

Competition and Teachability

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Paper presented at the conference on Teachability of Language honoring Dr. Richard Schiefelbusch, Kansas City, October 1986. To appear in "The Teachability of Language" R. Schiefelbusch and M. Rice (Eds.)

Introduction

We know that language is learnable because every day hundreds of thousands of children are born and nearly all of them become proficient speakers of at least one and sometimes several human languages. It may be that this learning is facilitated by innate learning mechanisms and by the child's general cognitive capacity. But, this capacity would mean nothing if the child did not receive rich input from his native language. Given this, we may ask whether language is also teachable. Can a teacher or parent facilitate language learning by presenting language to the child in some particular way, or is it enough for the child to simply hear the speech of those around him? If language learning can be facilitated by controlling the child's diet of linguistic forms, then we can say that language is "teachable."

Language is indeed teachable, as long as the teacher understands the principle of competition and the need to reinforce correct structures. Because forms grow in strength with each correct presentation, the teacher must maintain a shared referential focus with the learner and present forms that express shared meanings. The main thesis of this chapter is that teaching must focus on the clear presentation of positive instances. However, we cannot understand the role of positive emphasis until we understand the principle of competition. And we cannot understand competition until we examine certain basic issues in the structure of language. But this is the way it should be. Instructional methodology should be grounded on developmental theory and developmental theory should be grounded on fundamental principles in cognitive psychology and linguistics.

Theories of acquisition can succeed only if they are illuminated by rich understandings of the nature of human language. Sensing this, child language researchers often select a particular linguistic theory "off the shelf" and apply it to the study of language learning. There are many well-articulated formalist theories of syntax, phonology, and even partially-articulated theories of semantics. The problem is that these theories have been designed to account not for psycholinguistic data, but for particular aspects of adult competence. The mapping between competence and performance may be extremely oblique and this obliqueness is more than a technical difficulty. It means that attempts to ground process models on competence grammars have often been misleading and counter-productive. While formalist approaches to language structure have the advantage of being carefully stated and fully generative, this advantage is outweighed by two serious disadvantages. First, current formalist theory substitutes description for explanation, leading us to turn away from investigations of why speakers select particular devices to express particular intentions. Second, current formalist theory tends to force the language acquisition researcher into a series of nativist assumptions that are seldom supported by the empirical data.

The major alternative to formalist theory is functionalist theory (Dik, 1978; Foley & Van Valin, 1984; Givon, 1979). A strength of functionalism is its emphasis upon the predictability and reasonableness of grammatical markings and patterns. Unlike formalist theory, functionalist theory attempts to provide an explanation of why language is the way it is. However, a major weakness of many functionalist theories is that they do not lead to concrete predictions about language processing. Functionalists have begun to correct this deficiency. The Role and Reference Grammar of Foley and Van Valin (1984), the Cognitive Grammar of Langacker (1986), Talmy (1978), and the Construction Grammar of Fillmore (1986) are good examples of how functionalist theory can provide the underpinnings for a model of language processing. These models agree with the approach in this chapter. Fillmore's model is particularly useful, because it specifies exactly how the processor should interact with linguistic structures. In the tradition of the work in dependency grammars (Tesnière, 1959; Sowa, 1984; Hudson, 1984; and many others),

Fillmore views language as a system of coarticulated “constructions.” Constructions are not abstract categories or units, but are structures based on particular lexical items (MacWhinney, 1982) and that specify how these items enter into meaningful associations with other items. This focus on the coarticulations of lexical items is what makes Construction Grammar interesting for psycholinguistics. Lexical items are readily available to the child and it is easy to trace the child’s learning of lexically-based constructions. Construction Grammar seems to be the grammatical approach most suited to language acquisition research.

The present work seeks to extend such accounts by developing a basic system for models of language comprehension, production, and acquisition. The system should characterize how language operates in the speaker and the listener, while also offering an explanation of why language works as it does, stated in terms of social, psychological, and neurological variables that shape human language. In other words, what we are trying to develop is an empirically-grounded process model. Until such a model is fully formulated, it makes little sense to engage in disputes between nativism and empiricism or between formalism and functionalism. After a process model has been formulated, some of the issues currently being debated will be supplanted by newer more detailed issues.

The Competition Model

The model here is called the Competition Model. Earlier formulations of the model can be found in MacWhinney (1978, 1982, 1986, 1987) and Bates and MacWhinney (1979, 1982). Empirical work supporting the model has been reported in some 15 journal articles summarized in Bates and MacWhinney (1987) and in MacWhinney and Bates (in press). The research emphasizes cross-linguistic and cross-group comparisons. Languages studied include Chinese, Dutch, English, French, German, Hebrew, Hungarian, Italian, Japanese, Serbo-Croatian, Spanish, and Turkish. Subject groups include children of varying ages, normal adults, aphasics, second language learners, and bilinguals. The underlying linguistic representation is strongly lexicalist. The processor works in a bottom-up and cue-driven fashion to construct a dependency graph, rather than a standard parse tree. The lexical item is the main controller of every aspect of parsing, generation, and acquisition.

The underlying idea in the Competition Model is that mental processing is competitive in the classical Darwinian sense. In the biological world, each species adapts to a particular niche or habitat. In that niche, each individual competes with other members of its species, while cooperating in the competition against other species. The habitat of each species is tightly controlled by the abilities and proclivities of competing species, of predators, and of species that serve as food sources.

The mental world also demonstrates this tight, interlocking dependency. In perception, many ideas are called, but few are chosen. The final perception of a situation is determined by those constructs which, together, most successfully matched the stimulus. No single idea can win out in mental processing unless it cooperates properly with other ideas. Cooperation allows a percept or an action to gain strength from the other actions with which it interlocks. The better the fit with other ideas, the more an idea can win out over its competitors. In this way, competition is eternally linked to cooperation. In language processing, the unit of competition is not the species or the individual, but the lexical item. The domain of each word is shaped by the meanings and sounds to which it responds and by the response range of the lexical items with which it competes. When we process sentences, each lexical item sets up expectations for other lexical items. When processing is

successful, these expectations interlock tightly. However, as in natural systems, there is always some variation in the system which can occasionally lead to error.

Few psychologists have trouble accepting the notion of competition. Indeed, many consider it an obvious, possibly mundane, fact about mental processing. Competition is a central fact in current connectionist models of cognition such as the Parallel Distributed Processing (PDP) account of Rumelhart and McClelland (1987). The basic assumptions of the Competition Model match closely with those of PDP connectionism. In some areas of the model, such as morphophonology, we (Taraban, McDonald & MacWhinney, in press) have implemented the full PDP approach. However, we have not yet developed a complete PDP translation of the Competition Model processor, although we have done some preliminary work on that implementation.

Connectionism is not the only brand of psychology that recognizes the importance of competition. Freud's psychodynamics and Herbart's apperceptive mass both emphasize the competition between ideas for emergence into consciousness. Response competition is an important construct in most accounts of attention and motor control. Competitive systems are also common in production system models within cognitive psychology and Artificial intelligence (Newell & Simon, 1972; Anderson, 1983). These systems are fundamentally parallel in conception and use various conflict resolution heuristics to control competition between productions.

Just as competition is a commonplace to psychologists, so it is a foreign doctrine for linguists. In the grammars of the Chomsky hierarchy (Hopcroft & Ullman, 1969), productions or rules do not receive support from other rules, nor do productions compete. If the left hand side of a rule matches, it fires. If it does not match, it does not fire. In standard linguistic theory, a situation with two productions firing in competition would be unacceptable. This overt exclusion of competitive systems has led to narrowness in formal theory where nearly all of the research on learnability, computability, and convergence has focused on non-competitive non-probabilistic grammars within the Chomsky hierarchy. The present work seeks to correct some of this bias.

How Lexical Competition Controls Processing

Perhaps it would be best to begin with a word of caution and advice. Only the last two sections of this chapter deal explicitly with issues of focal interest to the student of child development. The bulk of the chapter is addressed to a more basic question: "What is the shape of language processing?" One cannot reasonably answer the question "How is language learned?" without first considering the question "What is language?" Language structure and processing are completely intertwined: There is no distinction between competence and performance. This understanding of language processing allows us to take a fresh look at the issues of language learning and language learnability. This fresh look derives entirely from the new view of language as competition.

Competition and Segmentation

The first type of competition occurs when we listen to an incoming speech signal. The ear and the auditory pathways perform an analysis of the physical properties of the auditory signal. This analysis yields a series of phonetic properties corresponding to the various segment types of the language. We assume that the child has available an accurate representation in terms of segment types. But this assumption is too strong in two

important ways. First, in real life, the signal is often full of noise. Planes fly overhead; TV's blare in the background; and people have coughs. Signals are seldom as clear as we imagine them to be, as anyone who has attempted to transcribe from an audio recording can attest. Another major problem is that the auditory apparatus may be impaired. Even normal children may suffer from ear infections and various higher-level auditory deficits that often go unnoticed and undiagnosed. Thus, the signal is seldom perfectly perceived.

Despite these difficulties, we show a remarkable ability to comprehend even noisy messages. This is because comprehension is not based on matching the input to the lexicon. Rather, it is based on matching the lexicon to the input. In the computational simulation of the Competition Model, each word in the lexicon attempts to find itself in the input. This is done through a parallel matching procedure. Both auditory processing and articulatory processing use the same underlying structure, so it is important to understand exactly how the lexicon can be accessed in parallel. To achieve parallel addressing, segments are associated to relative positional addresses. The position of segments is coded as occurring within a hierarchy of four slot types as discussed in MacWhinney (1987).

Competition in auditory processing is between alternative possible lexicalizations of stretches of auditory information. The lexicon is the major controller of the segmentation of the speech stream. When enough cues accumulate to support a given item, that item segments off a part of the speech stream as "known." Many approaches to the segmentation problem (Cole, Jakimik, & Cooper, 1980; Cooper & Paccia-Cooper, 1980; Wolff, 1975) in child language focus on the issue of the availability of juncture cues to perceptual segmentation. However, it is a mistake to think that there are enough juncture cues in the input to achieve a full segmentation of speech. Moreover, the lexicon is so powerful a base for segmentation that segmentation need not rely on juncture cues.

Consider the segmentation of the phrase "daddy is coming" or /dadiIzkVmIN/. Let us imagine a child lexicon which includes the lexical item /dadi/ "daddy," but not /IzkVmIN/ "coming." The item 'dadi' will match segments 1 through 4. The remaining material will be tagged as not lexicalized and the child will attempt to learn its meaning to add to his lexicon. Schematically:



Or consider the recognition of /bVni/ "bunny." Here, the child might have the lexical items /bVn/ "bun" and /ni/ "knee" and could conceivably segment /bVni/ into /bVn/ and /ni/. However, because "bunny" derives activation from all the cues that support both "bun" and "knee," it is stronger than any single competitor and can therefore defeat the competition.

The exact fit of the lexicon to the input is often rather sloppy. As we have noted, in real life, the signal is often noisy. When the child cannot find an exact match between the lexicon and the input, he may settle for some close match. The sloppiness of the matching process often displays itself later, when the child uses a form that appears to have been misperceived or misanalyzed. For example, instead of "screen door" the child may say "scream door." Given that mother and father stand at this door and yell out to the child on occasion, this may not be a totally unreasonable segmentation. In this case, context tends to prime the item "scream," inducing the child to hear an /n/ as an /m/. Or, the child may say "on your market, set, go" instead of "on your mark, get set, go." Not knowing the form "mark," it makes more sense to segment the new phrase with the known word "market," even if it leads to ignoring the /g/. Many other "perceptual malapropisms" of this type are reported by Fay and Cutler (1977).

Lexical effects on segment detection have been demonstrated by Ganong (1980), McClelland and Elman (1986), and others. A variety of studies including Warren and Warren (1970) have shown that the detection of lexical items can be influenced by the presence of associated words or ideas in the previous context. MacWhinney, Pleh, and Bates (1985) go yet further and show that, when the auditory signal is unclear, syntactic expectations can influence lexical activation. In all of these cases, it is clear that the segmentation mechanism is tolerant of a certain sloppiness of match between the input and the lexicon. There is a reason for this. In fact, much of the speech we hear is rich with errors. If we were to reject matches between the input and the lexicon whenever any discrepancy was noted, we would often find no match at all. Instead of doing this, what we do is attempt to find the best match to the input which still preserves those aspects of the input which are heard clearly.

Competition and Roles

As segmentation progresses, lexical items become activated. Once several lexical items are activated, the listener begins to get an idea about what the speaker intends. However, without placing the items he has recognized into relation with each other, this idea can be only vague and approximate. To solve this problem, language has developed a system of roles that use cues to place lexical items into relation with one another (Tesniere, 1959). Like the form-function relations expressed in lexical items, roles are also form-function relations. For roles, the forms are the surface word order patterns and morphological markings that cue particular relations; the functions are the underlying meaningful relations without which semantic interpretation could not proceed. If we were just to utter lexical items one after another, we would have only a vague notion of how to fit these words together into ideas. Roles provide us with a way of knowing what goes with what. This is their function. In the work of the transformationalist school (Chomsky, 1981), syntactic relations are taken as purely formal objects. In the Competition Model, as in other work in the functionalist school (Dik, 1978; Foley & Van Valin, 1984; Givon, 1979), roles are viewed as a way of expressing relational functions.

The way in which a lexical item controls roles is through its “valence description” (Tesniere, 1959; Fillmore, 1986). The lexicon is basically a system of connections where each lexical item has a valence description which indicates its connections to roles and cues for those roles. As in chemistry, the valence of a lexical item is the type of item with which it combines to form a larger unit. Valences specify roles and the kinds of items that can fill these roles. A lexical item may have a valence description that specifies several arguments or it may only specify one argument. We can think of each lexical item as a predicate and each argument as attached to this predicate through a role, as in this notation:

predicate — role —> argument

For example, the opening up of a role for a subject of the verb “goes” can be diagrammed as:

goes — S —> argument

Here the “S” stands for “subject” which is the role played by the argument vis a vis the predicate. In this way, the sentence “John goes” can be diagrammed as:

goes — S —> John

Often predicates can take several arguments, but in such cases each argument is bound to the central predicate by its own relation.

Before looking at further examples of valence descriptions in the Competition Model, we first need to examine the varieties of grammatical roles recognized in the model:

1. Subject: This is a central argument of the verb, it is defined functionally as in MacWhinney (1977).
2. Object: This is the second central argument of the transitive verb. It is defined functionally as the entity most involved in the activity or state of the verb (see Pinker, this volume).
3. Indirect: In English some verbs such as “give” have this as a third central (unmarked) argument. It is the secondary perspective or the indirect object.
4. Complement: Various cognitive verbs and modals allow whole clauses to serve as their objects and subjects.
5. Head: The head relation is actually a broad class of relations between descriptors on modifiers and the things they describe. It holds between an adjective and the noun it modifies, between a prepositional phrase and the noun to which it attaches, between a relative clause and its head, and between a noun and another noun that describes it (sometimes in an appositive relation and sometimes with a copula). Adjuncts of the verb or circumstantials also have verbs as their head. Sometimes these arguments are adverbs which simply attach to the verb. Sometimes they are prepositions which attach in two directions. First, they attach to the object of the preposition. Then, the whole prepositional phrase attaches to the verb, as if it were an adverb. A few verbs, such as “put” or “live” take obligatory locative arguments. Usually modifiers are optional and their attachment is left as a job for the preposition.
6. Coordinate: The item or phrase coordinated to another item or phrase is the coordinate. The coordinate conjunction has both a “head” and a “coordinate.”
7. Topic: The item the sentence is “about” is placed into the role of topic vis-a-vis the rest of the sentence.
8. Antecedent: The item to which a “phoric” element points is its antecedent.

The central roles of subject, object, indirect, final, and head are further differentiated for case roles. Thus, the subject may be an agent, a patient, an initiator, a recipient, an executor, an actor, an experiencer, or a complement. The object may be a patient, a stimulus, a product, or a complement. The indirect may be a recipient or a beneficiary. These case roles have little impact on syntax, but they are crucial for semantic interpretation.

Let us look at a few examples of valence descriptions. First consider a very simple lexical item--the adjective “big.” The valence description of “big” specifies only one argument and this argument takes the role of the head. Semantically, the head plays the role of the object being measured. The valence description for “big” is simply:

$$\text{big} \text{ ---H---} \rightarrow (\text{post}, \text{noun})$$

This valence description says that “big” requires an argument with the role of head and that the cues that support the candidacy of an item for this role are that it be a noun that follows the word “big.” The head noun is typically a measurable object. However, we can treat virtually any concept as measurable, so this is not much of a cue.

Prepositions such as “on” are also one-place predicates. The item “on” has this syntactic frame:

- * (pre, verb, movement) <—E— on —H—> (post, noun)
- * (pre, noun)

Here the asterisks indicate competing role assignment types. The exohead that wins in this competition is the one that best matches the cues specified in one of these competing types. This frame specifies that either a verb or a noun may serve as the exohead. Consider the sentence “the man positioned the coat on the rack.” The exohead of “on” could be either “positioned” or “the coat.” In the Competition Model, these two alternative attachments of the prepositional phrase are said to be in competition with each other.

Verbs like “sink” that have both transitive/causative and intransitive readings can be represented by two competing lexical entries. The two forms have these representations:

1. (pre, N, animate, causer) <—S— sink —O—> (post, N, moved)
2. (pre, N, moved) <—S— sink

Competitive processing must resolve the choice between these two forms of “sink.” The presence of nominals to fill both of the roles specified by the transitive “sink” will make that form win out in the competition with the intransitive “sink” for lexical activation.

So far, the reader may be assuming that valence descriptions are idiosyncratic properties of lexical items. Nothing could be farther from the truth. In accord with its basic functionalist approach, the Competition Model seeks to derive valence descriptions from the meanings of words. Currently, we are working to construct a set of inheritance patterns for English. An example of such a pattern would be one that states that all common nouns in English expect to be modified by a delimiting determiner or the plural. For example, a word such as “dog” cannot appear as a common noun by itself. However, it can appear as “the dog,” “another dog,” or simply “dogs.” By virtue of the semantic features that probabilistically define the group of common nouns, the noun “dog” also requires delimiting modifiers.

Many of the connections from verbs to roles are semantically predictable (Pinker, this volume). For example, concrete action transfer verbs such as “give,” “pass,” and “throw” can all take a recipient indirect. However abstract transfer verbs such as “recommend” and “donate” do not follow this same pattern. Verbs like “fill” that focus on the goal as the object generally place the material being transferred into a “with” phrase, as in “Paul filled the tub with water.” On the other hand, substance movement verbs like “pour” that allow the material to serve as the object must then treat the goal in a locative phrase, as in “Paul poured the water into the tub.” In some cases this predictability of roles from semantic cues (or what Pinker, this volume, calls “criteria”) is exceptionless. In other cases, it runs up against specific lexical exceptions and preemptions from existing items. Our eventual goal with this analysis is to go from a set of semantic features to a set of valence descriptions perhaps in the context of a parallel distributed processing network of the type of McClelland and Kawamoto (1986). Such a system will allow for the emergence of generalities on the basis of semantic features, while still tolerating exceptions for high frequency items (Stemberger & MacWhinney, 1986).

Role Competition

The empirical work upon which the model (Bates & MacWhinney, 1987) is based has been performed in many languages. Some of our collaborators in this research include: Edith Bavin, Cristina Caselli Antonella Devescovi, Angela Friederici, Michele Kail, Kerry

Kilborn, Reinhold Kliegl, Janet McDonald, Sandra McNew, Judit Osman-Sagi, Csaba Pleh, Stan Smith, Jeffrey Sokolov, and Beverly Wulfeck.

Languages differ markedly in the strengths they assign to basic grammatical cues. In English, the cue of preverbal positioning is the strongest cue to identification of the subject role. Given a sentence like “The eraser are chasing the boys,” English-speaking subjects show a strong tendency to choose “the eraser” as the subject and, hence, the actor. This occurs despite the fact that the noun “boys” has the cues of verb agreement, animacy, and humanness all on its side. These three weak cues are just not enough to counterbalance the strength of the preverbal position cue in English. In Italian, however, the corresponding sentence is *la gomma cacciano i ragazzi* in which *la gomma* “the eraser” has support from the cue of preverbal positioning and *i ragazzi* “the boys” has support from the cues of agreement, animacy, and humanness. As Bates, MacWhinney, Caselli, Devescovi, Natale, and Venza (1984) show, agreement is a much stronger cue in Italian than it is in English. In Italian, the strongest cue is verb agreement and the second strongest cue is preverbal positioning. Thus Italians interpret this sentence as meaning “The boys are chasing the eraser.”

How Competition Works During Processing

The processor for the Competition Model takes the cue strengths estimated in these empirical studies and uses them to control role assignment. This processor is a combination of a segmenter, a lexicalizer, and a parser, since it performs all three acts at once. As it “moves through” the utterance from beginning to end, it activates candidate lexical items which, in turn, activate role expectations. As soon as a role expectation is activated, the processor checks in the pool of currently lexicalized items and clusters of items to see if the expectation is filled. The cues supporting this filling include word order, grammatical markings, prosodic cues, and lexical class information. If a match is noted, a candidate valence attachment is formed. Sometimes several competing attachments are formed. If the strength of one of the competing attachments becomes overwhelming, the processor “commits” itself to that attachment. Undoing a committed attachment involves backtracking or garden-pathing. However, in many cases, the final decision between competing attachments is not made until the end of the sentence or clause. Nonconfigurational languages like Warlpiri and variable word order languages like Hungarian receive a straightforward treatment in the Competition Model, since assignment of arguments to roles in these languages is primarily based on cues provided by grammatical markings, which are on an equal footing with word order cues.

The parser is driven by the attempt to instantiate the arguments of each predicate. A sentence parses successfully if all expectations are instantiated and no argument is left unattached. In a sentence such as “*John gave Bill the key Frank,” the word “Frank” is extra material that does not attach to any other argument. In a sentence such as “*John put the plate,” there is a missing argument, since it is not clear where John is putting the plate. Following Fillmore (1986), the parser allows arguments to be instantiated in five different ways.

1. *Direct instantiation* : Arguments may be instantiated directly in the clause currently being processed.
2. *Coinstantiation* : Arguments may be coinstantiated as arguments of higher clauses in complement constructions.
3. *Extraposition* : Arguments may be instantiated through extraposition.
4. *Distant instantiation* : Arguments may be instantiated at a distance through “raising.”
5. *Null Anaphora* : Finally, some arguments may be ellipsed under specified conditions for anaphoric identification.

To understand how roles work to build up dependency structure in Competition Model terms, it may be helpful to look at a simple example of a dependency structure. Consider the sentence “Mary likes a young soldier” which has the following structure:

(a <—H—> (young —H—> soldier) <—O—> likes <—S—> Mary

The labels S, O, and H on the nodes represent the subject, object, and the head, respectively. Double headed arrows indicate bi-directional or covalent bonds and single headed arrows indicate uni-directional or ionic bonds. In this structure, “Mary” plays the subject role and the phrase “a young soldier” plays the object role. These two arguments are bound to the verb covalently, since nominals expect to be the arguments of verbs and the verb “likes” is looking for two arguments. “Young” takes “soldier” as its head and the phrase “young soldier” is the head for the operator “a.” The noun “soldier,” like all common nouns, generates an expectation for a determiner such as “the” or “a” and this expectation is taken over by the phrase “young soldier” in accord with the principle of inheritance from head to phrase. When “a” attaches to “young soldier,” a covalent bond is formed from the expectation of “a” for a nominal and the expectation of the nominal phrase for a determiner.

Now let us look at how this structure is pieced together during processing. First the processor lexicalizes “Mary.” Since “Mary” is a proper noun, it does not expect any modifiers, but it does expect to fill some role vis-a-vis a verb. At this point, “Mary” with its unfulfilled expectation is the only item in the “fragment pool” of activated items that are not yet bound to verbs. Next, segmentation moves on to lexicalize “likes.” This verb expects a subject in pre position and an object in post position. Whenever a new item is lexicalized, all of the currently unattached items in the fragment pool become possible candidates for the roles expected by that item. Since “Mary” is a noun in pre position, and since it expects to be the argument of a verb, a covalent subject role bond is formed between “Mary” and “likes.” There is no competition for this role, so the binding is fairly strong. There is then only one active fragment in the fragment pool. Next, segmentation lexicalizes the determiner “a” and the adjective “young.” Both of these modifiers expect a following noun. Until “soldier” is lexicalized, these two items remain unbound in the “fragment pool.” After lexicalizing “soldier,” however, all the current unfulfilled expectations can be fulfilled. First “young” binds to “soldier,” because it is in pre position. This cluster then functions as a complex noun which then binds to “a.” Finally, the nominal cluster “a young soldier” fills the post verbal slot for an object. At this point, all the roles are filled and all items are attached. The trace for this processing is as follows:

Item	Roles	Cues	Links
Mary	Arg'	—	—
likes	Subject	Pre,N,Anim,Sg	Mary <—S—> likes
	Object	Post,N.	
a	Head	Post,N,Sg	
young	Head	Post,N	
soldier	Arg',H'		young —H—> soldier
			a <—H—> (young soldier)
Final:			Mary <—S—> likes <—O—> (a <—H—> (young —H—> soldier))

The symbols Arg' and H' in this trace indicate that an item expects to be the argument of a verb or the head of some determiner.

As a further example of how parsing works in the Competition Model, let us consider the processing of a sentence with a center-embedded relative clause such as “the dog the cat chased ate the bone.” First, the unattached units “the dog” and “the cat” are built. The next item is “chased” which opens up argument roles for a subject and an object. The only real candidate for the subject role is “cat” which is in preverbal position and gets bound to this role. Then the processor encounters “ate” which opens up subject and object roles. There is no simple item in preverbal position, so the “clustering” procedure works to take all the material in preverbal position as a unit. To do this, “the dog” is taken as the head of a relative clause (RH) which places it in the role of the “described” and which inserts it as the object of “chase.” Finally, the item “bone” receives support from the postverbal positioning cue and wins out with no competition for the role of object of the verb “ate.” The trace for “the dog the cat chased ate the bone” is as follows:

Item	Roles	Cues	Links
the	Head	post,N	—
dog	Arg',H'	—	the <—H—> dog
the	Head	post,N	—
cat	Arg',H'	—	the <—H—> cat
chased	Subject	pre,N,Sg,Anim	(the <—> cat) <—S—> chased
	Object	post,N	
ate	Subject	pre,N,Sg,Anim	relative clustering
	Object	Post,N	
Clustering: (the <—> dog) <—D— (the cat <—S—> chased <—O—> = RH)) <—S—> ate			
the	Head	post,H	
bone	Arg',H'	Arg',H'	the <—H—> bone
Final: ((the <—> dog) <—D— ((the <—> cat) <—> chased <—> = RH)) <—> ate <—> (the <—> bone)			

Adults tend to impose a hierarchical structure on phrases more than do children. The literature on adjective ordering (Martin & Molfese, 1971, 1972; Richards, 1979; Scheffelin, 1971; Schwenk & Danks, 1974) shows that children do not have clear ideas of the logical relations encoded by variations in adjective ordering. Hill (1983) argues that children initially compose relations such as “a big car” from flat structures rather than hierarchical structures. In other words, children may code “a big cat” as the flat structure:

a —H—> cat <—H— big

rather than as the hierarchical structure:

a —H—> (big —H—> cat)

Although adults may also make occasional use of flat structures, it is clear that children must eventually learn to hierarchicalize clusters.

Prepositional Phrase Attachment

A particularly well-studied type of role competition is for the role of the head of the prepositional phrase. Consider, “The women discussed the dogs on the beach.” We can interpret this sentence as saying that the dogs are on the beach or as saying that the women engaged in the discussion are on the beach. In the former case, the head of the prepositional phrase is the nominal. In the latter case, it is the verb.

The psycholinguistic literature investigating such sentences is fairly large. Frazier and Fodor (1978) have used subjects' supposed preference for attachment of prepositional phrases to the verb as support for the Sausage Machine model of sentence processing. Oden (1978) has pointed out that a resolution of the competition between alternative parses requires the full real-world context described by the sentence. Ford, Bresnan, and Kaplan (1982) have shown how an LFG parser can handle attachment by following principles of local attachment and thematic control. The Competition Model approach to attachment is most similar to the approach of Ford, Bresnan, and Kaplan. It differs from that approach primarily in the importance it assigns to the preposition as an independent source of activation and in the emphasis it places on competition.

In the Competition Model, prepositions first attach to their heads yielding prepositional phrases. These prepositional phrases can then function in one of two ways. They can function as adverbs and attach to a verb or they can function as modifiers and attach to a noun. In a sentence such as "the women discussed the dogs on the beach" both possibilities exist. These two readings of the preposition are in competition. The final interpretation of the sentence depends on which reading wins out in the end.

Valence Shifts

This chameleon-like behavior of the preposition is an example of a widespread phenomenon in language. Many words shift their meanings depending on the nature of the forms to which they attach. We will call these changes "valence shifts." Such shifts are usually between an unmarked or default state and a marked state. For prepositions, the unmarked form is the nominal modifier. Shifts to the adverbial reading occur in the presence of certain features on the verb. For example, the verb "put" has a very strong expectation for a locative goal adverbial; the verb "position" has a somewhat weaker expectation; and the verb "break" has a weaker expectation. Thus, in the following three sentences, activation of the adverbial reading of the preposition "on" is increasingly less likely:

1. The woman put the vase on the table.
2. The woman positioned the vase on the table.
3. The woman broke the vase on the table.

However, as in Bock (1986a, 1986b), the adverbial reading of "on" can be primed by being used in a previous utterance, as in "The man picked up the pitcher and broke it on the table. Then the woman broke the vase on the table."

Relative pronouns such as "who" or "which" can also show a competition between differing attachments. Relativizers first play a role in their own clause, serving as an argument of the verb. Then the whole relative clause can attach either to a noun, a verb or an adjective. The head may be a nominal as in "Bill bumped the lamp which then fell onto the floor." The head may be an adjective as in "Tim was depressed, which is not a good thing to be." Or, the head may be a whole clause, as in "Mary criticized John, which surprised me."

Immediacy of Processing

This system is designed to handle grammatical information as it enters the auditory buffer. In this sense, the system implements the principle of "immediacy of processing" espoused by Thibadeau, Just, and Carpenter (1982) and Marslen-Wilson and Tyler (1981). For example, each noun in a clause is a possible candidate for assignment to the role of subject. Cues serve to strengthen or weaken the candidacy of each noun for this role. For example,

when parsing a sentence such as “the dogs are chasing the cat,” the assignment of “dogs” as the subject 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 post-verbally, its candidacy as the object further supports the candidacy of “dogs” as the subject. Thus, at each point in the processing of the sentence, the strength of the candidacy of “dogs” is updated. The system tends to increase its “commitment” to a given attachment as cues supporting that attachment accumulate. Because the language designs the cues to permit ongoing updating, the need for backtracking is minimized. However, garden-pathing can occur when a competition between fragments is decided in the “wrong” way early on and the correct initial fragment can no longer be retrieved.

Competition and Phrase Structure

How does the Competition Model account of grammatical structure relate to traditional phrase structure analysis? In the work of child language researchers such as Brown (1973), Bloom (1970), and Pinker (1984), phrase structure plays a role as the central organizer of all of syntactic development. Accounts that focus more on the patterns governing relations between individual items have been offered by Braine (1976), MacWhinney (1975b), and Schlesinger (1977). The most powerful argument supporting the analyses of those who believe in the early presence of full phrase-structure competence is that, since adult performance is controlled by phrase-structure rules, children must eventually acquire these rules in full form and that it is better to have the child start this task early. To start the child on the path of language learning with lexically-based formulas, according to this view, is to start him off with an incorrect hypothesis from which he must eventually retreat. The Competition Model approach we are offering here undercuts this argument. In the Competition Model, the connections between lexical items and roles learned by the child are the same connections used by the adult. Because children are learning the same things they will need as adults, they are not exploring a dead end along the route to learning the language. Rather, they are moving incrementally and monotonically toward the adult state. Given this, one cannot argue that the learning of the role-relational structure of particular lexical items is a grammatical cocoon that must later be sloughed off by the language learner.

Models that require that the child acquire phrase structure at the beginning of language learning must deal with a number of tough problems. In such accounts the acquisition of languages with VSO word order is problematic, since this order breaks up the “verb phrase.” In the Competition Model this is not a problem because the model does not group the object and verb into a separate phrase. All that is necessary for processing of VSO order is either morphological or positional cues that clearly mark the object. The fact that children have no trouble learning VSO languages like Welsh supports the Competition Model analysis and calls the standard phrase-structure analysis into question. The acquisition of non-configurational languages such as Warlpiri (Bavin & Shopen, 1987) and Hungarian (MacWhinney, 1986) would also appear to be a problem for phrase-structure analyses. Such languages differ from configurational languages only in that the morphological cues are so well developed that they need not be supplemented by positional cues. The cue-based processor of the Competition Model is ideally suited for dealing with non-configurational cue processing because it allows affixes on stems to directly cue the roles of those stems.

Pinker (1984) presents further problems that phrase-structure analyses must address. For each of these issues, Pinker proposes a series of strategies that can acquire the necessary competence. However, in few cases is there independent evidence for these strategies. Rather, we need to believe in Pinker’s principles largely because, if we do not believe in them, it is not clear how phrase structure could be learned. In the Competition Model, on

the other hand, phrase structures are epiphenomena, with the core of the grammar being composed of the arguments entered on particular predicates. It is true that the Competition Model includes a process of clustering groups words into units that function like phrases, but nearly all of the apparatus of a full phrase-structure grammar including the X-bar principles of Jackendoff (1977) is avoided in this account. By relating arguments to predicates, the listener builds up not a tree, but a dependency graph. Moreover, this graph is constructed from lexical items outward. There is no top-down parsing of the type proposed by Marcus (1980) or Wanner and Maratsos (1978), and there is no need for a separate encoding of phrase-structure rules. Instead, the items are attached correctly on the basis of information coded on lexical items.

Competition and Polysemy

So far, we have discussed how alternative segmentations compete during lexicalization and how role slots activate competing attachments. The third type of competition during comprehension is between different polysemic readings of a given lexical item. This is the problem of lexical ambiguity. The activation of a lexical item leads to the activation of each of its polysemes. These polysemes are then placed into competition. The polyseme supported by the strongest cues wins. Polysemy within the same part of speech cannot be resolved by syntactic cues alone. The word “needle” can refer to a pine needle, a sewing needle or a phonograph needle. Consider a sequence such as “The gardener had finished raking up the pine cones, when he found some needles stuck in a pin cushion.” At first, “needles” appear to be pine needles, but the words “stuck” and “pin cushion” quickly block that reading and leave us with the reading of “sewing needle.” In Lashley’s famous garden-path sentence “Rapid righting with his uninjured left hand saved from destruction the contents of the capsized canoe” readers often mistake “righting” for “writing” because of the association between “writing” and “hand.” The effect is very strong when the sentence is read aloud, thereby removing the orthographic cues. In general, nonsyntactic polysemy is resolved in favor of the polyseme with the most associations through spreading activation to other items in the sentence.

To resolve polysemy, the processor must look at two cues. If we hear that “the needle pricked her finger” we assume that the needle in question is a sewing needle and not the needle of a pine tree. The semantic features of sharpness and penetration contained in “prick” are cues to the activation of the proper polyseme of “needle.” These connections are the same ones that would be postulated in many theories of semantic memory (Anderson, 1983). By activating words related to a target polysemic item, we spread activation to that item and help it win out over its competitors (Cottrell, 1985).

Polysemy between parts of speech is resolved by more deterministic cues. For example, the sound /tU/ is ambiguous between the locative preposition “to,” the infinitive “to,” the numeral “two,” and the modifier “too.” In a sentence such as “I went to the store,” all four polysemes are viable candidates up to the beginning of the article. When the article is lexicalized, only locative polyseme remains viable. The infinitival reading would have required a following verb. The other two readings would have required either a following adjective or a following noun.

By allowing each polyseme to be activated and by then allowing cues to determine the competition between rivals, problems in parsing can be handled directly. Consider a sentence such as “I know that cats are playful.” Up to the plural marker on “cat,” there is a competition for the word “that” between a reading as a complementizer and a reading as a deictic determiner. The cue for the determiner reading is the presence of a following singular noun. The cues for the complementizer reading are the presence of a verb that

takes a complement and the presence of a well-formed complement clause following. Here, the determiner reading loses because the following noun is plural. A similar competition occurs with a pair of sentences such as:

1. What soldiers did it?
2. What soldiers did is what he films.

Another important type of polysemic competition is between adjectives and their corresponding zero-derivation nominals. Consider a sentence such as “The old can get in for half price.” Here, the adjectival reading of “old” requires that the following word be interpreted as a noun. The word “can” is itself ambiguous between a nominal and a verbal reading. However, the nominal reading is blocked by the fact that the verb “get” requires a plural subject. As Milne (1986) shows, agreement cues are often important in resolving such competitions. This leaves the much weaker nominal polyseme of “old” as the remaining competitor. As the nominal reading gains activation, it allows the verbal reading of “can” to gain activation, and finally the correct reading of the sentence surfaces. In the sentence such as “have the students take the exam” the main verb and auxiliary verb readings of “have” compete up to the end of the verb “take.” At that point, the auxiliary reading would require a participle, as in “Have the students taken the exam?”

A similar chain of events occurs when interpreting “The communist farmers hated died.” When “farmers” appears after “communist,” the adjectival polyseme dominates strongly. However, when this reading fails to provide a subject for the verb “died,” relative clustering is attempted. In order to have clustering work, “farmers died” needs a head and the nominal reading of “communist” provides this. However, the adjectival reading has dominated so strongly by this point that it is difficult to recover the nominal reading. In a sentence such as “the trash can hit the table” both the adjectival and nominal readings of “trash” continue in competition. Then the nominal and auxiliary verb readings of “can” also compete. Since the adjectival reading of “trash” goes with the nominal reading of “can” and the nominal reading of “trash” goes with the auxiliary reading of “can,” both interpretations continue competing and the sentence remains ambiguous. Similarly, in the sentence “I took her waffles” both the possessive and the indirect readings of “her” yield possible interpretations and the sentence is ambiguous.

Even grammatical markers can be polysemous. Consider the suffix -s which marks not only the plural of the noun, but also the singular and plural possessive of the noun, and the third person singular present on the verb. The part of speech of the stem is not enough to decide this competition, since many English nouns can also be verbs. However, the items preceding the stem generally tip the scale in the right direction. If the stem is a proper noun, the suffix is probably a possessive. If the stem is a common noun, it will be preceded by a determiner. Since determiners cannot precede verbs, this is a very strong cue against the verbal polyseme. The possessive is itself polysemous. Consider the phrase “Reagan’s defeat” which could be either, say, a defeat of the hecklers by Reagan or a defeat of Reagan by the hecklers.

Probably the most extensive competitive processing of polysemy is that needed to resolve anaphora. Following MacWhinney (1985) we can divide anaphora into five major types: exophora, clause external anaphora, clause internal anaphora, cataphora, and metaphora. Cues such as parallel function, gender, number, implicit causality, and action readiness all operate to favor one type of phoric reading over the other. Within each phoric type, there may be any number of possible candidate referents. However, the number of strong candidates is usually confined to the elements currently in the discourse foreground. For example, consider these sentences:

1. When it was copied, my file disappeared.
2. It disappeared, when my file was copied.

In the first sentence, the presence of the subordinating conjunction licenses a possible cataphoric reading for “it.” This is not the only possible reading, however, since an exophoric reading would also be reasonable. In the second sentence, the referent must be either exophoric or clause external anaphoric because it must be fully referential at the time of mention. The Competition Model allows each polysemic reading of each word it encounters to continue as long as its competitors have not yet received overwhelming support and the weak reading quickly loses out.

Competition and Lexical Packaging

In production, ideas and intentions are converted into lexical items. The conversion of ideas into items involves a competition between items. This competition is based not upon perceptual cues, but upon the cues that represent the properties of ideas. These cues are motives--things the speaker wants to express. There are many possible ways a given set of ideas could be packaged into a set of lexical items. The speaker generally tries to select a packaging that 1) makes it clear to the listener what the referents are, and 2) conveys interesting new information about these referents. There is an important trade-off between new information and conveying old information and every sentence strikes its own balance in this regard. In addition, each sentence must use a central verb that places the various referents into the correct roles.

Perhaps the most basic commitment a speaker makes when producing a sentence is the choice of a speech act type. The choice between declarative, imperative, and interrogative forms is fundamental and influences much of the further selection of material in the sentence. This choice involves a competition between alternative speech acts. Usually, the illocutionary force of a speech act matches its perlocutionary force. However, sometimes this natural coalition breaks down and sentences exhibit certain indirect speech act properties. The relation of speech acts to sentence form has been widely discussed in the literature.

The choice of a speech act type, a sentence topic, and a main verb are all commitments that have their impact on the overall packaging of the sentence. In this sense, we can think of these various decisions as centers of lexical commitment. Once the speech act type is selected, the next center of commitment in the clause is the topic. The topic is frequently a noun that has already been lexicalized in previous discourse. The selection of a topic is an important matter, since there are often several topics that have been kept active in previous discourse, and one speaker’s set of topics may not match the other speaker’s set of topics. In addition, either speaker may wish to introduce new topics at any given point in the discourse. All of these possible topic candidates are in competition at any given point in the discourse. The candidacy of a particular topic is promoted by its recent mention by both speakers and by its centrality in the conversation. However, these givenness cues are not enough to determine the competition. The most important cue in favor of a given topic is whether or not it is a part of some message the speaker crucially wants to discuss. The competition between continuing old shared topics and introducing new not-shared topics is a tough one. Sometimes we find that we can never bring a conversation around to the topic we wanted to discuss because of the other speaker’s insistence on pursuing a different agenda.

In English, making a commitment to a topic noun then further commits the speaker to selecting a verb that places the topic in the subject or perspective role (MacWhinney, 1977).

If the verb is intransitive, no further major commitments are entailed. However, if the verb is transitive, an object must be selected and sometimes a third obligatory argument must also be selected. Often there is a competition between alternative verbs or sets of verbs. For example, verbs like “buy” and “sell” are in direct competition. Other competitions are between two-clause and one-clause packagings by verbs. For example, the verb “knocked over” often competes with a verb such as “went over to and bumped into and thereby pushed over.” The earlier verb conflates a series of verbs that each might require its own clause. The sentence planning mechanism need not have all of the nominal arguments fully selected when lexicalizing the verb. However, it commits itself to lexicalizing them eventually. A particularly extensive sort of commitment is incurred by verbs that take complement clauses, since complementation can be recursive.

The other major commitments made in sentence packaging are more optional. The inclusion of further specifications of the nouns can involve relative clauses and appositive phrases which involve further recursion. There can also be temporal, locative, benefactive, and other circumstantial descriptions of the activity of the clause. Sometimes these circumstantials involve the lexicalization of prepositions. Prepositions work as independent centers by promoting lexicalization of the object of the preposition and by searching for attachment to a verb or a noun head.

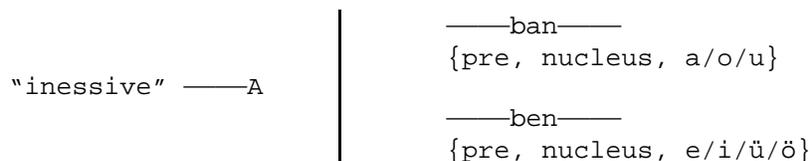
In order for lexicalization to terminate, several conditions must be fulfilled:

1. The verb must be lexicalized and each of its arguments must be filled.
2. There should be no activated prepositions that are not attached to verbs.
3. There should be no active attempts to further characterize any noun.

Of course, it is possible to begin articulation of the subject of the verb even while working on the specification of further arguments.

Competition and Allomorphy

In some cases, the activation of a particular lexical item involves allomorphic competition. For example, activation of the plural suffix in English actually activates three competing allomorphic alternatives: -s, -z and -Iz. This competition is resolved by cues activated by the stem. In English, the presence of a final sibilant is a cue that boosts the strength of the -Iz suffix. The presence of a non-sibilant with final voicing boosts the strength of the -s suffix. Or, to take another example, consider vowel harmony in Hungarian. For a suffix like the inessive, the allomorph -ban competes with the allomorph -ben, relying on the shape of the final vowel of the stem.



In these examples from English and Hungarian, the competition is based entirely on phonological cues. In more abstract systems, additional stem cues are used. These additional cues include semantic properties of the stem and operators with which the stem is associated. Systems like gender in Indo-European are of this type. These systems are pieced together bit-by-bit on the basis of concrete cues (MacWhinney, 1978). For example, in learning Spanish, the child first uses stem final -o as a cue to use the masculine

Competition Model analysis of language is the way it can clarify our understanding of language acquisition.

What are the basic structures the child must learn? First, he must extract from experience a set of concepts to serve as the meanings expressed in words. Second, he must acquire a set of lexical items that map sounds onto concepts. Third, he must learn how to fill the role relations required by these lexical items. Fourth, he must acquire cues to resolve allomorphy. Fifth, the child must acquire cues to resolve polysemy. Let us look at how the Competition Model accounts for each of these five types of learning.

Concepts

Before the child acquires language, he develops a set of things he wants to talk about. These are the functions that underly the forms of language. Lexical acquisition is initially driven by the child's interest in expressing some meaning. As Brown (1973) and MacWhinney (1975a and b, 1978, 1986) have argued, the child usually develops an interest in the concept expressed by a word before actually acquiring that word. Bates and MacWhinney (1987) refer to such pre-linguistic learning of the semantics of lexical items as functional readiness.

There are many ways the child can develop functional readiness for an item. The one-year-old child may have developed a concept of "dog" from repeated encounters with dogs. The child may find that being able to categorize a new animal as a dog is useful in that it helps predict actions that animals may take, such as barking, jumping, licking, and sniffing. Some months later, the same child may have learned enough language to be able to use terms such as "want" and "gimme." He sees a small stuffed dog among a collection of other stuffed animals, including a stuffed alligator and a stuffed seal. The child says "gimme." The parent is not sure which animal he wants and says "doggie?" while handing him the stuffed dog. The child is elated. At the same time, he learns to associate the sound "doggie" with the concept of "dog" that he has used for some months.

If the child is very cautious, he will only attempt to acquire a new form when he is sure that the adult is focusing on a function for which he does not yet have a name. In the case of the "doggie" example, the child recognized that the stuffed dog was present and that the parent was looking at the dog. If something goes wrong and the child associates /dAg/ to "alligator," all is not lost, since the child can later learn the form /aligeItor/ which will drive out the erroneous form.

Lexical Items

Concepts need not be fully formed before the child begins to learn words to express them. Rather, the acquisition of lexical items itself can be a prod to conceptual development. If, instead of handing the child a dog, the parent had given the child a stuffed alligator and named it, the child could still have attempted acquisition of a new form. In this case, however, the function was not ready before the form was encountered. Rather, having heard a new form, the child searches about for a function it might express (MacWhinney, 1978). In both cases, the child makes a first "stab" at a meaning on the basis of his best guess about what the new form might mean. During early lexical learning, there are three major processes that work to build up an initial association between a group of semantic features and a phonological and role assignment pattern.

Segmentation The child detects an unknown phonological string. Sometimes this string is presented by itself. Sometimes it is segmented from other material. The importance of the extraction of an unknown string is discussed in MacWhinney (1978).

Episodic Encoding The child makes a fast mapping of some current referent to the new phonological string. This is the process of jumping-in with an episodic encoding. If this initial mapping is incorrect, it will be weeded out by the competition. If the child thinks the sound “alligator” means “dog,” competition will simply weed out this bad guess. It is not important that this initial fast mapping be completely accurate. Rather, what the child needs to do is to establish a beachhead to link a form to a function. Eventually, competition will fix errors in the initial mapping. What the child does during “jumping in” is simply to establish a first episodic encoding. This encoding is a pairing of a particular sound sequence with a particular event or state in the real world. Each time the child hears that same word, he can store a new episodic encoding. We need not assume that each episode is always encoded without fail. Rather, we only need to believe that enough episodes are encoded to provide a rich empirical database for further learning. Children and other new learners may pay more attention to individual episodes than advanced learners. These stored episodes then form the basis for cue extraction.

Cue extraction After having learned the first association of the sound /dOg/ to a referent, the cues for the usage of the word are precisely the set of features of the first exemplar. At this early point, all cues are equally valid. As the database of episodic associations of a sound to referents grows, some cues begin to stand out. If a feature appears in each new exemplar, then it is high in overall cue validity and its cue strength is also kept high. If a feature only occurs in a few exemplars, its cue strength will begin to fall and eventually it will no longer influence processing. The features present in experienced exemplars comprise the “confirmed core” of valid cues which serves as the child’s surest guide to the usage of the lexical item.

Some words have more than one basic meaning. For these words, cue extraction preserves cues that are useful in picking out any one of the meanings. Only cues that never pick out a meaning at all are dropped. In comprehension, the word “bat” cues two major nominal meanings-- a flying mammal and a stick for playing games. For each of these two meanings, the form /bAt/ is a valid cue. Once the basic phonological cues do their job, there is still a competition and further cues must be used to resolve that competition. However, there is no attempt to decrement the phonological cues. In a sense, the word “bat” is always correct as a cue. The problem is that the representation that it cues is a competitive one. In production, two sets of cues are valid for selecting out the noun “bat.” There is no competition in production between the polysemes because we would never confuse an animal with a stick.

Roles and Cues to Roles

Role acquisition goes through the same steps as lexical acquisition. Consider how the child begins to acquire the valence description for “red” from the phrase “a red ball.” The child hears this phrase spoken in the context of handling a ball which has just been painted with red poster paint. First, the child must segment the phrase into lexical items. Second, by episodic encoding jumping-in, the child stores an initial encoding of the role relation between “red” and “ball.” This initial role relation may include information about the non-inherent quality of the ball’s redness and the completeness of the painting. Over time, the child continues to acquire additional episodic encodings of pairs of words. During cue extraction, the child will sift out the most valid features of the relation. As in lexical learning, roles are learned by depending on a conservative “confirmed core” with features

whose cue strength depends on their cue validity. As in lexical learning, the maintenance of episodic traces of word combinations helps defend against too rapid generalization.

The child learns about roles by storing cues relating to both the predicate and the argument.

1. Positional Cues: The child records the position of the argument vis a vis the predicate.
2. Auditory Cues: The child records the segmental and suprasegmental phonological properties of the argument.
3. Semantic Cues: The child records the semantic concepts that describe the argument and the predicate.
4. Lexical cues: The child records the lexical identity of all items attached to the argument, as well as all items attached to the predicate.

The child is trying to figure out the cues that should be used to assign an item to a particular role. For example, the child is learning that stressed words are likely to take the focus role or that animate nouns are strong candidates for the subject role. Only in the case of lexical cues is the child tracking not just information about the argument itself, but also information attached to the predicate to which the argument attaches. If the child were not tracking such secondary lexical information, he could not acquire agreement cues.

Consider the set of verbs like “give.” These verbs all have the semantic features of [action] and [transfer]. These features are cues to roles of subject-actor, object-patient, and indirect-recipient that compose the valence descriptions for these verbs (Pinker, this volume). These roles are learned from particular experiences or episodes. When the child hears “Bill gave a tomato,” he sees Bill giving a tomato to Hank and assumes that “Bill” is the subject and that “tomato” is the object. He also judges “Bill” to be the “giver” and the “tomato” to be the “transferred.” The child uses situational cues to guess at the role for each nominal.

The first time a child records a new argument for a predicate, only the information on the particular item that filled that slot is recorded. As new items are encountered in that slot, their cues are merged with the cues currently in the slot. Cues that are common across exemplars grow in strength. Cues that are not common drop out. If an argument is only occasionally attested in the data, it will not grow much in strength. So, if we only occasionally hear an indirect object with verbs that have semantic features like those in “report,” we will be uncertain about whether such arguments are possible. Since the packaging “Bill reported Tom the event” is in competition with the packaging “Bill reported the event to Tom,” the weakness of the indirect role on the former will lead to the victory of the latter form in competition.

An important consequence of the lexically-based nature of grammatical roles in the Competition Model is that the child only needs word pairs to acquire roles. For example, when the child hears a sentence like “The smart little boy gave the dog a bone,” he notices that there is “giving” in the situation and that the “dog” is a recipient. This teaches him that “give” takes a recipient in postverbal position with no other marking. In this case, it does not matter whether or not the dog is barking or the boy has a hat on or that he is referred to as “the smart little boy.” In fact, nothing about the subject or the object is relevant to the acquisition of the relation between the verb and the indirect object. In other accounts, such as those of Anderson (1977), Siklossy (1972), Wexler and Culicover (1980), Berwick (1987), and Pinker (1984), one must believe that the child receives complete representations of the meanings underlying every utterance he hears. If this were true, it is hard to understand why the child would pay attention to language at all, because everything would be clear in the situation. Even researchers who make this assumption realize that it is too strong. But the point is that, with the emphasis on lexically-based constructions in

the Competition Model, we are immediately able to replace this indefensible assumption with a more defensible mechanism of acquisition based on the encoding of pair-wise relations.

Allomorphs

The child must also acquire competing allomorphs and the cues for selection between allomorphs. Again, learning here precedes through segmentation, episodic encoding, and cue extraction. When the child finds that a single meaning takes on two articulatory forms, he associates each articulatory form to the meaning. Each phonological variant that appears in the surface is stored in its full surface form. Just as in role learning, the child must extract cues that determine the choice of one allomorph over the other. These cues can be:

1. **Auditory cues:** The mechanism records the auditory cues of the item and of its head. For example, the presence of a final /e/ on a stem in German activates choice of feminine markers.
2. **Semantic cues:** The mechanism records the semantic cues of the item and of its head. For example, the presence of the semantic feature or cue “tree” on a stem activates choice of feminine markers.
3. **Lexical cues:** The mechanism records the lexical items attached to the head. For example, when the suffix “-keit” is attached to the head, this activates feminine articles, pronouns and suffixes in German.

As in the learning of cues to roles, the learning of cues to allomorph selection requires that the child be keeping track of these three basic types of predictors. The only difference between cue tracking for allomorphy and role cue tracking is that there is no need to track the shape of arguments of the head for allomorphic decisions. When establishing new allomorphs, the child uses as cues the semantic and phonological properties of the stem or head, along with the lexical identity of items attached to the head. Each allomorph develops connections to the cues that aid in its selection. As argued by Braine (1987), the child attempts to maximize the features of each allomorph which involves maximizing their size in segments. Here again, there is a conservative “confirmed core” which delineates what the child really knows. However, the child may be forced to go beyond this confirmed core when no alternatives are available.

Polysemes

It is difficult to overestimate the importance of polysemy in language. The strongest cases of polysemy appear as homonymy, but this is only the tip of the iceberg. With a word like “ball” we can imagine any number of concrete types of balls. As Anderson and Ortony (1975) have pointed out, the “ball” we imagine with “Arnold Palmer lost his ball” is quite different from the one we imagine with “Joe Montana lost his ball.” In one case, we have a golf ball, in the other a football. Both forms are activated by the same phonology. The listener’s problem is to use further cues to select one of these over the other. He does this by attending to the semantic features of the words with which the polysemes are associated. Thus, words such as “tee,” “club,” and “Arnold Palmer” prime the golf ball polyseme of “ball,” while words such as “punt,” “goal,” and “Joe Montana” prime the football reading.

Why Does Competition Work?

At this point, the critical reader may wonder what is in the Competition Model that allows it to succeed as an account of language acquisition where other accounts have failed. The

reasons include: gradualism, local control of contrast, cue extraction, cue validity, conflict validity, and form-driven learning.

Gradualism

A major advantage of the focus on competition is the way it allows us to deal with gradualism in development. As long as child language researchers worked with standard adult-based descriptions of competence they were forced to imagine a child who came to the language learning task complete with a fairly elaborate set of hypotheses. According to this view, the major thing that happens during development is the weeding out of false hypotheses. Given this view, the only thing really surprising about language acquisition is that it takes so long. If the two-year-old comes equipped with the full mechanism of the adult language, why are his utterances so primitive? One line of reasoning says that his grammar is not primitive at all, and that if we had better tools for studying the child's mind, we would see within it a fully developed adult grammar. It is difficult to prove this hypothesis wrong. That is what makes it of so little scientific use. Another approach views the child's grammar as fully specified by the genes but emerging slowly during the course of maturation. This second version of the strong nativist hypothesis could presumably be tested. However, it would be difficult to decide whether advances in the child's performance are due to maturation of the linguistic system, as opposed to maturation of the cognitive system.

The Competition Model provides an alternative to those approaches which seek to house all of adult grammar in the mind of children. What we see when we look at language acquisition is a gradual development. Mastery of the phonological contrasts of the language is a step-by-step process. During the second and third years, each week sees the acquisition of new sounds, patterns of sounds, or refinements in the articulation of existing sounds in particular words. For years, each day sees the learning of several new words. Each day the child sharpens his use of old words and acquires new meanings for old words. Syntactic patterns also emerge in a gradual way. New patterns such as auxiliary inversion for questions are first applied to a few words and then a few more. The Competition Model views this gradualism as an important indicator of the true course of development. Contrary to the claims of nativist theory, the child seems to be proceeding in a bottom-up fashion, acquiring the language system brick by brick.

Local Control of Contrast

Competition is related to certain other principles that have been proposed as central to language learning. Like Clark's (1987) Principle of Contrast or Pinker's (1987) Uniqueness principle, the Principle of Competition guarantees that the language will not tolerate a situation in which two different forms express exactly the same meaning. Because of competition, full synonymy is not possible. As Bolinger (1965) noted, "when I say two different things I mean two different things by them." The Uniqueness Principle and the Principle of Contrast are reflections of a more general principle -- the Principle of Competition. Consider a multidimensional grid in which the points in the grid represent a particular combination of values on the semantic cues of the system. For example, one set of cues such as "utensil," "for drinking," "handle," and "cylindrical" might activate the item "mug" in the adult language. If the child codes this intersect of cues with the form "cup," he will place the incorrect form "cup" into competition with the correct form "mug." The correct extension of "mug" will be reinforced during comprehension. Eventually, after repeated presentation and occasional use in conflict cases, "mug" will come to dominate over the use of "cup" for this particular conjunction of cues. For other areas in the semantic cue space, it is "cup" that will come to dominate over "mug." A similar

competition will lead to the elimination of errors in role assignment. The part of semantic space that is used to activate the form “*goed” is also used to activate the form “went.” Since the latter form receives more reinforcement in the input, it will eventually come to dominate over the erroneous form “*goed.”

The situation is much like population genetics. If two species of birds are competing for exactly the same ecological niche, one of the two species will win out and the other species will move into another niche or die out altogether. The niche of the losing species may overlap partly with that of the winning species, but it cannot be an exact overlap. Why must this be true? Because the two species are genetically different, they must also differ in one or more phenotypic characteristics. Each difference has some level of impact on the survivability of the species in each microenvironment of its niche. In some cases the impact will be small, in others it will be large. Each impact will be felt in the ability of the species to compete in a given microenvironment. To the degree the species loses out in many major microenvironments, its overall survival can be threatened. Or, while losing out against its original competitor, it may shift over to competing against new competitors and its entire niche will change significantly. If one species has a thicker beak, it will be able to eat seeds with a tougher shell or husk, perhaps coming to dominate in areas around certain species of trees. However, this thickness of the beak may be a disadvantage in catching small insects and the other species will dominate in areas around ponds and meadows where insects abound.

A similar situation arises in language. Consider two possible past tenses of the verb “weave.” We say that the Navajo mother “wove” a blanket for her child. But we say that the basketball player “weaved” his way down the court. The competition between “weaved” and “wove” is paralleled throughout the irregular past tenses. In such situations, allomorphic patterns give rise to competing formations. As Butler and MacWhinney (1983) and Stemberger and MacWhinney (1985) have shown, there is a good chance that even erroneous forms like “keeped” will be stored as lexical items. Once they are stored, competition places pressure upon these forms to differentiate semantically.

Cue Extraction

The extraction of cues is not a passive process. Although some cues are highly available, others are fairly low in availability. Still others must be constructed out of the raw materials of perception. Cue extraction works first to discover cues within episodic encodings. If these encodings are sufficiently rich, valid cues will slowly surface. In other cases, the child must work to enrich his episodic encodings. This will happen when a new item has a semantic range that overlaps that of the confirmed core of a current item. For example, the child may have learned something about the word “pine” and then see a tree that looks like a pine, but which is called a “spruce.” The child does not ignore this new word, but assumes as does Clark (1984) that words have conventional meanings that contrast. At first, the child does not understand the basis of this contrast. However, “spruce” can coexist with “pine” receptively, since the forms are not in competition in comprehension. However, the child will not use “spruce” in production until he can figure out a way for it to compete successfully against “pine.” Each time he hears “spruce” he attempts to gather cues that may separate it out from “pine.” Eventually the child will begin to count needles, look at their shape, and study the barks and forms of pines and spruces. As his episodic encodings become richer, he will be able to begin to construct the cues he needs to make the differentiation.

A similar period of free variation occurs for superordinates. When the child first hears the word “animal” used to refer to a dog, it works in effect as another name for “dog.” At the

same time, the child is receptive to any data that can distinguish the two forms. In this particular case, the child will also hear “animal” being used to refer to cats, mice, and horses. During this period, the word “animal” is in variation with a variety of forms. However, it is also gaining strength from those features shared by cats, mice, dogs, and horses. This then leads to the formation of a concept which expresses the shared features, but which loses out when the child wishes to express more detailed features. In this way, the child uses competition to acquire superordinates (Callanan, 1982; Rosch, 1977).

Conflict can also arise between a subordinate term such as “dachshund” and a basic-level term such as “dog.” Again, the child allows the forms to coexist for some time as variants. During this probatory period, the form “dachshund” gains support from features such as “short” and “long-eared.” This allows the form to carve out a niche vis-a-vis “dog,” so that when the child sees a dog that is clearly a dachshund and wishes to emphasize its exact identity, he uses “dachshund” rather than “dog.” However, if the child is talking to a friend, and the friend has only one dog, he asks, “What’s your doggie’s name?” rather than “What’s your dachshund’s name?”

In each of the examples above, we see language serving as a goad to conceptual development. Language can also serve as a goad to conceptual acquisition in the area of grammatical constructs. MacWhinney (1987) discusses research on aspects of conceptual structure important in determining grammatical form. Similar discussions can be found in Langacre (1986), Slobin (1986), and Talmy (1978). Each discussion underscores the cross-linguistic importance of certain basic concepts. However, as Bowerman (1986) correctly notes, none of our current models of conceptual structure permit sufficient flexibility to account for the great diversity of grammatical categories across languages. If we look just at variations in the ways of marking the subject and the object, we find an astonishing diversity of mappings. There is the nominative-accusative marking type of English, the ergative-absolutive marking type of Batsbi, the agent-patient marking type of Lakhota and Hungarian, the topic-marking system of Lisu, and the case-focus marking type of Tagalog. Within each of these types many options exist. For example, in Tzutujil we find not just ergative-absolutive and ergative-dative markings, but also two forms of “antipassive” markings. One is used to take the absolutive (patient) out of its close association with the verb. It is indeed the mirror-image of the by-clause in the English passive. The other leaves the absolutive in close relation to the verb but gives it focus. In English, structures such as clefts, pseudo-clefts, and extraposition express other forms of subjecthood. Yet other subjects are “raised” from lower clauses and some are missing altogether, with words like “it” and “there” in their place. Given this rich diversity of marking types, what concepts should be attributed to the two-year-old. Is it reasonable to imagine that young children all around the world have the concept of the antipassive even if it turns out that their language never uses it? Probably not.

On the other hand, if we scratch down one level below this diversity of marking forms, we may reach a level of conceptual primitives that is not so far from the world of the two-year-old. This is the world of concepts such as “first mover,” “one who started the action,” “one who maintains the action,” “one who exercised volition and will,” “one who applied force,” “one I am focusing on,” “one who was mentioned before,” and so on. Even these concepts may not be in their full adult form at the age of 2. A two-year-old may think of focus only in perceptual terms. Later, he will learn to use it as a narrative and evidential device. But even having just a rudimentary understanding of the concept should be enough to allow the child to begin working on the linguistic form used to express it. This is where Bowerman’s work (this volume) seems most important. She has stressed how conceptual reorganization can occur under the pressure of contact with the linguistic system. This seems to be exactly what happens, although it is not yet clear just how this retroactive or, rather, abductive pressure is exerted. One possibility is that new categories

are formed simply by combining more primitive cues. This is the basic cue extraction method of the Competition Model. A second possibility that I discussed above is that the presence of a form serves as a goad to increase the breadth of episodic encodings and that new cues are then extracted from these encodings. A third possibility is that, once a category has been abstracted for some items, it is simply “imposed” on the semantic structure of items that behave the same way in the syntax. For example, treatment of “beans” as a mass noun may be based more on the fact that it cooccurs with “some” than that it is a uniform quantity. Within the connectionist framework of Rumelhart and McClelland (1987) such analogies could emerge automatically. In a network of projection from semantic features to syntactic expectations, words that have the same syntactic expectations could begin to assume the same semantic features.

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 (MacWhinney, Pleh, and Bates, 1985). Following Brunswik (1956), the Competition Model argues 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, the validity of a cue to assignment to the object role is assessed 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 (in press) 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 can then be defined as the product of reliability times availability. Following McDonald, the Competition Model represents 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. Validity is then defined as the product of availability times reliability. Since the B + C term cancels out when multiplying reliability times validity, validity becomes the ratio of C divided by A + B + C. This is precisely the way one wants to define validity, since this is the ratio of cases that are available and reliable over total cases.

These notions can be illustrated by looking at how validity works for the cue of preverbal positioning in English. This cue is an excellent guide to assignment of a noun phrase as the subject. 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), Sokolov (in press), and McDonald (1986, in press)

demonstrate, both availability and reliability can be calculated from studies of the input to the language learner.

Conflict Validity

So far, we have painted a picture of a child who focuses only on what is right, hoping thereby that errors will be choked out by correct forms. For the young child, this picture is generally accurate. However, as learning progresses, it is clear that the child pays more and more attention to the conflicts between cues. Both McDonald (1986, in press) and Sokolov (in press) find that, for young children, cue validity is an excellent predictor of cue strength. However, this prediction is best during the initial stages of cue learning. As learning progresses, the best predictor of learning becomes what McDonald (1986, in press) has called conflict validity, rather than simple cue validity. Conflict validity is the validity of the cue in those particular instances where it conflicts with other cues to the same role. For example, case-marking conflicts with word order in a sentence such as “the dogs saw she.” In English, this conflict is resolved in favor of word order and the sentence is given an SVO interpretation, but in Dutch the corresponding sentence is resolved in favor of case-marking and is given an OVS interpretation. Such conflicts between case-marking and word order are rare even in Dutch. Because they are so rare, it is difficult to estimate their frequency from text counts. Because children have not yet been exposed to many such conflicts, the strength of cues in their system is more determined by overall cue validity than by conflict validity.

Let us distinguish two basic types of learning: positive learning and conflict learning. Positive learning simply involves the strengthening of individual forms. If, by their nature, strong forms come to dominate weaker forms, this is simply a by-product of positive learning. For example, in a garden one can plant ivy and nasturtiums. Because the ivy grows so vigorously, it will eventually choke off sunlight to the nasturtiums. In this way it will dominate without there being any direct “blocking” relation between the two plants. In conflict learning, on the other hand, the child learns a specific link between two forms such that, when form A occurs, the use of form B is specifically blocked. This occurs because activation is siphoned off from form B to form A. This would happen in our example if nasturtiums contained a chemical that specifically suppressed the growth of ivy or vice versa. Or for an example in language learning, if the child has learned a blocking relation between “broke” and “*broke”, then when the combination of the bare stem with the past tense yields “*broke”, the specific connection between “broke” and “*broke” siphons activation off from “broke” to “*broke.” In this way, the child does not have to rely solely on the strength of “broke” as a way of preventing usage of “*broke.” A clear case of learning based on conflict cases has been observed by McDonald (1986) for Dutch. Dutch marks case on pronouns just as in English. However, unlike English, Dutch allows OVS word order. Thus the Dutch counterpart of “*him saw I” is perfectly good. However, in such a sentence the weak case cue is in conflict with the strong word order cue. Even at age 8 children still go with the word order cue. Eventually, they learn that when these two cues are in conflict case wins over word order.

Episodes Versus Cues

MacWhinney (1975, 1978, 1982, 1987) has repeatedly emphasized the importance of the contrast between rote and analogy. The Competition Model preserves this emphasis in terms of the contrast between episodic encodings and generalized cues. Many aspects of language learning are best understood in terms of the interplay between rote and analogy. Just above, we discussed the conflict between “*broke” and “broke.” In this conflict, the rote form “broke” has a strong episodic base whereas the analogistic form “*broke” shows

the importance of general cues. There are a variety of ways in which the interplay between rote and analogy can be represented. The connectionist architecture of Rumelhart and McClelland does well at capturing the child's acquisition of cues in morphological learning, but does not properly express the facility with which the child acquires particular rote associations. Recent connectionist work explores further architectures in terms of their balance toward either rote or analogy. From this work, an architecture should emerge that is capable of correctly representing the facility with which the child acquires new rote forms, the thoroughness of his abilities to extract cues, and the tenacity of the conflict between rote and analogy.

Form-driven Learning

In general, functional learning precedes formal learning. However, this is not always the case. Learning also involves the "abduction" of semantic facts on the basis of formal regularities. For example, given a sentence such as "The man niffed the plate at the fence," the child can abduce some of the semantics of "niff" on the basis of its valence description. The child does this by attending to the underlying system of connections between semantics and verb frames. This system tells us that "niff" takes a subject and an object and that the action of the subject on the object is like that in "hit" and "slam."

The importance of a mechanism of this type has been stressed by MacWhinney (1978), Maratsos and Chalkley (1980), Bowerman (1982), and Schlesinger (1977). Bates and MacWhinney (1982) stressed the importance of functional characterizations of role-relational classes. Abduction uses these relations to go from form back to function. There is evidence that even very young children are able to infer the class of a word from cooccurrence data. For example, Katz, Baker, and Macnamara (1974) found that, beginning around 17 months, girls who were given a proper name for a doll learned this name better than girls who were given a common noun. In the proper noun frame, girls were told that the doll was called "Zav"; in the common noun frame they were told that the doll was "a zav." Thus, even at this early age, children seem to realize that names with articles are common nouns and names without articles are proper nouns. This ability to infer the semantics of words on the basis of cooccurrence continues to develop. By age 8, Werner and Kaplan (1950) were able to show in their classic "corplum" experiment that children could acquire many aspects of the semantics of abstract nouns from highly abstract sentence contexts.

The connectionist models of Rumelhart and McClelland (1987) and McClelland and Kawamoto (1986) do a good job of simulating abductive learning. Abduction is particularly clear in the McClelland and Kawamoto model. Words that behave formally like other words begin to be treated like those words. For example, in a sentence such as "the doll hit the ball" the simulation has a tendency to begin to attribute animacy to "the doll" on the basis of its status as the subject of "hit." In fact, this learning is not incorrect, because in both fantasy and fiction we often treat dolls as animate.

Teachability and Buffering

The analysis provided by the Competition Model allows us to draw a fairly clear set of implications for language instruction. Most importantly, the analysis suggests that the clearer the input, the clearer the learning. There is no need in the Competition Model to imagine that the child must learn on the basis of negative instances. Rather, what is crucial is that the parent present clear exemplars of lexical items and grammatical role frames. If the parent encounters a child error, then he should only recast that utterance if he can be

sure that he knows what the child was trying to say. If the parent recasts the wrong meaning, he will teach the child the wrong form. Since all forms are always in competition, by continually reinforcing correct meanings, the parent is always indirectly weakening wrong forms. This interpretation of parental feedback to children is strongly supported in recent work by Warren-Leubecker, Bohannon, Stanowicz, and Ness (1986) and Hirsh-Pasek, Trieman, and Schneiderman (1984).

An appreciation of the importance of competition is at the heart of the didactic interactions that occur between children and their parents. Recent work by Bohannon, Stanowicz, Ness, and Warren-Leubecker (1986), Hirsh-Pasek, Trieman, and Schneiderman, 1983, Demetras and Snow (1986), and Ninio (1986) indicates that parents are indeed quite sensitive to the well-formedness of their children's speech. Ill-formed utterances are more likely to elicit recasts and repetitions of a variety of types. The exact shape of the recasting depends upon the nature of the error in the ill-formed utterance. It appears that the parent's didactic method is based on an understanding of the importance of competition and contrast. When the child makes a phonological error, the parent can usually retrieve the meaning of the utterance. The parent can then repeat the utterance in the correct shape. This reinforces the correct pronunciation of the form and, by competition, decrements all alternative pronunciations. When a referent is named by the wrong nominal, the parent again often knows what the real referent is and can simply rename it with the correct term. In the competition framework, by providing one positive instance for the correct form-function mapping, the parent implicitly provides many negative instances.

The parent's problem is somewhat more serious when the child makes a complex error or when he makes several errors in one sentence. In such cases, the parent may not be able to retrieve the child's meaning at all. Without retrieving the meaning, it would be risky to recast the child's form, since that might amount to teaching the child the wrong form-function mapping. In practice, when there are several errors or when there is a complex error, adults do not recast the child's sentence, but instead use clarification attempts to make sure what the child meant to say (Bohannon, in press).

The Competition Model assigns an important role to the parent as teacher, but it does not suggest that language cannot be learned without instruction. Instead, the basic message of the Competition Model to the language teacher and clinician is that language learning is a very richly buffered system. It provides the child with many skills for language learning without making learning dependent on any one skill. The only principle that must be intact is the principle of competition. If the child's rote learning abilities are weak, or if his analogistic capacities are weak, language learning can still continue. If there is little corrective feedback or if the input is noisy, language learning can still progress. If the child pays attention to the wrong cues or the wrong data sources or makes initial incorrect hypothesis, all is not lost. The absence of any particular support for language learning is not critical, since the other capacities can then move in to keep the system buffered and on track.

This notion of multiple buffering also has implications for the study of language disorders. The model as currently formulated is largely a model of normal development, although we have recently applied the model to the cross-linguistic study of agrammatism (Bates and Wulfeck, in press). To apply this model to the study of developmental language disorders, many important additions will have to be made. For the normal child, development is heavily determined by cue validity and the control of cue conflicts. Language has been designed for the normal child to minimize the impact of biological differences and maximize the child's ability to respond to variations in the structure of the target language. When a child has a disability that interferes with normal comprehension or production, the course of language acquisition is both a response to cue validity and an attempt to overcome the

disability. According to the model, there are various ways normal processing and learning can be disabled:

1. The encoding of incoming phonological information could be noisy or inadequate.
2. The encoding of the basis of semantic constructs could be inadequate.
3. The ability to use the lexicon to segment the speech stream could be impaired by problems in the speed or the accuracy of lexical access or by problems in performing lexicon-input matches.
4. Inadequate social and attentional focusing could lead to inaccurate fast mappings of early items.
5. Inadequate feedback to the child or problems in processing this feedback could lead to insufficient support of correct mappings and hence failure to disable incorrect mappings.
6. Memory or input disabilities could interfere with cue detection.
7. General noisiness in the system could lead to a high level of speech errors, even once devices had been acquired.
8. Problems in controlling the serialization of an essentially parallel system could lead to speech production errors, stuttering, and other output problems.

These problems can be viewed as problems affecting cue cost. Minimal disfunctioning in any one of these areas might slow down the pace of language acquisition, but the multiple buffering of the system should allow the child to recover from mild disabilities. On the other hand, major blockages in abilities such as auditory processing could result in major deformations of the normal course of acquisition. To develop a correct understanding of the relations between learning in disabled children and learning in normal children, we will need a model that has well developed formulation both of normal responses to cues and the impact of particular disabilities in terms of cue costs. Hopefully, such a model could stimulate increased cooperation between students of normal language acquisition and students of language disabilities.

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«@FoleyVanvalin84»
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«@BatesMacwhinney87»
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«@Anderson83»
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«@CooperPacciacooper80»
«@ColeJakimikCooper80»
«@Wolff75»
«@FayCutler77»
«@McClellandElman86»
«@MacwhinneyPlehBates85»
«@Ganong80»
«@Tesniere59»
«@Pinker87»
«@BatesMacwhinneyCaselliDevescoviNataleVenza84»
«@MartinMolfese71»
«@MartinMolfese72»
«@Richards79b»
«@Scheffelin71»
«@SchwenkDanks74»
«@FrazierFodor78»
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«@Macwhinney84a»
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