

Applying the Competition Model to bilingualism

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ADDRESS FOR CORRESPONDENCE

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This special issue brings together a set of four papers devoted to the experimental study of sentence processing by bilinguals in their second language. The basic finding reported in this research is that, in many cases, learners transfer their L1 sentence processing strategies onto sentence processing in L2. Moreover, the influence of this transfer can be detected in weakened form even in fluent bilinguals who have spoken L2 for many years. In effect, these studies report on a kind of comprehension analog to "foreign accent" that first came to light during work on sentence comprehension within the framework of the Competition Model of Bates and MacWhinney (1982).

This new research demonstrates the usefulness of viewing sentence processing not in terms of discrete, non-variable grammatical rules, but in terms of cues whose strengths and interrelations vary as a result of learning and processing. The studies by Gass, Kilborn and Cooreman, Harrington, and McDonald each provide evidence in support of a common set of theoretical claims. Interestingly enough, this theoretical basis is provided by a psycholinguistic model, rather than a linguistic model. It is important to understand why this work should be based upon a psycholinguistic model, rather than a linguistic model.

Formal linguistic models can tell us a great deal about language *competence*, but they explicitly eschew any treatment of language *performance*. For the grammarian, the logician, or the computer scientist, this focus on competence grammars vastly simplifies the task of formal description. But, for students of second language learning, a focus on the study of competence is inappropriate and counterproductive. Second language instruction has as its goal not the establishment of some abstract competence in the students, but the development of a high level of actual language performance. Thus, it is factors leading to changes in performance that are the central concern of second language research.

Let us consider for a moment some of the basic empirical facts about second language learning that any model must deal with. When we look at the sentences produced by second language learners, we see a mixture of correct formations, overgeneralizations, and omissions much like the errors and omissions produced by children. However, there is a major difference between the adult and the

child: the adult has a much larger knowledge base upon which to construct his new system. Consider the case of lexical learning. The child must devote a great deal of energy to learning the meanings underlying words (MacWhinney, 1984, 1987; Keenan & MacWhinney, 1987) before going on to learn the association between the meaning and some lexical item. For example, the English-speaking child must learn to distinguish various types of pieces of furniture such as chairs, stools, couches, benches, sofas, hammocks, stepstools, etc., when trying to learn the meaning underlying the word "chair." On the other hand, the adult can often take a fully acquired meaning from L1 and apply it to L2. When the older second language learner then goes ahead and tries to learn the meaning of the word "silla" in Spanish, none of the work he did in childhood has to be repeated. The fully prepared concept underlying "chair" is simply mapped over onto "silla." This is a case of strong positive transfer and is an exceedingly important process in L2 acquisition.

Can we follow earlier theory in viewing bilingual learning as involving both positive and negative transfer? Not without rethinking what we mean by negative transfer. When languages map meanings in similar ways, it is easy to see how positive transfer can lead to major gains. But research has not always indicated a clear role for negative transfer. Let us contrast three views of the nature of negative transfer. In the first view, the learner obligatorily transfers all aspects of L1 onto L2. When the transfer is inappropriate – whether it be in the sound system, the lexical system, or the grammar – the learner must exercise overt effort to unlearn the transferred material. But this view provides too rigid a characterization of negative transfer. Whereas it may be relatively easy to unlearn the use of the phonological string /telbl/ for "table" when learning Spanish, it may be much more difficult to unlearn the use of particular English phonemes in Spanish words. For example, learners of Spanish may try to use English /b/ for *boca* 'mouth' even though the correct initial phoneme is half-way between English /b/ and /v/. If we simply think of negative transfer as involving a general carrying-over from L1 to L2 of individual pieces of knowledge, the fact that some types of transfer are easy to unlearn and that other types of transfer are hard to unlearn cannot be readily explained.

A second way of thinking about negative transfer is to deny that it exists. This view equates transfer with positive transfer. If a learner has acquired some structure in L1 which he finds, upon testing, can be successfully applied to L2, transfer then occurs. If an L1 structure is not applicable to L2, it is not transferred. In this view, transfer is not automatic, but depends upon information being shown to be useful in L2. For those areas of L2 where transfer has not occurred, the L2 learner is in the position of the L1 learner and must simply learn from scratch. This second view of negative transfer is also less than fully satisfying. It assumes that the learner is able to refrain from using L1 structures whenever they have not been fully tested. However, the actual exigencies of communication are such that a learner may often have to find some way of expressing himself, even if that way is substandard (Klein & Perdue, in press). For example, if a learner of Spanish wants to talk about a pretty girl, he may know *bonita* 'pretty' and *muchacha* 'girl,' but have no idea about how these words should be ordered. Here, he can rely on L1 strategies to get the ordering *bonita muchacha* which happens to be wrong for Spanish. Would a learner

refrain from saying anything about the girl simply because he had no idea where to order the adjective? That seems unlikely. Rather, he would simply go ahead and choose one order or the other and it is most likely that he would choose the order that corresponds to the order in L1. In this instance, this would involve a negative transfer. So it seems that the view which denies the possibility of negative transfer is too rigid. The existence of negative transfer is particularly clear in phonology. When learning new words in L2, the learner often has no way of avoiding the inappropriate transfer of L1 phonemes until he has fully acquired the various phonemes and combinations of phonemes of L2.

There is a third possible view of negative transfer which is suggested by the work reported in this issue and which is most compatible with the Competition Model approach. This is the view of both positive and negative transfer as processes influenced by a system of cue strength and cue validity. In this view, forms are initially transferred on the basis of just their ability to apply to new cases. However, if these applications lead to errors, the strength of the transfer is weakened. At first, individual cues are evaluated independently in terms of their validity. However, as learning continues, systematic relations between cues begin to play an important role in determining exactly what is transferred and how it is transferred. In the Competition Model, transfer is not an all-or-none affair. Generally speaking, languages differ not so much in the nature of the meanings they express, but in the ways in which they group these meanings together. It is differences in these groupings of meanings and the weights on meanings which cause the greatest problems for the language learner during the learning of both L1 and L2. In this view, what is crucial in transfer is not so much what cues are transferred, but what strengths these cues have in their relations to various meanings. In order to understand this more complex view of positive and negative transfer, we will need to take a somewhat closer look at the basic principles of the Competition Model.

THE COMPETITION MODEL

The Competition Model of Bates and MacWhinney (1981, 1982, 1987), MacWhinney (1986, 1987), and McDonald (1986) was first formulated to deal with data from normal adult and child L1 speakers. However, over time, we have found that the model can be generalized to deal also with L2 acquisition and with language loss in aphasia. Given these generalizations and the recent extensions of the model to deal with on-line processing, it is reasonable to think of the Competition Model as a general psycholinguistic model. This sketch of the model will explain its overall scope and how it is designed to apply to language processing in general and second language performance in particular. In order to better understand the significance of work in the Competition Model for psycholinguistics, let us take a brief look at these five core concepts of the model:

1. two-level mapping;
2. cue strength and competition;
3. cue validity;
4. systematic interactions between cues;
5. processing limitations.

Two-level mapping

The notion of a two-level mapping is based on the functionalist claim that the forms of language are used to express communicative intentions. Only two levels of units are specified in this performance model: a *functional* level (where all the meanings and intentions to be expressed in an utterance are represented) and a *formal* level (where all the surface forms or expressive devices available in the language are represented). For both the L1 and the L2 learner, the functional basis of particular linguistic devices is pivotal in shaping the learning process. Students of language acquisition generally agree that language learning is motivated semantically, at least initially. Writers such as Macnamara (1982) and Pinker (1987) view the semantic basis of grammar as a cocoon to be sloughed off during development. In the Competition Model (MacWhinney, 1987), on the other hand, semantic motivation is viewed as continuing throughout learning. For L2 acquisition, a similar distinction holds. What makes it possible to view language as fully functionally motivated within the Competition Model is the fairly complex view of the way in which forms map onto functions. Three types of mappings are involved: form-function mappings, form-form mappings, and function-function mappings.

Form-function mappings involve direct correlations between forms and functions. For example, the form of preverbal positioning in English is highly correlated with the function of expressing the actor role. Only in constructions such as the passive and the pseudo-cleft is this correlation violated. The principle of direct mapping does not require that the relationships between form and function stand in a one to one relation. Rather, direct mapping means that it is possible for languages to integrate on a single level cues that refer to different data types. In sentence comprehension, the parser is able to consider compounds or configurations of lexical semantic cues (e.g., animacy), morphological cues (e.g., agreement markers), word order cues (e.g., preverbal position), and intonational cues (e.g., contrastive stress). This contrasts with modular theories in which each distinct data type is handled by a separate processor (Fodor, 1983; Garrett, 1980).

Form-form mappings involve correlations between forms themselves. As Maratsos and Chalkley (1980) have argued, children are able to piece together form classes on the basis of co-occurrence information. They do this by noting that things that act the same way in certain constructions also act the same way in other constructions. As MacWhinney (1975, 1978, 1982, 1987) and Braine (1971, 1976, 1987) have noted, the child appears to be guided by two principles in deciding what to correlate with what. One principle is that of semantic connectedness. The other is positional patterning. Together, these two principles tightly delimit the scope of the cooccurrence patterns that the learner considers. By examining formal correlations between items that are positionally connected and semantically related, the learner can acquire the basic form-form correlations of the language.

Function-function mappings involve correlations between functions. These correlations are supported by the shape of the real world in which certain things tend to cooccur and arbitrary random cooccurrence of properties is the exception

rather than the rule. A paradigm case of functional correlations occurs in the area of those functions that are related to subject and topic. Here, there is a natural correlation in the real world between a participant being an actor and its also being an instigator, a mover, a first mover, a perpetrator, a supporter of the activity, and a causer. At the same time this participant is likely to be definite, animate, willful, topical, and foregrounded. All of these various functions are intensely confounded.

Function-function mappings, form-function mappings, and form-form mappings do not work independently in the language system. Rather, these mappings tend to move together in the form of "coalitions." Coalitions are groups of function-function correlations that are in turn correlated with groups of form-form correlations and form-function mappings. Consider the coalition underlying the English "subject." In our view, "subject" is neither a single symbol nor a unitary category. Rather, it is a coalition of many-to-many mappings between the level of form (e.g., nominative case marking, preverbal position, agreement with the verb in person and number) and the level of function (e.g., agent of a transitive action, topic of an ongoing discourse, perspective of the speaker). Notice that the entries at the level of form include both "obligatory" or "defining" devices like subject-verb agreement, and "optional" correlates like the tendency for subjects to be marked with definite articles. This is what we mean when we say that there is no sharp line between obligatory rules and probabilistic tendencies.

Through generations of experience with the competition process, languages have evolved to exploit natural coalitions whenever it is possible to do so. Nevertheless, it does occasionally happen that functions which prototypically "go together" have to be split apart and assigned to different items in order to express an idea adequately. To illustrate, consider what happens when the coalition between agency and topicality breaks down in English and Italian. This can occur, for example, when we need to topicalize "the ball" even though "John" did the hitting. In such cases the grammar has to determine which of the two elements should "win" access to devices like preverbal positioning and verb agreement. A typical "compromise" solution, provided by both English and Italian, is selection of the passive: the patient/topic "ball" wins access to the major subject devices, but the agent is placed in a special "by clause" that signals its continued semantic role. In terms of prototype theory, this is the kind of "hedging" and category-mixing that often occurs when categorization decisions have to be made for peripheral members. In a sense, it is a sentence-level analogue to word-level expressions like "An ostrich really is a bird," designed to mark explicitly the peripheral status of a category assignment.

The other way in which the competition between agency and topicality can be resolved is through topicalization. Topicalization is an illustration of a typical "divide the spoils" solution. In Italian topicalization, preverbal position is assigned to the topicalized patient, but verb agreement is still assigned to the agent. In other words, the set of surface devices comprising "subject" is simply split up and assigned to separate elements. This kind of splitting rarely occurs in English, although we do find informal constructions like "Now that I'd really love to see!" The highly-correlated subject devices in English tend to be as-

signed as a block, while the lower correlations among the same devices in Italian permit the coalition to be split up for non-prototypical situations.

The point is, simply, that a series of compromises are made in both sentence comprehension and sentence production. The ideal situation does not always hold. In fact, the fully prototypical instance of a category such as "subject" may actually be fairly rare (like the "ideal member" that is extracted but never taught in studies of artificial category learning such as Posner & Keele, 1968). This is possible because our knowledge of a "prototypic subject" is the emergent property of a great many weightings between individual forms and functions. It is the result of a lifetime of distributional analysis, and not a template derived from any single instance of grammatical learning.

Cue strength and competition

The second major principle of the Competition Model is that forms and functions compete interactively during both comprehension and production. This general principle can be implemented in a variety of computational architectures. One computational architecture that we have found useful is the connectionist network architecture outlined by Rumelhart, Hinton, and Williams (1986) for which there is a robust learning algorithm called Back Propagation. In Taraban, McDonald, and MacWhinney (in press), we have used this architecture to simulate the acquisition of German article declension.

The mapping assumptions of the Competition Model can all be expressed in connectionist terms. We can view cue strength as a property of the connections between units. For example, the strength of preverbal positioning as a cue to the actor role can be viewed as the weight on the connection between the preverbal positioning node (an input node) and the actor node (an output node). If the preverbal positioning node is activated, it then sends activation to the actor node in proportion to the weight on the connection. With this kind of mechanism, no sharp line is drawn between probabilistic tendencies and deterministic rules. An obligatory relationship between form and function is nothing other than a connection whose strength approaches unity. This permits us to capture statistical differences between adult speakers of different languages, e.g., the tendency for English listeners to "trust" word order more than their Italian counterparts. It also permits us to capture facts about speech errors (Stemberger & MacWhinney, 1986a, 1986b; MacWhinney & Anderson, 1986) and language change (Anderson, 1979; Chen & Wang, 1975; Givon, 1979; Holden, 1976). In gradual and probabilistic terms; we are not forced to postulate a series of all-or-none decisions, i.e., moments where parameters are definitively set and rules are added or dropped. In our work to date this connectionist architecture has been most helpful. However, we are aware of various limitations in current connectionist formulations (Pinker & Prince, 1987), and we are not offering up connectionism as a solution to all outstanding problems in psycholinguistics.

Cue validity

Having completed our discussion of mappings and cue strength, we now move on to what is the most important construct in the Competition Model as it applies

to L2 learning. This is the construct of cue validity. Following Brunswik (1956) and Gibson (1966), the Competition Model holds that human beings possess psychological mechanisms that lead them to act in accordance with the validity or information value of cues in their ecology. This means that validity is an objective property of the cue itself, i.e. a property of the perceptual environment relative to some organismic state. Because cue validity is defined as a measurable property of the linguistic environment, it becomes the major predictive construct in the Competition Model. MacWhinney (1978) and MacWhinney, Pléh, and Bates (1985) have analyzed cue validity into two components: cue availability (i.e., how often is this piece of information offered during a decision making process?), and cue reliability (i.e., how often does the cue lead to a correct conclusion when it is used?).

Availability, in the scheme of McDonald (1984), is best expressed numerically as the ratio of the cases in which the cue is available over the total number of cases in a given task domain. For example, the availability of preverbal position as a cue to the subject is very high in English, but relatively low in Italian. This reflects the fact that subjects are frequently omitted in Italian, leaving many verbs in sentence-initial position. If an L2 English learner of Italian attempts to simply transfer over the English cue to Italian, he would find that, in many cases, the cue is simply not available.

Reliability can be expressed numerically as a ratio of the cases in which a cue leads to the correct conclusion, over the number of cases in which it is available. For example, preverbal position is a highly reliable cue in English, where it is almost always assigned to the agent of a transitive action; it is a very unreliable cue in Italian (when it is available at all), since OV and SOV constructions are both possible and likely. If the L2 learner of Italian attempted to simply transfer the English cue with its English weight, he would frequently fail to understand OV and SOV constructions in Italian, thinking that *Franco la pasta mangia* means that the spaghetti has become carnivorous and is eating Franco. The reliability of preverbal position is very high in English and very low in Italian – a fact that is reflected in the performance of English and Italian listeners in the experiments reported by Gass.

Systematic relations between cues

The simple model of cue validity based on availability and reliability is useful in understanding the early stages of L1 and L2 learning. By simply looking at availability and reliability, it may be possible for the learner to control some 95% of the grammar in actual sentence production and comprehension. However, in order to gain control over this last 5% of the language, the learner needs to pay attention to ways in which cues interact to form systems. McDonald (1986) and McDonald & MacWhinney (in press) have shown that the construction of systems of cues goes beyond attention to cue reliability and validity.

The clearest case of relations between systems of cues is the case of bilingual sentence processing. A Spanish–English bilingual must be able to react to word order cues in one way when processing Spanish and another when processing English. In a sense, each cue in his system is a compound cue in which one aspect of the cue is the nature of the language being spoken. If the bilingual can

fully separate his two languages in this way, errors will be kept at a minimum. However, the cost of this organization of two full sets of processing relations is fairly high and the bilingual may attempt to make short-cuts. One short-cut is to simply allow for a transfer of L1 strategies onto L2. L1-dominant systems of this sort are described in Bates and MacWhinney (1982) and each of the articles in this issue. Transfer of L1 to L2 was also evident in one group of Spanish-English bilinguals studied by Wulfeck, Juarez, Bates, and Kilborn (1986) in Southern California. However, Wulfeck et al. found that a second group of subjects appeared to warp both L1 and L2 into a single mixed system. In this mixed system, the SVO word order cue was quite important, even though it is not a major cue for Spanish monolinguals (Kail, in press). For this group, agreement marking was also an important cue, although it is a weak cue in English monolinguals. Thus, a system of this type shows a warping of both L1 and L2 in the interest of the forging of a single processing system.

Kilborn (1987) found some evidence of bilinguals with a partially separated set of L1 and L2 cues. Perhaps there are some "true" bilinguals who have completely native-like cues in both languages. In addition, Bates (personal communication) has tested two subjects who seem to have totally lost any use of L1 strategies, now using L2 processing weights in both L1 and L2. One of these was an American woman who moved to Italy as a young adult. The other was a German woman who had moved to the United States as a child with her family.

We find, then, four patterns of cue weights: (1) transfer of L1 onto L2, (2) abandonment of L1 for L2, (3) merger of L1 and L2, and (4) partial attainment of separate L1 and L2 systems. What factors lead speakers to develop one of these four solutions over others? Unfortunately, we do not yet know the answer to this question. However, there are a number of factors which are suggested by the cue validity framework of the Competition Model. One factor in the mixed system speakers studied by Wulfeck et al. (1986) could well be the prevalence of code-switching in communities such as the Chicano and Latino community in Southern California. In real life situations where discourse cues are often present and where there is intense code-switching, a merged system of cues may allow the listener to correctly understand well over 95% of all sentences without switching between processing systems. In effect, the merged system trades a slight loss in accuracy off against a substantial improvement in processing load. On the other hand, some of Wulfeck et al.'s subjects gave evidence of preferring Spanish L1. For these subjects, the additional reduction in error was sufficiently important to warrant the maintenance of two separate cue systems.

Speakers that allow L1 strategies to transfer onto L2 without showing much susceptibility to transfer in the opposite direction, such as the German-English bilingual discussed in Bates and MacWhinney (1982) might well have a quite different language learning history. These speakers may often grow up as monolinguals and acquire L2 later in life. During the initial period of L2 acquisition, they rely on the transfer of L1 strategies to aid sentence comprehension. This leads to some errors, but at the same time these speakers are learning to use higher-level discourse cues as an aid in processing across both languages. As these cues develop, the lower level cues become less important and begin to fossilize in their early transferred form. At this point, the functional pressure for

reshaping this "accented" comprehension system may then no longer be present.

This view of relations between systems of cues may be helpful in understanding a variety of both individual difference effects and cue "prepotency" effects. Gass suggests that semantic cues may have a certain universal prepotency in both L1 and L2 learning. In particular, her data indicate that English learners of Italian are quick to drop their strong use of word order and rely on the animacy cue, whereas Italian learners of English are somewhat slower to drop their use of animacy and adopt the strong use of word order shown by English monolinguals. Gass's view of animacy as an easily accessed or prepotent cue is also supported by Harrington's finding that some English speakers in Hawaii fail to show the strict use of second noun strategies for NNV and VNN reported for English speakers in Colorado by Bates, McNew, MacWhinney, Devescovi, and Smith (1982) and MacWhinney, Bates, and Kliegl (1984). Both Harrington and Kilborn & Ito (in press) found that Japanese learners of English were slow to pick up on the word order cue when compared to English learners of Japanese who are quick to pick up on the animacy cue. Furthermore, the existence of a group of subjects in Kilborn and Cooreman's Dutch group that tended to rely rather more on animacy cues in both Dutch and English seems to further indicate the pervasiveness of the animacy cue across languages and groups. Along these same lines, we should note that there is evidence of a fairly strong use of the animacy cue in Italian (Bates et al., 1981) and Hungarian (MacWhinney et al., 1985). Thus, there does indeed seem to be some evidence that, in this particular experimental design with animacy paired off against word order and stress, many groups tend to go for animacy despite the fairly high validity of the word order cue.

Before we conclude, however, that there is a universal built-in prepotency for animacy as a cue to sentence interpretation, let us think about the nature of positive and negative transfer in L2 learning. First, we should remember that the tendency of L1 subjects to rely on the animacy cue in Italian and Japanese is somewhat over-magnified in the design of Bates et al. (1981), which is basically also the design used by Gass and Harrington. In Japanese, as in other case marking languages, the presence of a case marking is the major cue to sentence interpretation. However, in Harrington's sentences, the case marking was omitted. Similarly, MacWhinney et al. (1984) have shown that the major cue to sentence interpretation in Italian is not animacy, but subject-verb agreement, but this major cue in Italian was not a part of Gass's design. But it is not the omission of these other cues from the experiments that is crucial. What is crucial is how we should think about the transfer process. One can reasonably ask whether Japanese learners of English initially attempt to find a case marker in English or whether Italian learners of English initially hope to find enough markings on the verb to permit them to rely on the agreement cue. If learners do attempt this type of general transfer of morphological marking as a way of interpreting sentences, it is quickly blocked by the absence of reliable formal devices in English. A piece of evidence indicating that such general transfer of cue type is attempted can be found in the report by Kilborn and Ito (1988) that English learners of Japanese attempt to make rigid use of SOV order as a cue, much as they have made rigid

use of SVO order in English. Indeed, these English learners relied much more on SOV than native speakers of Japanese.

In the case of the animacy cue, the transfer from L1 to L2 in this set of languages is relatively smooth. But this is entirely in conformity with what we would expect from a fairly traditional type of contrastive analysis. In those areas where languages are the same, positive transfer is quick and easy. In those areas where structures are somewhat similar, but not entirely identical, there is positive and negative transfer and a period of learning. Where languages show no correspondence between form-function mappings, all that the L2 learner can transfer are the meanings to be expressed. He must then start over from scratch to construct a new set of mappings from functions to forms. Thus, the tendency of L2 speakers to quickly transfer of the use of animacy but not word order cues needs to be viewed in the light of a theory of transfer and cue mapping. What these data tell us is that any cue that has similar mappings in both L1 and L2 will be a candidate for positive transfer. In areas where L1 and L2 show little formal correspondence, there will be only the basic positive transfer of functions.

Processing limitations

So far, we have sketched out a processing system that has no fundamental resource limitations. In this simple system, cue strength is a direct function of cue validity. Even if a cue is hard to process and maybe even hard to hear, we would expect it to be a strong cue according to this simple model. We know, of course, that this simple account is wrong. In our work with monolinguals during the last few years we have learned more about two major types of processing limitations: perceivability and assignability. In a study of Hungarian case-marking (MacWhinney, Pléh, & Bates, 1985) we have found that, when a marker is difficult to detect, initial acquisition can be markedly slowed and the use of the marker even by adults becomes much more variable. Thus, the clarity of marking is an important processing limitation (Slobin, 1973). Furthermore, the work of Kail (in press) and Devescovi and Caselli (in preparation) with the processing of agreement cues and clitics in Italian and French indicates that those grammatical devices that violate local marking (Ammon & Slobin, 1979) are quite difficult to learn and confront even adults with processing difficulties.

As we learn more about the exact shapes of these processing difficulties, we hope that we will also begin to learn more about the ways in which reorganizations of systems of cues can serve to deal with an ever increasing processing load. At the same time we hope that we will learn more about the roots of some of the individual differences that appear in bilingualism.

NEW DIRECTIONS

Current work with the Competition Model is attempting to construct a more complete understanding of the entire language processing system. To do this, we are broadening the model in two major ways. First, rather than simply taking measures of sentence interpretation at the end of the sentence, we are now looking in detail at the processing of sentences as it occurs on-line. To do this, we are working with techniques such as probe monitoring, on-line sentence

interpretation, error detection, and word recognition, all with computer-presented digitized speech. The addition of the time dimension to our understanding of language processing opens up a whole new microworld of processing phenomena. From the viewpoint of our understanding of second language learning, such an understanding is crucial. We need to understand both how a learner initially processes a sentence, as well as how he eventually decides on the meaning of a sentence once it is completed. In real conversations, there is little time for off-line deliberation and monitoring. Therefore, what we need to know is whether the second language learner may be experiencing particular problems with the on-line processing of sentences (cf. Kilborn, 1987).

A second major area where we continue to expand the Competition Model is in the area of sentence production. Here, we are studying how learners map the set of intentions that they have from L1 onto the set of devices of L2. Our earlier work in this area (MacWhinney, 1977; MacWhinney & Bates, 1978) and that of Sridhar (1988) indicates many important areas where we should be able to expect positive transfer between languages. However, at the same time, we know that second language learners often have severe problems learning to produce L2 sentences even when their comprehension abilities are fairly good. Some of these problems are subtle. For example, Japanese learners of English tend to make frequent use of Japanese-like topicalization structures such as "as for the doll" even though such structures are quite rare in English. This would indicate that some negative transfer of processing strategies and mappings may be blocking successful acquisition of L2.

As we continue to develop the Competition Model in these two ways, we believe that it will become increasingly useful as a tool for research in second language acquisition. As we deepen our understanding of the use of cues during the on-line processes of both comprehension and production, we will develop an increasingly realistic picture of the second language learner and we will be able to understand what it is that leads to successful second language learning.

REFERENCES

- Ammon, M. S., & Slobin, D. I. (1979). A cross-linguistic study of the processing of causative sentences. *Cognition*, 7, 3-17.
- Andersen, H. (1979). Morphological change: Towards a typology. In J. Fisiak (Ed.), *Historical morphology*. The Hague: Mouton.
- Bates, E., & MacWhinney, B. (1981). Second language acquisition from a functionalist perspective: Pragmatic, semantic and perceptual strategies. In H. Winitz (Ed.), *Annals of the New York Academy of Science Conference on Native and Foreign Language Acquisition*. New York: New York Academy of Sciences.
- Bates, E., & MacWhinney, B. (1982). Functionalist approaches to grammar. In E. Wanner & L. Gleitman (Eds.), *Language acquisition: The state of the art*. New York: Cambridge University Press.
- Bates, E., & MacWhinney, B. (1987). Language universals, individual variation, and the competition model. In B. MacWhinney (Ed.), *Mechanisms of language acquisition*. Hillsdale, NJ: Erlbaum.
- Bates, E., McNew, S., MacWhinney, B., Devescovi, A., & Smith, S. (1982). Functional constraints on sentence processing: A cross-linguistic study. *Cognition*, 11, 245-299.
- Braine, M. D. S. (1971). The acquisition of language in infant and child. In C. Reed (Ed.), *The learning of language*. New York: Appleton-Century-Crofts.

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- Braine, M. D. S. (1976). Children's first word combinations. *Monographs of the Society for Research in Child Development*, 41, Whole No. 1.
- Braine, M. D. S. (1987). What is learned in acquiring word classes: A step toward an acquisition theory. In B. MacWhinney (Ed.), *Mechanisms of language acquisition*. Hillsdale, NJ: Erlbaum.
- Brunswick, E. (1956). *Perception and the representative design of psychology experiments*. Berkeley: University of California Press.
- Chen, Matthew Y., & Wang, William S-Y. (1975). Sound change: actuation and implementation. *Language*, 51, 255-281.
- Fodor, J. (1983). *The modularity of mind: An essay on faculty psychology*. Cambridge, MA: MIT Press.
- Garrett, M. (1980). Levels of processing in sentence production. In B. Butterworth (Ed.), *Language Production: Vol. 1. Speech and talk*. London: Academic.
- Gibson, J. J. (1966). *The senses considered as perceptual systems*. Boston: Houghton Mifflin.
- Givon, T. (1979). From discourse to syntax: Grammar as a processing strategy. In T. Givon (Ed.), *Syntax and semantics: Discourse and syntax*. New York: Academic.
- Holden, K. (1976). Assimilation rates of borrowings and phonological productivity. *Language*, 52, 131-147.
- Kail, M. (in press). Cue validity, cue cost and processing types in French sentence comprehension. In MacWhinney, B., & Bates, E. (Eds.), *The cross-linguistic study of sentence processing*. New York: Cambridge University Press.
- Keenan, J., & MacWhinney, B. (1987). Understanding the relation between comprehension and production. In H. W. Dechert & M. Raupach (Eds.), *Psycholinguistic models of production*. Norwood, NJ: Ablex.
- Kilborn, K. (1987). *Sentence processing in bilinguals*. Doctoral dissertation, University of California, San Diego.
- Kilborn, K., & Ito, T. (in press). Sentence processing in Japanese-English and Dutch-English bilinguals. In B. MacWhinney & E. Bates (Eds.), *The cross-linguistic study of sentence processing*. New York: Cambridge University Press.
- Klein, W., & Perdue, C. (in press). The learner's problem of arranging words. In B. MacWhinney & E. Bates (Eds.), *The cross-linguistic study of sentence processing*. New York: Cambridge University Press.
- Macnamara, J. (1982). *Names for things*. Cambridge: MIT press.
- MacWhinney, B. (1975). Pragmatic patterns in child syntax. *Stanford Papers and Reports on Child Language Development*, 10, 153-165.
- MacWhinney, B. (1977). Starting points. *Language*, 53, 152-168.
- MacWhinney, B. (1978). The acquisition of morphophonology. *Monographs of the Society for Research in Child Development*, 43, Whole no. 1.
- MacWhinney, B. (1982). Basic syntactic processes. In S. Kuczaj (Ed.), *Language acquisition: Vol. 1. Syntax and semantics*. Hillsdale, NJ: Erlbaum.
- MacWhinney, B. (1984). Where do categories come from? In C. Sophian (Ed.), *Child categorization*. Hillsdale, NJ: Erlbaum.
- MacWhinney, B. (1986). The UNIBET: A proposal for phonological notation. *Transcript Analysis*, 3, 90-92.
- MacWhinney, B. (1987). The Competition Model. In B. MacWhinney (Ed.), *Mechanisms of language acquisition*. Hillsdale, NJ: Erlbaum.
- MacWhinney, B., & Anderson, J. (1986). The acquisition of grammar. In M. Gopnik & I. Gopnik (Eds.), *Studies in cognitive science*. Norwood, NJ: Ablex.
- MacWhinney, B., & Bates, E. (1978). Sentential devices for conveying givenness and newness: A cross-cultural developmental study. *Journal of Verbal Learning and Verbal Behavior*, 17, 539-558.
- MacWhinney, B., Bates, E., & Kliegl, R. (1984). Cue validity and sentence interpretation in English, German, and Italian. *Journal of Verbal Learning and Verbal Behavior*, 23, 127-150.
- MacWhinney, B., Pléh, Cs., & Bates, E. (1985). The development of sentence comprehension in Hungarian. *Cognitive Psychology*, 17, 178-209.

- Maratsos, M., & Chalkley, M. (1980). The internal language of children's syntax: The ontogenesis and representation of syntactic categories. In K. Nelson (Ed.), *Children's language: Volume 2*. New York: Gardner.
- McDonald, J. (August 1984). *Semantic and syntactic processing cues used by first and second language learners of English, Dutch, and German*. Doctoral dissertation, Carnegie-Mellon University.
- McDonald, J. L. (1986). The development of sentence comprehension strategies in English and Dutch. *Journal of Experimental Child Psychology*, 41, 317-335.
- McDonald, J., & MacWhinney, B. (in press). Levels of learning: a comparison of concept formation and language acquisition.
- Pinker, S. (1987). The bootstrapping problem in language acquisition. In B. MacWhinney (Ed.), *Mechanisms of Language Acquisition*. Hillsdale, NJ: Erlbaum.
- Pinker, S., & Prince, A. (1987). On language and connectionism: Analysis of a parallel distributed processing model of language acquisition. Unpublished paper, M.I.T.
- Posner, M., & Keele, S. (1968). On the genesis of abstract ideas. *Journal of Experimental Psychology*, 77, 353-363.
- Rumelhart, D., Hinton, G., & Williams, R. (1986). Learning internal representations by back propagation. In D. Rumelhart & J. McClelland, (Eds.), *Parallel distributed processing, Vol. 1: Foundations*. Cambridge: MIT Press.
- Slobin, D. I. (1973). Cognitive prerequisites for development of grammar. In C. A. Ferguson & D. I. Slobin (Eds.), *Studies of child language development*.
- Sridhar, S. (in press). Cognitive structures in language production: a cross-linguistic study. In B. MacWhinney & E. Bates, (Eds.), *The cross-linguistic study of language processing*. New York: Cambridge University Press.
- Stemberger, J., & MacWhinney, B. (1986a). Form-oriented inflection errors in language processing. *Cognitive Psychology*, 18, 329-354.
- Stemberger, J., & MacWhinney, B. (1986b). Frequency and the lexical storage of regularly inflected forms. *Memory and Cognition*, 14, 17-26.
- Taraban, R., McDonald, J., & MacWhinney, B. (in press). Category learning in a connectionist model: Learning to decline the German definite article. In R. Corrigan (Ed.), *Categorization*. New York: Cambridge University Press.
- Wulfeck, B., Juarez, L., Bates, E., & Kilborn, K. (1986). Sentence interpretation strategies in healthy and aphasic bilingual adults. In J. Vaid (Ed.), *Language processing in bilinguals: Psycholinguistics and neurological perspectives*. Hillsdale, NJ: Erlbaum.