

## The Development of Sentence Interpretation in Hungarian

BRIAN MACWHINNEY

Carnegie -Mel/on University

CSABA PLEH

*Eotvos Lor and University, Hungary*

AND

ELIZABETH BATES

*University of California at San Diego*

In order to test certain assumptions of the "competition model" of B. MacWhinney, E. Bates, and R. Kliegl (1984 *Journal of Verbal Learning and Verbal Behavior*, 23, 127-150), we conducted three experiments on sentence understanding by Hungarian preschool children. According to the competition model, the listener uses verbal cues in a probabilistic manner to make judgments concerning the grammatical roles of the different noun phrases in a sentence. The order in which children develop control of these cues is said to depend on cue validity. The cues manipulated in these experiments included case marking, word order, animacy, stress, phonological detectability, and person of the possessor. The studies examined the impact of these cues on the choice of an agent. The results were well predicted by the competition model. Experiments 2 and 3 indicated that ungrammatical sentences are processed in ways similar to comparable grammatical sentences, thus supporting the ecological validity of the experimental method and of previous research based on the use of this method. There was also evidence for the use in Hungarian of (1) a first-noun-as-agent

This research was carried out with support from the National Science Foundation Linguistics Program, from the National Institute of Child Health and Human Development, and from the Hungarian Ministry Education to Csaba Pleh (Grant 29-02-84), with the cooperation and support of the international Research Exchanges Board (IREX) and the International Relations Institute of Hungary. Our thanks to Karoly Halmi for assistance in preparing equipment for the studies, to Katalin Szakacs and Ferenc Dudas for assistance in administering the studies, to Andras Vargha for help in data analysis, and to the directors and staff of the nursery schools of the Eotvos Lorand University, the Hungarian Academy, and the BOMI Institute. We thank Gyorgy Szepe for the idea for Experiments 2 and 3. Experiment 3 was conducted by Kamilla Boda, Valeria Csato, and Katalin Solymos. Send requests for reprints to Dr. Brian MacWhinney, Department of Psychology, Carnegie-Mellon University, Pittsburgh, PA 15213.

strategy, (2) a preverbal-definite-noun-as-agent strategy, and (3) a strategy of choosing the agent as the noun closest to ego. Although case marking was the strongest cue at all ages, its strength in Experiment 1 at the youngest ages was less than what would be predicted by cue validity alone. Experiments 2 and 3 indicate that this delay in acquisition may result from certain problems with phonological detectability of the accusative suffix in Hungarian. It is proposed that cues cannot be acquired unless they are detectable. Together with cue validity, the notion of cue detectability allows us to account properly for the cross-linguistic data currently available on the development of comprehension strategies for simple sentences. In the discussion section, we consider implications of the competition model for the general theory of cognitive development. © 1985 Academic Press, Inc.

In learning a language, a child must be guided by intuitions that are both extremely powerful and extremely flexible. The child's strategies must be powerful enough to acquire the intricate set of relations, conditions, and counterconditions that constitute the grammar of the target language. However, since the child has no idea at the outset which of the many possible language structures he will learn, his approach to language learning must also be extremely flexible and general. By looking at the acquisition of languages whose structure differs radically from that of English, we can learn a great deal about the ways that these strategies function when confronted with a markedly different learning task.

In this paper we examine the development of the comprehension of simple sentences in Hungarian. Although Hungary is located in the middle of the Indo-European language area, its people speak a language of the Finno-Ugric family. Two aspects of this language are particularly important for our current investigation. The first is the variable order of major constituents in Hungarian. In a simple sentence such as "the dog chased the cat" there are two nouns (N) and a verb (V); one of the nouns ("the dog") is a subject (S) and the other ("the cat") is the object (O). English allows only the SVO order, as in "the cat chased the ball." Sequences such as "chased the cat the ball" or "the ball the cat chased" are not grammatical. However, Hungarian permits all possible orderings of the three major elements: SOV, OSV, SVO, OVS, VSO, and VOS. Although major constituents take all possible orders, the order of elements within constituents is quite strict.

Although word order in Hungarian is variable, it is not "free." Rather, it is governed by a set of principles. The most important principles governing word order assignment are these:

1. When the object is indefinite with no article, it must precede the verb. The orders OVS (ball chased the cat) and SOV (the cat ball chased) are possible with indefinite objects with no articles. However, these orders are not possible when the object is definite.

2. When either the subject or the object is given very strong highly marked stress, that stressed element must precede the verb. Since the verb itself may be stressed, all six word orders are possible when there is a stressed element.

3. When the object is definite, it normally follows the verb. However, this does not occur when the object is stressed. Thus SVO order (the cat chased the ball) is standard for sentences with definite objects.

4. When the verb is focused and fronted, both VSO (chased the cat the ball) and VOS (chased the ball the cat) orders are possible. Definiteness is not relevant to the choice between VSO and VOS orders.

For our present purposes, what is most important here is the fact that the unmarked order is SVO when the object is definite and SOV when the object is indefinite without an article.

The second aspect of Hungarian grammar that is important for the design of the current study is the uniformity of the way in which Hungarian marks the object of the verb. In fact, it is because case marking is so uniform that word order can be varied so easily. With the exception of the patterns to be discussed in Experiments 2 and 3, direct objects of the verb are always marked by the accusative suffix on the noun. This suffix is composed of the phoneme *lil* sometimes preceded by a "linking" vowel. Thus, the word for "house" in Hungarian is *hdz* and the accusative is *hdzat*. There is no passive construction in Hungarian. Thus, when there is a transitive verb, it is nearly always the case that the noun without the accusative marking is the agent. Whereas English uses word order as the principle cue to case role assignment (Bates, McNew, MacWhinney, Devescovi, & Smith, 1982), Hungarian allows word order to vary and relies on case marking in order to determine "who does what to whom."

These properties of variable word order and uniform marking of case provide us with three important types of acquisitional contrasts. First, we can compare data on the acquisition of Hungarian with data on the acquisition of other languages with variable word order and uniform case marking. Second, we can compare data on the acquisition of Hungarian with data on the acquisition of languages like Italian or Serbo-Croatian which have same word order variability but either no case marking or nonuniform case marking. Third, we can compare the acquisition of Hungarian with the acquisition of English, a language which has neither case marking nor variable word order.

In order to guide the conduct of such comparisons across languages, MacWhinney and Bates (Bates & MacWhinney, 1982; Bates et al., 1982; MacWhinney, Bates, & Kliegl, 1984) have proposed a functionalist model called the "competition model." This model is being advanced as a min-

imalist model—a model which makes the minimal number of assumptions. A particularly valuable property of such simple models is that they are easily falsified. In fact, we will soon see that there is reason to believe that the absolutely minimal model cannot account for certain details of the acquisition of Hungarian. However, we will also see that it is possible to formulate a revised competition model which can properly account for these and other new facts. We believe that the revisions that we propose do not compromise the basic assumptions of the model, as they are expressed in the next section.

#### THE COMPETITION MODEL

The competition model is a particular instantiation of a general functionalist model of language performance and acquisition. Bates and MacWhinney (1982) argued that the central claim of linguistic functionalism is that the grammatical devices of natural language exist to serve a set of communicative functions. MacWhinney (1984) shows how grammatical devices on the clausal level are used to (1) identify the role relations of the arguments of the verb, (2) bind anaphoric items to their referents, and (3) express meanings such as presupposition, focusing, contrast, and foregrounding. The experimental work testing the competition model has focused upon the set of devices that tell us about role relations or about "who did what to whom." The initial formulation of the competition model (Bates & MacWhinney, 1982) focused on providing a functionalist characterization of categories such as "subject" and "object." It was argued that such categories develop to express a set of naturally related functions such as topicality, agency, givenness, and perspective.

As the empirical basis for the model has developed, we have begun to articulate the functionalist position in terms of an on-line sentence processing model. In its current form (MacWhinney et al., 1984) the competition model makes a series of seven fairly strong claims or assumptions about the control of sentence processing. After discussing each of these seven assumptions, we consider how they interrelate.

1. *Direct mapping.* For the grammar, only two levels of processing are specified in the model: a functional level (where all the meanings and intentions to be expressed in an utterance are represented) and a formal level (where the surface forms are represented). This two-leveled conceptualization of language structure is a very traditional one, articulated most thoroughly perhaps by Saussure in his classic introduction to linguistics. Saussure thought of the linguistic sign as a two-faced object with one face turned toward meaning and the other toward form. In our conceptualization, the mappings between the formal and functional levels are said to be direct. However, as we note in the next point, these mappings

are not necessarily one to one. This notion of direct mapping means that we are claiming that it is possible for languages to integrate on a single level cues that refer to different data types. Thus the parser is able to consider on an equal footing lexical semantic cues such as animacy, morphological cues such as agreement markers, word order cues such as preverbal placement, and intonational cues such as stress. If we were to discover evidence for a separation of cues by linguistic levels, we would have evidence against direct mapping. However, as we see in Experiments 2 and 3 below, it may be possible to make this first assumption even stronger by including a role for acoustic information during parsing.

2. *Multiplicity of form-function mappings.* In natural languages, mappings of a single form onto a single function are quite rare. Rather, languages make extensive use of polysemy, thereby producing grammatical systems in which a given form maps onto several functions and a given function maps onto several forms. An extremely strong version of the functionalist position would hold that each form maps onto a single function. However, as discussed in detail in Bates and MacWhinney (1982) and MacWhinney (1984), this strong assumption cannot be right. Rather, it must be the case that a single form can map onto several functions and that a single function can map onto several forms. For example, a listener may make use of a variety of cues for identification of the "actor." This would include preverbal positioning, agreement with the verb, and animacy. However, these cues could be overridden by presence of a passive verb.

3. *Ongoing updating.* In order to control the interaction of the various cues that impinge on sentence processing, we believe that the parsing system engages in an ongoing updating of assignments of nouns to case roles. For example, when parsing a sentence such as "the dogs are chasing the cat," the assignment of "dogs" as the agent is first promoted by its appearance as the initial noun. Then the fact that "are chasing" agrees with "dogs" in number further supports this assignment. Finally, when cat appears postverbally its binding to the object case role further supports the candidacy of "dogs" as agent. Thus, at each point in the processing of the sentence the candidacy of "dogs" is updated. In this case, each updating increases the strength of this candidacy. Because the language designs the cues to permit ongoing updating, the need for backtracking is minimized (Marcus, 1980). Like Marcus, we assume a small lexical/auditory buffer. There is no need in the competition model to bind "moved elements" to gaps (Chomsky, 1982), rather elements are bound directly to roles on the basis of the available cues.

4. *Coalitions and the breakdown of coalitions.* Languages do not choose the mappings between forms and functions randomly. Instead, these mappings reflect the fact that certain things tend to go together

"naturally." For example, in many languages, the functions of perspective, agent, actor, and topic prototypically map onto the set of devices that constitute the "subject." This is to say that a coalition of functions is mapped onto a coalition of forms. Although language is structured to maximize coalition, it can also happen that functions that prototypically "go together" are split apart and assigned to different items. Consider what happens when the coalition between agency and topicality breaks down in English. This can occur when we need to topicalize "the ball" even though "John" did the hitting. In such cases the grammar has to determine which of the two elements should "win" access to the device of preverbal positioning. At the same time, it must have a default mapping available for the item that loses in the competition. For example, if the topic wins out in English, the agent must be placed into a "by clause."

5. *Competition.* The model assumes that there is a dynamic control of the mapping of form onto function in comprehension and of function onto form in production. This mapping is understood to be governed by a system of parallel activation with strength-based conflict resolution much like that found in word-level processing models of Thibadeau, Just, and Carpenter (1982) or McClelland and Rumelhart (1981). The competition model extends these word-based models to the sentential level to account for assignment to grammatical roles and other parsing decisions. As the parser moves through the sentence, cues are used to accumulate evidence for alternative syntactic decisions. For example, each noun in a clause is a possible candidate for assignment to the role of "agent." As the parser progresses, it accumulates evidence that strengthens or weakens the candidacy of each noun for the agency role.

6. *Cue strength.* Each link between a form and a function is given a weight or strength. No sharp line is drawn between probabilistic tendencies and deterministic rules.

7. *Cue validity.* From the viewpoint of developmental psychology and learning theory, the most important claim of the competition model is that the primary determinants of cue strength are cue validity and task frequency. For our current analyses, the most important factor is cue validity. Following Brunswik (1956), we argue that human beings possess psychological mechanisms that bring them in tune with the validity of cues in their ecology. Cue validity is assessed within a given task domain. For example, we can assess validity within the domain of sentences that require a decision regarding who did what to whom. This is the domain of transitive sentences. Note that some tasks are very frequent tasks and others are very infrequent. The task of deciding which of two sides of a balance scale has more weight is an infrequent task. The task of deciding who was the actor in a transitive sentence is a much more frequent task. Cue strength will be a function of both task frequency and cue validity

in that cues for highly infrequent tasks will be learned later. However, within a given task domain, the major determinant of order of acquisition and eventual cue strength should be cue validity.

MacWhinney (1978) and MacWhinney et al. (1984) analyze cue validity into two components: cue availability and cue reliability. If a cue is there whenever you need it, it is maximally high in availability. McDonald notes that availability can be expressed numerically as the ratio of the cases in which the cue is available over the total cases in the task domain. If a cue always leads you to the correct conclusion when you rely on it, it is maximally high in reliability. Reliability can be expressed numerically as the ratio of the cases in which the cue is reliable (leads to correct assignments) over the cases in which it is available. Validity is defined as the product of reliability times availability. Following McDonald (1985), we can represent cases where the cue is not available as  $A$ , cases where the cue is available but not reliable as  $B$ , and cases where the cue is available and reliable as  $C$ . Then availability is the ratio of  $B + C$  divided by  $A + B + C$ . Reliability is the ratio of  $C$  divided by  $B + C$ . We can then think of validity as the product of availability times reliability. Since the  $B + C$  term cancels out when we multiply reliability times validity, validity becomes the ratio of  $C$  divided by  $A + B + C$ . This is precisely the way we want to define it, since this is the ratio of cases that are available and reliable over total cases.

We can illustrate these notions with the case of the cue of preverbal positioning in English. This cue is an excellent guide to assignment of a noun phrase as the actor. The cue is present in almost all sentences and almost always correct (except in structures like the passive). The cue of agreement with the verb is not so highly valid. It is only available when there is a competition between two nouns and when those two nouns *differ in number*, as in *The dogs are chasing the cat*. As MacWhinney (1978), MacWhinney et al. (1984), and McDonald (1984) demonstrate, both availability and reliability can be calculated from studies of the input to the language learner.

These seven assumptions of the model are fairly intimately interrelated. The basic processing mechanisms of competition and ongoing updating are linked directly to the rest of the assumptions. The assumption that patterns vary in strength is perhaps the most fundamental of the seven assumptions. The process of competition is based upon an accumulation of strength by each of the competing assignments or hypotheses. The assumption of competition is, in turn, important because it allows us a way of representing the coalitions and breakdowns of coalitions between meanings as they compete for expression through devices. The assumption of a direct mapping between cues and their interpretation allows the competition mechanisms to play a central role. The strongest version of

the model *is* nonmodular (in regard to processing at least). It holds that all cues available in the input can be used to boost or undermine the candidacy of competing alternative meanings. Competition also allows us a way of implementing ongoing updating. The data that are being updated are assumed to be all the cues in the signal, whether these cues are morphological, syntactic, or intonational. Finally, all of the processing assumptions are necessary to allow us to understand development as a response to cue validity. By thinking of processing as the interaction of many separate but related cues, we are able to think of learning as directed toward the acquisition of relatively simple structures. If a particular cue is high in applicability, but low in reliability, it will be learned early. However, its use will lead to errors or overgeneralizations. At the same time, more conservative and more reliable cues may be weaker initially, but will be slowly strengthened until they eventually can overcome the more widely applicable cues. Thus our understanding of cue validity as influencing acquisition relies heavily on a competition model of the processing system.

It is important to note that there is no role in the competition model as currently formulated for strong linguistic universals (Chomsky, 1965). This is not because we have evidence that such universals do not exist. It is because we believe that experimental data supporting the existence of such universals have not yet been obtained. For example, Bates et al. (1984) examined the evidence for two putative innate/universal hypotheses in language acquisition. The first was a proposed primacy of word order over morphology (Pinker, 1982). The second was a supposed universal dependency by very young children on animacy contrasts in interpreting transitive sentences. In both cases, it was shown that the age of acquisition of cues to sentence processing could be explained better through the construct of cue validity than through these universals. We return to a more general discussion of this problem at the end of this paper.

#### EXPERIMENT 1

In the present study, we seek to apply the competition model to a language with a structure markedly different from those to which the model has been applied in the past. As mentioned earlier, application of the model to the acquisition of Hungarian is interesting because of the high validity of the accusative suffix as a cue to case-role assignment and because of the extreme flexibility of word order in Hungarian. The first experiment we conducted examined the relative weights of case marking, animacy, word order, and stress in Hungarian children and adults.

## Method

### *Subjects*

This experiment utilized four groups of subjects, each with 24 members. The adult control group was composed of 24 psychology majors at the Eotvos Lorand University in Budapest—all were between the ages of 19 and 30. The children were all enrolled in state-supported nursery schools. The youngest group had an age range of 2;6 to 3;5 with a mean of 3;1. These children were enrolled in the nursery school of the BOMI Institute. The other two groups of children were enrolled in the preschools of the University and the Academy of Sciences. The age range of the second group was 3;7 to 4;4 with a mean of 4;0. The age range of the third group was 5;0 to 6;0 with a mean of 5;7. In the interest of comparison with other work we studied only children of middle and upper social class families, although Pleh and Vargha (1982) have shown that social class status has no significant effect on the development of sentence interpretation strategies in young children in Budapest. All groups had equal numbers of males and females.

### *Materials*

Sentences were constructed to vary the factors of case marking, word order, animacy, and stress. Case had three levels (no case, case on the first noun, and case on the second noun). In Hungarian, the case marking is placed on the noun that is the object of the verb and the agent or subject goes unmarked. Case is marked by the suffix *-/*. For example, the nominative of "cat" is *macska* and the accusative is *macskdt*. Examples of these three options include

1. A macska atugorja a kutya  
The cat over-jumps the dog
2. A macskat atugorja a kutya  
The cat-acc over-jumps the dog
3. A macska atugorja a kutyat  
The cat over-jumps the dog-acc

Since accusative case marking is obligatory, only 2 and 3 are grammatical.

Similarly, word order was varied on these three levels: NNV, NVN, and VNN. Taking the case-marking configuration of 3 above, we have these three further options:

4. A macska a kutyat atugorja  
The cat the dog-acc over-jumps
5. A macska atugorja a kutyat  
The cat over-jumps the dog-acc
6. Atugorja a macska a kutyat  
Over-jumps the cat the dog-acc

There are nine stimulus types yielded by crossing the three levels of case marking with the three levels of word order. Of these nine, six are grammatical in Hungarian. The three that are not grammatical are the three with no case marking. Within the six grammatical sentences, there is one sentence type that is the most common and least marked. As we noted earlier, when the object has a definite article, the unmarked pattern is SVO. This means that the NVN sentences with case marking on the second noun are the least marked and most canonical stimuli. Of course, if the object had been without an article, the canonical order would be SOV.

In addition to word order and case marking, the factor of animacy was varied on three levels. On the first level, both nouns were animate. On the second only the first was animate.

On the third, only the second was animate. The animate figures were man, woman, boy, girl, penguin, sheep, camel, kangaroo, baby, hippopotamus, lion, fish, gorilla, soldier, horse, giraffe, crocodile, deer, dog, bear, wild pig, donkey, duck, stork, goat, pig, and monkey. The inanimate figures were block, apple, table, chair, basket, television, pipe, pencil sharpener, lock, broom, bottle, boot, telephone, book, pencil, pen, shoe, tree, ring, necklace, wristwatch, and bush. The verbs were push over (leloki), jumps over (atugorja), hits (me-giiti), beats (megveri), pushes away (eltolja), and grabs (elfogja). All of the verbs expressed a highly transitive, punctual action and used separable verbal prefixes. Examples of sentences with animacy variations are:

7. A macska atugorja a kutyat.

The cat over-jumps the dog-ace.

8. A macska atugorja a ceruzat.

The cat over-jumps the pencil-ace.

9. A macskat atugorja a ceruza.

The cat-ace, over-jumps the pencil.

Finally, stress was varied on two levels. Half of the sentences were pronounced with a neutral, noncontrastive intonation, with the prefix in preverbal position. In this pattern stress is on the prefix. In the other half of the sentences, one of the sentence elements was stressed. As we mentioned earlier, a basic principle of Hungarian is that contrastive stress must be assigned to the element immediately before the verb (Kiss, 1981). We followed this principle when we were constructing our stimuli. In the NNV sentences, stress was placed on the second noun. In the NVN pattern, stress was placed on the first noun. In both of these cases, the prefix was separated and put after the verb, according to the rules of Hungarian grammar. In the VNN sentences, contrastive stress was placed on the verbal prefix which precedes the verb. It is because stress on the first noun in NNV or the second noun in NVN is unacceptable in Hungarian that we chose to vary stress on only two levels, rather than on three. These two levels are a contrast between default stress and grammatically appropriate contrastive stress.

This 3x3x3x2 design yielded a list of 54 stimuli. Actual sentences were created by selecting in a stratified manner from the pools of animate nouns, inanimate nouns, and verbs. Three alternative randomizations of the sentences were created.

#### *Procedure*

Subjects were examined individually. Small toys representing the two nouns were placed on the table in front of the child. The experimenter said the sentence aloud and asked the child to indicate who performed the action. During the warm-up trials, the question was posed in this form: "Show me: the lion pushes the pencil." After the child showed that he understood the task, the "show me" was dropped. The experimenter observed the child's enactment and noted which object was used as the agent.

### **Results**

Two sets of analyses were conducted: one for choice of actor and one for reaction times. The full ANOVA model involved four group levels with 3 x 3 x 3 x 2 crossed factorial design nested within each group. In addition to significance levels for each factor and interaction, we also report the statistic of proportion of variance accounted for, since this statistic is a close measure of the construct of cue strength in the competition model. All results are reported from the overall analysis of variance. An additional 20 analyses were conducted on subsets of the data to clarify the interactions. However, the results of these separate analyses

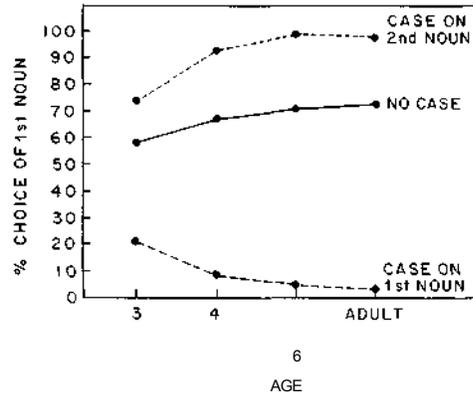


FIG. 1. The interaction of age with case marking.

are not fully presented. For the results of these further analyses and for complete AN OVA tables, the reader may consult the monograph-length Hungarian version of this paper (Pleh & MacWhinney, 1984).

#### *Case Marking*

As expected, there was a massive effect of case marking on choice of the first noun,  $F(2,184) = 1247.11$ ,  $p < .00001$ . Case marking accounted for fully 44.2% of the total variance. The size of this effect shows interesting changes over time, accounting for 12.5% of the variance at age 3, 50.8% at age 4, 64% at age 6, and 64.8% in adulthood. Use of case marking rises until age 6 when the development of its use stabilizes at a level near 100% in sentences with case marking, as can be seen in Fig. 1.

#### *Word Order*

Word order had a significant main effect,  $F(2,184) = 19.78$ ,  $p < .00001$ . In NVN sentences, the first noun was chosen as agent 60% of the time in NVN, 53% of the time in NNV, and 58% of the time in VNN. However, this main effect for word order was relatively weak, accounting for only 0.3% of the variance. We can gain a clearer picture of the nature of the word order effect if we look at the results for the block of sentences that had no case marking. When case is marked, the weak word order cues are overwhelmed. But when case is not marked, the effects of the weaker cues can be seen more clearly. For sentences with case not marked, there is consistent growth in the choice of the first noun as agent across the four age groups: 58, 67, 71, and 73%. The effect of word order is significant at all ages except the first. As shown in Fig. 2, this effect is concentrated in a first-noun preference for NVN and VNN orders. However, NNV sentences show both OSV and SOV interpretations. The resistance

## SENTENCE INTERPRETATION

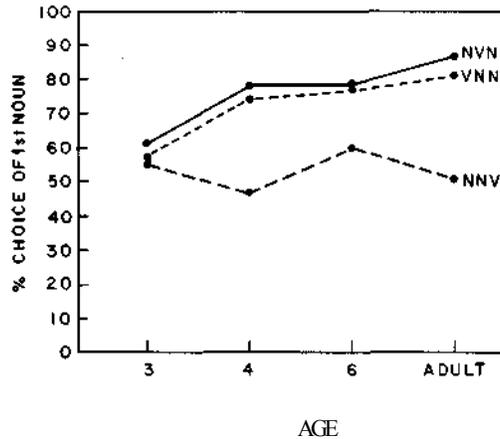


FIG. 2. The interaction of age and word order in sentences without case marking.

to the first-noun strategy in NNV sentences is supported by the fact that the first noun of the NNV can be interpreted as a preposed deictic fragment. This would be like interpreting the sequence "dog cat over-jumps" as if it were "(There's the) dog; the cat jumps over (him)." In Hungarian, the sentence would be "a kutya, a macska atugorja" interpreted as "(ott a) kutya. A macska atugorja." This is a more likely interpretation in Hungarian because the deletion of a definite object with no pronoun remnant is perfectly normal in Hungarian. Thus, in Hungarian, there is a way by which NNV sequences that are ungrammatical because of case-marker deletion can be mapped onto elliptical grammatical sentences.

### *Animacy*

There was a strong main effect for animacy. This effect appears not just for sentences without case marking. It even appears in an analysis restricted to sentences with case marking,  $F(2,184) = 23.31$ ,  $p < .00001$ , with animacy competing strongly against the fully grammatical case-marking cue. There was no main effect of animacy on latencies.

*Animacy and word order.* There was a significant,  $F(4,368) = 6.20$ ,  $p < .0001$ , interaction of animacy with word order for choice of first noun. This effect was concentrated in NNV sentences as can be seen in Fig. 3. When the first noun is inanimate, the use of OSV interpretations increases markedly.

*Animacy and case.* There was a significant interaction of animacy with case,  $F(4,368) = 5.97$ ,  $p < .00001$ . If the first noun was animate and the second was case marked, choices were most consistent. In those sentences where case was not marked, however, animacy played a particularly important role.

*Animacy and age.* There was a strong interaction between animacy use

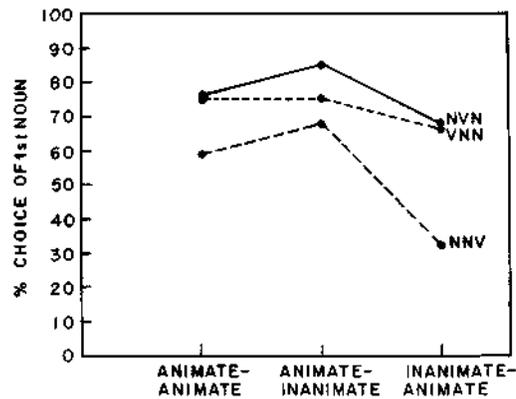


FIG. 3. The interaction of animacy with word order in sentences without case marking.

and age,  $F(6,184) = 11.37$ ,  $p < .00001$ , accounting for 1.5% of the variance. Figure 4 illustrates how the effect of animacy decreases over age for the two sentence types in which there is an animacy contrast. For the sentences without case marking, the reliance on the animacy cue shows a strong decline after the first age in terms of proportion of the variance accounted for: 13.4, 2.6, 1.4 and 1.7%. The interaction of animacy with case is significant,  $F(2,184) = 11.65$ ,  $p < .00001$ , as is the decline of the interaction with age,  $F(6,184) = 2.97$ ,  $p < .01$ . We examine this contrast in more detail in the discussion section.

### *Stress*

The effects of stress were quite weak. With stress added, the choice of the first noun dropped from 58 to 56%. For sentences with case marking the effects of stress were truly minimal. However, for the sentences with no case marking, addition of stress dropped first noun choice from 70 to 64%. The strongest effects of stress were concentrated in the adult group,  $F(1,23) = 13.00$ ,  $p < .001$ , where they accounted for 2% of the variance for the sentences without case marking. As Fig. 5 shows, there was an interaction between stress and word order for those sentences in which case was not marked. Unlike the other figures, Fig. 5 plots not absolute choice levels, but the effect of adding contrastive stress in terms of the relative increase or decrease in absolute choice. This form of plotting is helpful, because stress has its effect in terms of changes in basic response tendencies. If the second noun was stressed in NNV sentences, the choice of the first noun was decreased. But if the first noun was stressed in NVN sentences, it was more likely to be chosen. In other words, items with grammatically correct contrastive stress were chosen

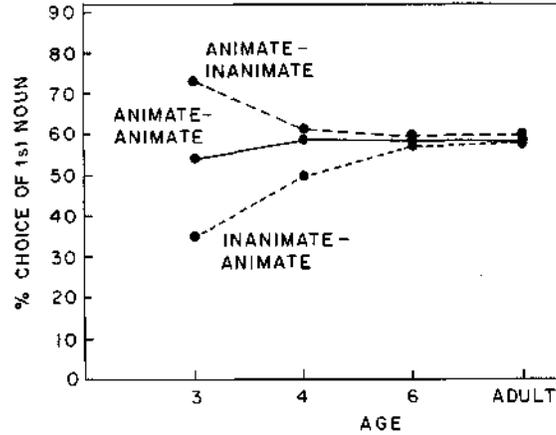


FIG. 4. The interaction of animacy with age.

as actors. This effect was concentrated in the adult group where it was significant,  $F(2,46) = 19.84$ ,  $p < .00001$ , accounting for fully 7.4% of the variance for those sentences which had no case marking.

#### Discussion

The major results of this study can be predicted directly from the competition model. For example, given that case marking is a fully reliable and always available marker of case role, it is not surprising that Hungarian children form a reliance on case marking at a very early age and that by age 6 this cue becomes the almost exclusive determiner of sentence understanding in grammatical sentences. In the youngest children, both animacy and case marking are important cues, although the reliance on animacy shows a continual decline up to age 6. Figure 6 charts the relative strength of case, word order, and animacy across age in terms of percentage of variance accounted for.

The decline over age in reliance on animacy cues (Figs. 4 and 6) is sharper in Hungarian than in Italian (Bates et al., 1982). As McDonald (1984) argues, declines over age in cue strength can best be attributed to encounters with sentences in which cues conflict. In Hungarian, whenever an inanimate noun is truly the actor, the animacy cue will conflict with the case cue and the animacy cue will be decremented. In Italian, this decrementation of the animacy cue will only occur when there is a conflicting grammatical cue. Since the agreement cue is the most reliable grammatical cue in Italian and since it is often not present, decrementation of animacy as a cue will proceed more slowly in Italian than in Hungarian.

Although the youngest children relied a great deal on case marking,

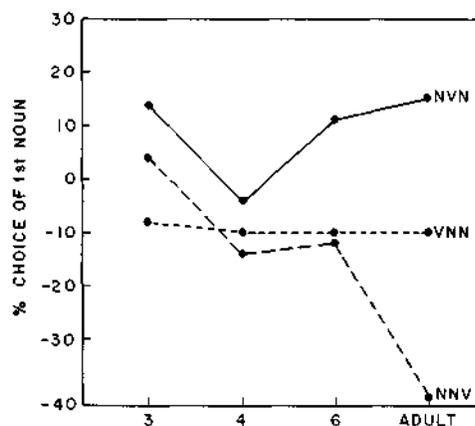


FIG. 5. The effect of adding contrastive stress in terms of the relative increase or decrease of percentage choice by age and word order for non-case-marked sentences.

this reliance was somewhat less than what would have been predicted by the competition model. One way of evaluating this slight delay in acquisition is to compare the Hungarian data with data collected from Turkish by Slobin and Bever (1982). Turkish resembles Hungarian in many respects. Both languages have a basic SOV order, both are agglutinative, and both have a highly regular accusative suffix. Since the Hungarian accusative is almost as completely valid as the Turkish accusative (-/, -«), one would expect that young Hungarians would rely on this cue just as much as the 3-year-old Turks studied by Slobin and Bever. The stimuli used by Slobin and Bever did not include an animacy contrast. However, comparing those sentences that had no animacy contrast and grammatical case marking, we find that Hungarian children between 2;6 and 3;5 obey the grammatical cue less than 70% of the time, whereas even younger (2;6) Turkish children obey the grammatical cue 80% of the time. Although the Hungarian cue is weaker than the Turkish cue, both are much stronger than the fairly unreliable case cues in Serbo-Croatian (Smith, unpublished) and Hebrew (Frankel, Amir, Frenkel, & Arbel, 1980; Frankel and Arbel, 1981, 1982). In Experiments 2 and 3 we examine some possible explanations for this discrepancy.

Given the basically free order of major constituents in Hungarian, the overall weakness of the word order cues (Fig. 6) is not surprising. The effects of word order were demonstrated most clearly in those sentences which did not have the powerful case cue. In those sentences there was evidence for a general first-noun strategy in NVN and VNN sentences—the same tendency that had been observed by Pleh (1981).

The strength of the VSO interpretation of VNN is somewhat more

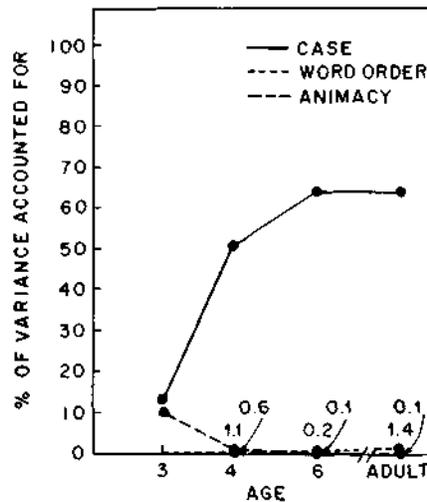


FIG. 6. Percentage of variance accounted for by main effects across ages. Choice A.

surprising. In such sentences, subjects seem to make no effort to preserve the "unity of the verb phrase" even though a VOS interpretation is available. This again points to the importance of the "first-noun-as-actor" strategy. The conflict between the general first-noun strategy and the preverbal-definite-noun strategy was best displayed in the competition between OSV and SOV interpretations of NNV sentences. Of these two strategies, the simplest is the first-noun strategy. Using this strategy, the listener simply assigns the first noun as agent. No memory for the overall form of the sentence is required. In the preverbal-definite-noun strategy, the listener must process the NV unit as a positional pattern. Thus, it is not surprising that the 3-year-olds seem to rely more on the absolute first-noun strategy.

Neither of these strategies require the processing of overall sentence patterns for canonicity (Slobin & Bever, 1982). As shown by Bates et al. (1982) and by MacWhinney et al. (1984), sentence interpretation in English can be understood in terms of use of processing of SV and VO units. Although the actual processing strategies in Hungarian are quite different, the conclusion is similar: listeners make use of proximal cues, rather than overall sentence form, wherever possible.

Finally, only the 6-year-olds and the adults showed a systematic use of stress as a cue to role assignment. In these groups, stress is used only when other more reliable cues are not present. This pattern is well predicted by the competition model. The adult groups tended to select the contrastively stressed noun as the agent. This strategy is quite different from that reported for Italian and German in MacWhinney et al. (1984).

In German, adult subjects use stress to reverse whatever interpretation of the sentence they would normally derive. In Italian stress cancels the default SVO interpretation for NVN. However, NNV and VNN patterns are uninterpretable without stress ( $N7W \Rightarrow SOV$  and  $VNN \Rightarrow VOS$ ). Thus, in all three orders in German and in NVN order in Italian stress signals reversal, whereas in Hungarian a stressed definite noun is taken as the agent. It is not clear whether this interpretation would also be given to nouns with indefinite articles or "zero" articles.

One objection that can be raised against Experiment 1 is that it contains a rather large proportion (33%) of ungrammatical stimuli. The extreme form of this objection would hold that studies of sentence and word processing can never make use of ungrammatical stimuli. This would force us to dismiss a considerable amount of the work conducted over the last 30 years without indicating whether this work is somehow inconsistent with work using only grammatical stimuli. Despite such problems, the criticism appears to have a certain face validity and it must be addressed squarely.

To begin our examination of this problem, we first note that a fundamental tenet of the competition model is that languages tend to cluster cues into coalitions. Coalitions can be thought of as natural confoundings of cues. For example, in English, preverbal positioning, nominal case marking on pronouns, animacy, and subject-verb agreement are all confounded as cues to agent case-role assignment. In experiments investigating the relative weights of these cues, such as Bates et al. (1982), MacWhinney et al. (1984), or McDonald (1984), it often occurs that sentences that deconfound these cues are ungrammatical. In most of these experiments, ungrammaticality arises when the experiment includes sentences that omit obligatory cues. Using such sentences, researchers have gathered a body of data that is remarkably orderly and which maps onto the differences between languages in predictable ways. However, the skeptic may wish to argue that the processing of ungrammatical sentences cannot provide reliable information about normal sentence-processing strategies. The claim made by those who would use such sentences is that the processing of both fully grammatical sentences and sentences containing grammatical errors occurs by reference to a single set of grammatical cues. The skeptic could make the plausible argument that only the grammatical sentences are processed by reference to grammatical cues, and that ungrammatical sentences are processed in some fundamentally different way. Although one can never prove that no differences exist between the processing of grammatical and ungrammatical sentences, one can set up tests that would potentially disconfirm the claim that standard grammatical cues and normal processes are used in processing ungrammatical sentences. This can be done wherever the

grammar of a language permits a natural omission of an otherwise obligatory cue.

Hungarian provides an interesting instance of just such a permitted omission of an otherwise obligatory cue. Whenever the object of the verb is a noun possessed by either the first person singular ("my dog") or the second person singular ("your house"), the accusative can be omitted. This omission is stylistically preferable, but not obligatory. Such possessed nouns are the only forms where accusative deletion is permitted. In Experiment 2, we use this fact to test for the "ecological validity" or generalizability of the findings obtained in Experiment 1. If we find that the processing of these sentences occurs in ways that are fundamentally different from the non-case-marked sentences in Experiment 1, we would have reason to question the generalization of the results from ungrammatical sentences to grammatical sentences.

## EXPERIMENT 2

### Method

#### *Subjects*

Adult subjects were 24 college students from the Eotvos Lorand University in Budapest. There were eighteen 4-year-olds and eighteen 6-year-olds enrolled in the nursery school of the Hungarian Academy of Sciences. Thus, all three groups came from populations identical to those sampled in Experiment 1.

#### *Materials*

The 36 test sentences used the nouns and verbs described in Experiment 1. Word order and animacy were varied as in Experiment 1. The major difference between the experiments is, fea.1, «v E^eOTftftxA 1, xvoae at \i<t \*s.e.wtoxiw, \asi. t-s&e, maxVixvj,. \sisXe,asi, ^n«. \«xv«4 possessive marking on four levels. We illustrate these four levels for the case of NVN sentences with two animates. We will translate the first-person singular possessive -m as "MY" and the second-person singular possessive -d as "YOUR."

10. A kutyam atugorja a macskad (-m, -d)  
The dog-MY across-jumps the cat-YOUR
11. A kutyad atugorja a macskam (-d, -m)  
The dog-YOUR across-jumps the cat-MY
12. A kutyad atugorja a macskad (-d, -d)  
The dog-YOUR across-jumps the cat-YOUR
13. A kutya atugorja a macska (-0, -0)  
The dog across-jumps the cat

The four types of sentences will be referred to as (-m,-d), (-d,-m), (-d,-d), and (-0,-0) types, respectively. In Sentences 10-13, only 13 is ungrammatical. It is included in order to provide a control comparison with the grammatical possessive Sentences 10 to 12 and for comparison with identical sentences such as 1 for Experiment 1. The sharpest of these comparisons is the one between 12 and 13 since both have two nouns with identical marking. The materials were randomized as in Experiment 1.

*Procedure*

There were two sets of figures. One set was painted red and one set was painted blue. Half of the child subjects were told that their color was red. The other half were told that their color was blue. On each trial the child was presented with four objects, such as two dogs and two cats with one of each painted blue and one of each painted red. If the sentence was "your dog chased my cat" and the child chose "dog" as the agent, then he/she should select a dog of his/her "own" color rather than the experimenter's color. The experimenter recorded two aspects of the child's response: (1) which noun was chosen as actor and (2) whether the child correctly interpreted the possessive marker on the noun chosen as actor in his/her color choice. Adults listened to the materials on tape and were asked to name the actor as fast as they could and the latency from the end of the sentence to the beginning of their reply was recorded.

**Results**

Significant main effects were found on choice for age,  $F(2,5T) = 10.50$ ,  $p < .00001$ , ending type,  $F(3,171) = 23.18$ ,  $p < .00001$ , and animacy,  $F(2,114) = 15.42$ ,  $p < .00001$ . The first noun was chosen 64% of the time at age 4, 83% at 6, and 76% in adulthood. In the adult latency scores, there were also significant main effects for ending type,  $F(3,69) = 3.09$ ,  $p < .05$ , word order,  $F(2,46) = 12.97$ ,  $p < .00001$ , and animacy,  $F(2,46) = 4.76$ ,  $p < .02$ . The strongest of these, the word order effect, accounted for 2.8% of the variance. As can be seen in Fig. 8, processing of NVN was much faster than NNV and VNN,  $F(2,46) = 12.97$ ,  $p < .00001$ .

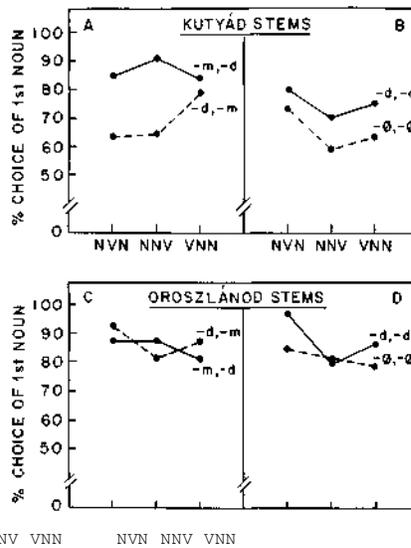


FIG. 7. The interaction of word order with ending type across stem types for choice data in Experiments 2 and 3.

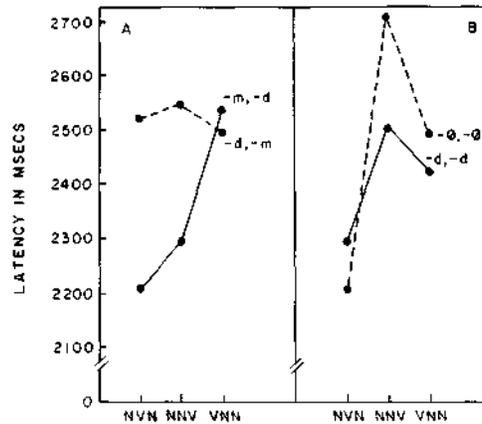


FIG. 8. The interaction of word order with ending type for latency data in Experiment 2.

#### *Ending Type and Word Order*

As can be seen in Fig. 7A, choice of the first noun as actor was highest in (-m,-d) sentences and lowest in (-d,-m) sentences. Moreover, reaction times were up to 300 ms slower to the (-d,-m) sentences (Fig. 8A). We believe that these data provide some evidence for phonological assimilation of the possessive /d/ to the accusative /t/. In general, subjects attempt to interpret the first noun as the actor. When they encounter the -d in (-d,-m) sentences they are forced to consider the possibility that the /d/ was actually a /t/ and that the initial noun was in the accusative. In sentences with (-m,-d), the ending on the first noun cannot be heard as an accusative and the ending on the second noun can. Since this is the pattern that is also favored by the word order cues, reaction times for this sentence type are quick. In sentences with (-d,-d), either /d/ could be heard as a /t/. As we will see below, the way in which this is done varies with the word order of the sentence. In (-0,-0) sentences there is no chance to hear the first noun as an accusative. This leads subjects to take the first noun as the actor. When they find that the second noun has no ending that can be heard as an accusative, reaction times slow down and choice of the first noun as actor is decremented.

The interaction of word order with ending type for choice was also significant,  $F(6,342) = 5.19, p < .001$ . Figures 7A and B show that the nonassimilable (-0,-0) sentences replicated the results for Experiment 1 as shown in Fig. 3. However, in (-m,-d) sentences, where the possessive -d on the second noun could be interpreted as an accusative -, the tendency toward an SOV interpretation of NNV was increased (Fig. 7A). This finding supports the interpretation of NNV processing given for

Experiment 1. When possible, subjects prefer SOV to OSV, since SOV preserves first-noun-as-actor order.

For latencies, the interaction with ending type is also significant,  $F(6,138) = 4.75$ ,  $p < .0001$ . In (-m,-d) sentences, subjects take longer to respond when the order is VNN. In these sentences the first noun (the noun with the /m/) is not the initial word. Thus its candidacy for the actor role is not overwhelming and the competition between it and the second noun continues up to the last moment. In (-0,-0) and (-d,-d) sentences, NNV orders are particularly slow. These sentences violate the basic pattern for nondefinite objects. In the zero-type no pseudoaccusative is ever found. In the (-d,-d) type, the presence of the pseudoaccusative facilitates assignment of the second noun as the object.

The fact that NVN sentences with nouns with -m on the first noun were processed so quickly and consistently as SVO can be best interpreted by assuming that listeners judge nouns ending in -m to be "clearly not objects." Since these nouns are also initial and preverbal, the evidence supporting their candidacy as agents is convincing even before the next noun has been heard. Note that this means that listeners are using cues both positively and negatively. Thus, if it is exceptionally clear that a noun does not have an accusative suffix, this can promote its candidacy for agency.

We have noted that the results for the (-0,-0) sentences in Fig. 7B closely match those for the (-0,-0) sentences in Experiment 1. More importantly, the results for the (-d,-d) sentences and the (-0,-0) sentences in Fig. 7B show identical patterns although somewhat different absolute values. These data indicate that, when processing (-d,-d) sentences and (-0,-0) sentences, subjects rely primarily on word order patterns and the first-noun-as-actor principle. They do this most accurately in (-d,-d) sentences where the absence of case marking is "justified" by the presence of a balanced set of possessive markers.

#### *Animacy and Ending Type*

As in Experiment 1, the interaction of animacy with word order,  $F(4,228) = 4.56$ ,  $p < .001$ , arises from a tendency to use animacy more in the noncanonical NNV and VNN sentences. When the first-noun cue and the preverbal-definite-noun cue converge on the same noun, there is sufficient information to make a decision without paying attention to animacy. This tendency grows with age leading to a significant interaction of age with word order and animacy,  $F(8,228) = 3.81$ ,  $p < .0001$ . Animacy also interacts weakly with ending type,  $F(6,342) = 2.41$ ,  $p < .05$ . This interaction arises from the fact that in (-m,-d) sentences, the effect of

animacy is weakened. In such sentences the clarity of the word order and phonological cues make attention to animacy unnecessary.

#### *Choice of the Correct Color*

We present the results for the choice of the correct color in the discussion for Experiment 3.

### Discussion

This experiment yielded two important results. First, the fact that the (-d,-d) and (-0,-0) ending types behaved like each other and like the (-0,-0) stimuli in Experiment 1 provides evidence for the ecological validity of even ungrammatical stimuli in this task. The results of Experiment 2, together with those of Experiment 1, allow us to state the ecological validity hypothesis in a fairly strong form:

Ecological Validity Hypothesis: The processing of both grammatical and ungrammatical sentences proceeds by reference to the same sets of cues and processing patterns.

From this thesis one can derive the corollary that it is legitimate to use stimuli which deconfound grammatical cues, even if such stimuli are ungrammatical. In all cases, it is crucial, however, that researchers should be able to hypothesize a set of processing cues that can account for the results of both grammatical and ungrammatical sentences. For the strong form of this hypothesis to hold, none of the cues hypothesized for the processing of ungrammatical sentences should be ones that would not be used in the processing of grammatical sentences.

The second major finding of this study was that the tendency to hear the *-d* as a *-t* seemed to indicate that syntactic decisions can be heavily influenced by phonological detectability. If this apparent phonological assimilation is real, then it should be possible to systematically control detectability and thereby control assimilation. In order to conduct such a test, we conducted a third study which made use of a detailed fact of Hungarian morphophonology. For words like *kutya* "dog," the accusative *kutydt* "dog + ace." is quite close to the 2PS *kutydd* "dog + 2PS." But, for words like *oroszlán* "lion," this is not the case. The 2PS form *oroszlánod* "lion + 2PS" has a vowel that is not found in the accusative *oroszlándt*. Since the presence of this extra vowel adds an additional syllable to the word, it should be much harder to assimilate the possessive (-d) to the accusative (-t). To make this assimilation would be in spite of the fact that words of the *oroszlán* type use no linking vowel. In both perceptual and morphophonological terms, the contrast between *oroszlándt* "lion + ace." and *\*oroszlánót* "lion + ace." in Hungarian is much like the contrast between /dumpt/ and \*/dumpid/ for English *dumped*. In

the correct forms /dumpt/ as in *oroszdnt* the suffix is nonsyllabic; in the erroneous forms \*/dumpid/ and \**oroszdnot* the suffix is syllabic.

For ease of reference, we will call words of the *kutya* type "assimilable stems" and words of the *oroszldn* type "nonassimilable stems". If subjects were in fact assimilating *-d* to *-t* in Experiment 2, then we should observe a markedly different pattern of results for stems that do not permit such assimilation. Experiment 3 relies on this contrast. Readers who are interested in a fuller understanding of the morphophonological principles underlying this contrast are encouraged to consult the chapter on Hungarian morphophonology in MacWhinney (1978).

### EXPERIMENT 3

#### Method

The design and stimuli of the third experiment were in nearly all respects identical to those of the second. The only change in stimuli involved the use of nouns of the nonassimilable *oroszldn* type rather than the assimilable *kutya* type. Subjects were drawn from the same populations as in the earlier study, with the same numbers of subjects in each age group. For the adults only, latencies were measured from the beginning of the sentence.

#### Results

Because of the comparable design of Experiments 2 and 3, it was possible to conduct both an independent ANOVA for this study and an ANOVA comparing the results for both studies. Because of the complexity of the latter, wherever possible we simply compare the results of the independent ANOVAs for the two studies. From the overall analysis we only cite the facts that the interaction of stem type x ending type was highly significant,  $F(3,342) = 10.91, p < .00001$ , and that the main effect of stem type was also very strong,  $F(1,114) = 26.16, p < .00001$ .

#### *Ending Type*

The most important contrast between the two studies was that the effect of ending type markedly decreased in Experiment 3, declining from accounting for 3.3% to only 0.5% of the variance. The effect of animacy, on the other hand, grew from accounting for 2.9% to 3.7% of the variance. As can be seen in Fig. 9, the level of choice of the first noun as agent is consistently higher at all ages for the nonassimilable stimuli in Experiment 3,  $F(1,114) = 26.16, p < .00001$ . When faced with a decrease in the possibility of hearing a case suffix on either of the two nouns, subjects here were forced to rely only on word order and animacy. This principle holds for all of the types of sentences in Figs. 7C and D except (-0,-0). In (0,0) sentences the nature of the stem type leads to exactly opposite results. In (-0,-0) sentences with nonassimilable stems, phonological assimilation is actually easier than in the case of (-0,-0) endings with the

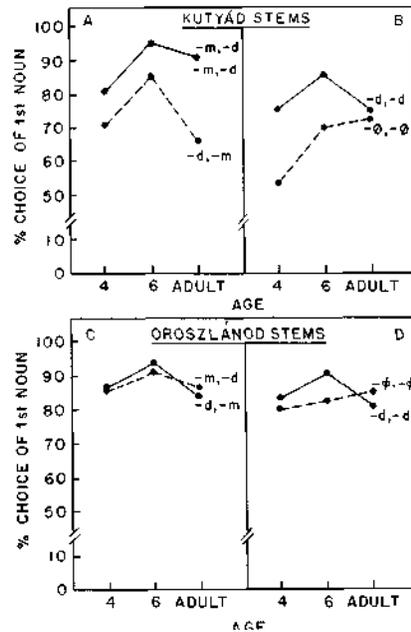


FIG. 9. The interaction of age with word order across stem type for choice data in Experiments 2 and 3.

assimilable stems of Experiment 2. This is because the presence of a *lil* after the bare stem of the *oroszlán* type is very hard to detect, whereas it is clear that a bare stem of the *kutya* type is not being inflected, since otherwise the final vowel would be lengthened. For this reason, subjects can allow word order to force the "insertion" of an accusative *-t* after the second noun in the sentences of Experiment 3. This is because the *oroszlán*-type stems simply add a bare *-t* which is particularly difficult to detect. The fact that a higher level of first-noun choice appeared for the (-0,-0) sentences in Experiment 3 than in Experiments 1 and 2 (compare Fig. 9D with Figs. 9B and 2) appears to be due to the fact that the stimuli in Experiment 3 all permitted the listener to hear the second noun as an accusative, without postulating an additional syllable. Here, again, we see evidence for the impact of phonological factors on sentence processing in Hungarian.

The latency data showed a much larger effect for ending type,  $F(3,102) = 115.68$ ,  $p < .00001$ . This effect accounted for fully 37% of the variance for latencies. The effect was concentrated in the fact that (-m,-d) sentences took 2425 ms whereas (-d,-m) sentences took 2682 ms. As in Experiment 2, the presence of the /d/ on the first noun tends to block the strength of its candidacy for the role of actor. We should note, however, that this effect in both experiments could also be explained by reference

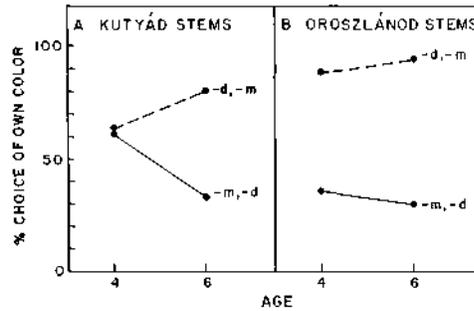


FIG. 10. The interaction of age with ending type across stem types for percentage choice of own color in Experiments 2 and 3.

to the notion of closeness-to-ego, as developed by MacWhinney (1977), Ertel (1977), and Silverstein (1976). As these authors have argued, there is a pervasive tendency in language for speakers to prefer sentence perspectives which are maximally close to their own real-life perspectives. In this particular experiment the factor of ego perspective is confounded with that of the assimilability of the second-person /d/ to the accusative *III*. Further research is needed to eliminate this confound.

The significant interaction of age with ending type in Figs. 9C and D,  $F(6,171) = 2.67$ ,  $p < .02$ , provides some weak evidence that 4-year-olds did not control the rules of morphophonology well enough to make a sharp distinction between assimilable and nonassimilable stems. By age 6 children sense clearly that *oroszlánod* cannot be an accusative. However, in the (-0,-0) sentences of Experiment 3 it is in fact more likely than in Experiment 2 that a bare nominative could be assimilated to the accusative.

#### *Animacy*

As noted, the main effect of animacy was significant, as was the interaction of animacy with age,  $F(4,114) = 6.18$ ,  $p < .0001$ , the interaction of animacy with ending type,  $F(6,342) = 3.51$ ,  $p < .002$ , and the interaction of word order with animacy,  $F(4,228) = 6.80$ ,  $p < .0001$ . The interaction of animacy with age involves an increased reliance on animacy with increasing age. This increase in reliance on animacy provides an interesting counterexample to those who view reliance on animacy as necessarily a primitive or immature strategy. As Bates et al. (1984) argued, the animacy cue has a status much like that of any other cue. In the case of those few Hungarian sentences which are truly not case marked, use of the animacy cue is a mature strategy. Of course, since such sentences are fairly rare, one cannot expect young children to have yet learned to use animacy in this special purpose way.

The interaction of word order with animacy arises from the fact that

when the first noun is both inanimate and ends with a *-d*, the use of the first-noun strategy drops. This is to say that when two weak cues conspire they can overcome another only slightly weaker cue.

#### *Word Order*

As can be seen in Fig. 7D, choice of the first noun as agent is strongest in NVN. Here the first-noun and preverbal-definite-noun cues converge to support SVO interpretations. In NNV the first noun is much less likely to be chosen as agent if it ends with *-d*. In this case the first-noun cue is not supported by the preverbal-definite-noun cue and is opposed by a weak caselike cue.

#### *Choice of the Subject's Own Color*

As we noted earlier, in addition to noting the type of object selected as the agent ("cat" or "cow"), we also noted whether the child was consistent in selecting the correct owner for the object. As can be seen in Fig. 10, there was a very significant interaction in Experiment 2 between age and ending type,  $F(3,102) = 5.86, p < .00001$ . At the youngest age, children found it difficult to act upon the experimenter's object without thinking of it as their own object. In (-m,-d) sentences this meant generally that they chose the first noun as agent, but thought of it as their own object. In (-d,-m) sentences, they took the second noun as agent but again tended to think of it as their own object. Comparing the results for Experiment 2 (Fig. 10A) with those for Experiment 3 (Fig. 10B) we see that when the possibility of mishearing the *-d* is removed, children avoid this particular type of error. These data indicate that children appear to be coping simultaneously with two partially separate decisions: the decision about whether to interpret a final dental as a cue to the accusative and the decision about whether to interpret a final dental as a cue to second-person singular possession. Figuring in the latter decision, particularly at age 4, is a general tendency to want the agent or perspective of the sentence to be maximally close to ego (Ertel, 1977; MacWhinney, 1977). A full examination of the interactions between these effects requires further experimentation.

Given the importance of stem type in Experiments 2 and 3, the reader might well wonder whether the results of Experiment 1 might not be confounded by our failure to control stem type. However, of the 50 nouns used in Experiment 1, only 4 were of the *oroszldn* type in which the accusative is hard to detect.

### GENERAL DISCUSSION

This research examined the extent to which the competition model could be applied to data on the acquisition of non-Indo-European languages. Hungarian was chosen for study because of its strong reliance

on accusative case marking as a cue to identification of case roles and because of the relative freedom of word order variation it permits. In Experiment 1, the competition model yielded correct predictions regarding the relative order of acquisition of the various cues in Hungarian and the ways in which those cues interact. The strongest cue was case marking. Animacy was used particularly where other cues were not available. Stress was used by 6-year-olds and adults to support choice of the stressed noun as agent.

Two word order processing strategies were observed in Experiment 1. The first was a pervasive tendency to choose the first noun as agent. This tendency is much like that observed in German, but not in Italian or English (MacWhinney et al., 1984). The second strategy involved the choice of the preverbal definite noun as agent. Use of these two patterns correctly accounts for both the choice and latency effects in these experiments. When these two cues converge, processing is speeded and choice is uniform. When they compete, other factors come into play and latencies increase.

Experiment 1 provided strong support for the competition model. However, much of the clearest evidence came from sentences in which the removal of the case cue leads to ungrammaticality. We were worried about the possibility that processing of these sentences might differ from processing of grammatical sentences in some fundamental way. Experiments 2 and 3 were designed to test the extent to which the processing of the ungrammatical stimuli in Experiment 1 and others like it could be considered "ecologically valid." In fact, no discontinuity between grammatical and ungrammatical processing was observed anywhere in these studies. The results for the (-0,-0) sentences in Experiments 1-3 were nearly identical. More importantly, the results for the (-0,-0) sentences and the (-*d*, -*d*) sentences indicate that experiments which set naturally confounded cues into competition can yield results that are interpretable, consistent, and plausible. This finding is particularly comforting given the focus within the competition model on the derivation of cues from interactions with the cues in the environment. Similar support for the ecological validity of competition stimuli has also been provided by Smith and Mimica (1984) for Serbo-Croatian.

Experiment 1 also provides us with interesting details regarding the relative speed of acquisition of the case and animacy cues. The rapidity of the decline of the animacy cue in Hungarian when compared to Italian appears to be the result of the strength of the victory of the case cue. The second developmental contrast arising from Experiment 1 relates to the fact that the reliance on case is not fully solidified until age 6. A comparison of the use of the case cue in Hungarian with the case cue in Turkish suggests that acquisition in Hungarian appears to be delayed by several months. Experiments 2 and 3 pointed out problems that subjects

have with correct detection of the accusative *-t*. According to the description of Turkish provided by Slobin and Bever (1982), there are no similar problems with the detection of the accusative (*-i,-u*). Under the pressure of word order and animacy cues, both children and adults can be led into thinking that an accusative was present where no case marking was present at all. These findings have consequences for both the theory of acquisition and the theory of sentence processing.

The theory of acquisition proposed in Bates et al. (1984) and MacWhinney et al. (1984) holds that the major determinant of the order of acquisition of cues is cue validity. Cue validity is taken to be a function of both reliability and availability. Reliability refers to the extent to which you can depend on a cue to not mislead you. Availability refers to the extent to which a cue is there when you need it. The current results indicate that the model must be amplified to provide a role for cue detectability. Although a cue may be available and reliable, this will do the child no good if the cue cannot be detected easily in the first place. In words such as *mokus-t* (= squirrel + ace) the accusative suffix is so hard to hear that it can only be clearly detected if it is precisely articulated. Various complexities of Hungarian morphophonology further decrease the detectability of the accusative. We believe that this is the source of the delay of several months in full reliance on the accusative suffix in Hungarian.

MacWhinney (1978, in press) and Peters (1983) have discussed some of the evidence for children regarding detectability and segmentability as factors in lexical acquisition. Without going into a full review of that subject here, it is still important to note that detectability is a topic that can be studied in its own right. Stress, final position, and juncture all appear to aid in the detectability of segments and morphemes. Without this initial detection, units cannot be acquired. Reliability and validity only begin to play a role in shaping cue strength once the cue is detected and initially acquired.

Apart from leading us to incorporate this added proviso into the competition model, the results of Experiments 2 and 3 also sharpen our understanding of the role of phonological processing in sentence comprehension. In fact, the principle of detectability is one that follows naturally from the notion of a direct mapping between cues and interpretations. If a cue provides a strong signal, it will provide strong support to an interpretation. If its signal is weak and hard to detect, it will provide less support. When word order, stress, and animacy cues converge on a given decision, the listener may actually be induced to reconstruct the auditory signal in the direction of what the syntactic cues require. This phenomenon is very much like the top-down morphological assimilations discussed by Stemberger and MacWhinney (unpublished) and Menn and MacWhinney (1984) or the phonological assimilations studied by Warren

and Warren (1970). Warren and Warren presented subjects with one of these four sentences:

It was found that the \*eel was on the axle. It was found that the \*eel was on the shoe. It was found that the \*eel was on the orange. It was found that the \*eel was on the table.

The asterisk represents a segment replaced by a cough. For these sentences, subjects heard the word *wheel*, *heel*, *peel*, and *meal* respectively.

There are a number of such studies pointing out lexical and semantic forces leading to phonemic restoration. The current study is, to our knowledge, the first to demonstrate the effects of syntactic expectations on phonemic restoration. In Experiments 2 and 3, we show that subjects can assimilate one of the nouns in a Hungarian sentence to an accusative, either if that noun is of the *kutya* type and ends in *-d* as in *kutydd* or if it is of the *mokus* type and the accusative is hard to detect in any case. However, as the signal itself becomes clearer, even the strongest top-down cues may not be able to force phonological assimilation. We believe that this finding underscores the extent to which phonological, word order, intonational, lexical, and contextual cues can operate interactively during on-line comprehension.

Finally, we would like to consider two implications of this general line of research for psychological theory. One issue that may have troubled the reader is the minimal importance that the model currently assigns to linguistic universals. Here the data themselves have shown us that the main forces acting upon the language-learning child are those of detectability, availability, and reliability. However, it may be that the importance of the linguistic environment that we have observed is not inconsistent with claims regarding linguistic universals. Once the child has acquired a form and begun to use that form regularly, she/he is working within the linguistic system and is subject to the rules of that system. However, during the period when the child has acquired nothing more than a handful of forms, attempts to map sounds into interpretations or to map intentions into utterances may rely on quite general strategies. At this early point, it also seems likely that individual differences will show themselves most clearly. Thus, the contrast between expressive and nominal styles or between reliance on imitation, production, or comprehension may be more important in the early stages than at later stages. In this sense, we may be seeing a larger contribution of the language learner himself at the early stages when the contribution of the environment is still rather amorphous.

A second major issue is the extent to which the competition model can make contact with a general model of human development. The model has been developed to deal specifically with the acquisition of grammat-

ical abilities. However, unlike models that rely on claims regarding innate structures and constraints (Wexler & Culicover, 1980), the competition model views linguistic processing as an integral piece of the overall architecture of cognition (J. Anderson, 1983). The developmental and cognitive literature is rich with competitionlike models and accounts. The rule-assessment analysis of Siegler (Siegler 1981; Siegler & Shrager, 1984) and the information-integration approach of N. Anderson (Anderson & Cuneo, 1978) can be seen as applications of competition-type models to nonlinguistic domains. Competition accounts are fundamental in much of the research on prototypes and fuzzy categories (Rosch & Mervis, 1975). One can find competition in infant search behavior (Sophian, 1984), visual-auditory cross-modal processing (Massaro & Cohen, 1983), and phonological processing (Menn & MacWhinney, 1984; Scott & Cutler, 1984), and competition can provide a useful characterization of data from studies of concept identification (Palermo & Eberhart, 1968). Well-articulated understandings of competition of both stimuli and responses can be found throughout the perceptual literature and the conditioning literature. Early cognitive competition models can be found in Herbart (1891) and Freud (1958). It is clear that the competition model has firm roots in psychological theory. This is its strength. The question is whether it will be possible to provide a full account of sentence processing that is based upon the competition between a set of cues. We have begun to construct this elaboration, but it is clear that there is still a great deal of work to be done.

## REFERENCES

- Anderson, J. (1983). *The architecture of cognition*. Cambridge, MA: Harvard Univ. Press.
- Anderson, N. H., & Cuneo, D. O. (1978). The height + width rule in children's judgments of quantity. *Journal of Experimental Psychology: General*, 107, 335-378.
- Bates, E., & MacWhinney, B. (1982). Functionalist approaches to grammar. In E. Wanner & L. Gleitman (Eds.), *Language acquisition: The state of the art*. New York: Cambridge Univ. Press.
- Bates, E., MacWhinney, B., Caselli, C., Devescovi, A., Natale, E., & Venza, V. (1984). A cross-linguistic study of the development of sentence interpretation strategies. *Child Development*, 55, 341-354.
- Bates, E., McNew, S., MacWhinney, B., Devescovi, A., & Smith, S. (1982). Functional constraints on sentence processing: A cross-linguistic study. *Cognition*, 11, 245-299.
- Brunswik, E. (1956). *Perception and the representative design of psychology experiments*. Berkeley: Univ. of California Press.
- Chomsky, N. (1965). *Aspects of the theory of syntax*. Cambridge, MA: MIT Press.
- Chomsky, N. (1982). *Lectures on government and binding*. New York: Foris.
- Ertel, S. (1977). Where do the subjects of sentences come from? In S. Rosenberg (Ed.), *Sentence production: Developments in research and theory*. Hillsdale, NJ: Erlbaum.
- Frankel, D. G., Amir, M., Frenkel, E., & Arbel, T. (1980). A developmental study of the role of word order in comprehending Hebrew. *Journal of Experimental Child Psychology*, 29, 23-35.
- Frankel, D. G., & Arbel, T. (1981). Developmental changes in assigning agent relations in

- Hebrew: The interaction between word order and structural cues. *Journal of Experimental Child Psychology*, 32, 102-114.
- Frankel, D., & Arbel, T. (1982). Probabilistic assignments of sentence relations on the basis of differentially weighted interpretive cues. *Journal of Psycholinguistic Research*, 11, 447-464.
- Freud, S. (1958). *Psychopathology of everyday life*. New York: New American Library, Mentor.
- Herbart, J. F. (1891). *A text-book in psychology*. New York: Appleton.
- Kiss, K. E. (1981). Structural relations in Hungarian, a "free" word order language. *Linguistic Inquiry*, 12, 185-213.
- MacWhinney, B. (1977). Starting points. *Language*, 53, 152-168.
- MacWhinney, B. (1978). The acquisition of morphophonology. *Monographs of the Society for Research in Child Development*, 43(Whole No. 1).
- MacWhinney, B. (1984). Grammatical devices for sharing points. In R. Schiefelbusch (Ed.), *Communicative competence: Acquisition and intervention*. Baltimore: Univ. Park Press.
- MacWhinney, B. (in press). Hungarian language acquisition as an exemplification of a general model of grammatical development. In D. Slobin (Ed.), *The cross-cultural study of language acquisition*. Hillsdale, NJ: Erlbaum.
- MacWhinney, B., Bates, E., & Kliegl, R. (1984). Cue validity on sentence interpretation in English, German, and Italian. *Journal of Verbal Learning and Verbal Behavior*, 23, 127-150.
- Marcus, M. (1980). *A theory of syntactic recognition for natural language*. Cambridge, MA: MIT Press.
- Massaro, D., & Cohen, M. (1983). Evaluation and integration of visual and auditory information in speech perception. *Journal of Experimental Psychology: Human Perception and Performance*, 9, 753-771.
- McClelland, J., & Rumelhart, D. (1981). An interactive activation model of context effects in letter perception: Pt. 1. An account of the basic findings. *Psychological Review*, 88, 375-402.
- McDonald, J. (1984). *The mapping of semantic and syntactic processing cues by first and second language learners of English, Dutch, and German*. Doctoral dissertation, Carnegie—Mellon University.
- McDonald, J. (1985). The development of sentence comprehension strategies in English and Dutch. *Child Development*.
- Menn, L., & MacWhinney, B. (1984). The repeated morph constraint: Toward an explanation. *Language*, 60, 519-541.
- Palermo, D., & Eberhart, L. (1968). On the learning of morphological rules: An experimental analogy. *Journal of Verbal Learning and Verbal Behavior*, 7, 337-344.
- Peters, A. (1983). *The units of language acquisition*. New York: Cambridge Univ. Press.
- Pinker, S. (1982). A theory of the acquisition of lexical-interpretive grammars. In J. Bresnan (Ed.), *The mental representation of grammatical relations*. Cambridge, MA: MIT Press.
- Pleh, Cs., & MacWhinney, B. (1984). Formai es szemantikai tényezok egyszeru magyar mondatok megerteseben es a megertes fejlodeseben. *Pszichologia*, (Whole No. 84).
- Pleh, Cs., & Vargha, A. (1982). Nehany nyelvfjlodesi mutato, melyeket nem befolyasol a szocialis helyzet. *Magyar Pszichologiai Szemle*, 34, 355-372.
- Rosch, E., & Mervis, C. B. (1975). Family resemblances: Studies in the internal structure of categories. *Cognitive Psychology*, 1, 573-605.
- Saussure, F. de (1966). *Course in general linguistics*. New York: McGraw-Hill.
- Scott, D., & Cutler, A. (1984). Segmental phonology and the perception of syntactic structure. *Journal of Verbal Learning and Verbal Behavior*, 23, 450-466

- Siegler, R. (1981). Developmental sequences within and between concepts. *Monographs of the Society for Research in Child Development*, 46(Whole No. 2). Siegler, R. S., & Shrager, J. (1984). A model of strategy choice. In C. Sophian (Ed.), *Origins of cognitive skills*. Hillsdale, NJ: Erlbaum. Silverstein, M. (1976). Hierarchy of features and ergativity. In R. Dixon (Ed.), *Grammatical categories in Australian languages*. Canberra: Australian Institute of Aboriginal Studies. Slobin, D., & Bever, T. (1982). Children use canonical sentence schemas: A crosslinguistic study of word order and inflections. *Cognition*, 12, 229-265. Smith, S., & Mimica, I. (1984). Agrammatism in a case-inflected language: Comprehension of agent-object relations. *Brain and Language*, 13, 274-290. Sophian, C. (1984). Developing search skills in infancy and early childhood. In C. Sophian (Ed.), *Origins of cognitive skills*. Hillsdale, NJ: Erlbaum. Stemberger, J., & MacWhinney, B. (unpublished). Frequency and the lexical storage of regularly inflected forms. Thibadeau, R., Just, M., & Carpenter, P. (1982). A model of the time course and content of reading. *Cognitive Science*, 6, 157-203. Warren, R. M., & Warren, R. P. (1970). Auditory illusions and confusions. *Scientific American*, 223, 30-36. Wexler, K., & Culicover, P. (1980). *Formal principles of language acquisition*. Cambridge, MA: MIT Press. (Accepted October 20, 1984)