta zoo-san ga usagi-san o tobikoeta
bear patted elephant rabbit jumped over
'The elephant that patted the bear jumped over the rabbit.'
14. (SOr) kuma- san o sika-san ga tobikoeta usagi-san ga taosita
bear deer jumped over rabbit knocked down
'The rabbit the deer jumped over knocked down the bear.'
15. (SSr) kirin-san o uma-san o taosita sika-san ga nadeta
giraffe horse knocked down deer patted
'The deer that knocked down the horse patted the giraffe.'

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