Individual Differences & Universals in Language Learning Aptitude

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NORMAL ACQUISITION PROCESSES EXPLAIN THE CRITICAL PERIOD FOR LANGUAGE LEARNING

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Psycholinguistic theory and the "critical period."

The primary language behaviors are speaking and listening—distinct skills which children master by age fifteen. If that is true, why do children also internalize a formal "grammar"? The present paper argues that the grammar is itself vital to the acquisition of these different language behaviors. Its main function is to reconcile conflicts in representation between the systems of speaking and listening that emerge during their separate development. The grammar is an internal mapping system that mediates between the two kinds of behavioral skill: it develops internally as conflicts of different kinds between the manifest skills occur. That is, grammar is formed in response to an internal need for consistency of mental representation.

This interpretation of the functional basis for the existence of grammar has consequences for a theory of the "critical period" in language learning. It makes it possible to *predict* that a critical period exists, directly as an intrinsic property of normal acquisition mechanisms, rather than postulating it as a supplementary fact about language acquisition. It also predicts qualitative facts about the critical period, which appear to be true.

Theoretical and practical reasons to study the critical period

At first blush, the question of whether or not there is a critical period for learning a second language seems to be entirely practical and pedagogic. Surely, it is of great importance for curricular decisions to know if it is difficult to learn a new

language after a specific age: it is correspondingly easy to understand the interest in the critical period on the part of those involved in second language teaching. However, a great deal of interest in the question has also been shown by those concerned with the biological basis of human language. Of course, such scholars are basically interested in a "critical period" for learning *any* language at all, not specifically for the acquisition of a second language. Their reason to be interested in second language learning is simply that the acquisition of one's first language always starts in early childhood, leaving no way to see if there is or is not a critical period for its acquisition. Variations in the ability to learn a second language with age could reveal variations in plasticity of linguistic function, and thereby give evidence on a possible critical period for the acquisition of a first language. This line of reasoning is in fact fallacious, although it is common in many areas of psychological research on functional plasticity. I return to the difficulties with it below; however, it is useful for an understanding of the question as a whole to place the general theoretical issues in their current intellectual context.

It is obvious that language is innate, at least in the sense that humans can learn it. The relevant issue is whether there are specific properties of language which are biologically determined and unique. Noam Chomsky (1965) gives an argument on this topic which varies according to a free variable. The free variable is the particular property of language that allegedly cannot be acquired by any theory of learning. The argument goes something like this:

1. There is a property, P, that is a grammatical universal of language (for example, the A-over-A principle, or some even more intricate grammatical principle).
2. No learning theory can account for the acquisition of P.
3. Therefore, P is genetically determined.
4. Therefore, language is innate.

Such claims have excited and agitated many, but they are not as radical as they are sometimes taken to be by learning theorists. For example, a phenotypic property can be determined genetically by the environment—body weight in elephants may be a phenotypic characteristic without direct control—e.g., elephants might be genetically disposed to eat fattening food; take the food away and, presto, elephants would be "genetically" thin. Analogously, take language environment away from a child and he/she won't speak (at least, so we believe). This crudely demonstrates that the linguistic environment contributes crucially to the language-learning child, which encourages the learning theorist to argue that the second step of the argument is invalid—namely, no one has convincingly shown that *no* theory of learning can in principle account for all properties, P. Thus, linguistic nativism requires a stronger empirical argument than the alleged unlearnability of all such properties.

One such empirical argument would be that language acquisition in humans has all the behavioral properties of a species-specific innate capacity in animals. This kind of empirical retreat for the nativist is represented most explicitly in the work

of Lenneberg (1967), in particular the claim that there is a "critical period" for the acquisition of language. The critical period is a redoubt for a diehard nativist. Suppose it turned out that there *is* a learning theory that is adequate for all P's in Chomsky's argument. It might still be the case that one could show that language is interestingly innate, because there is a critical period of the same nature as critical periods found by ethologists: e.g., for the acquisition of a filial sense in goslings. One could then accept the claim from learning theory that *some* learning theory will be able to account for the acquisition of all P's in language; at the same time it would still be the case that there is behavioral evidence that language is innate, namely the fact that there is a "critical period" for its acquisition. After all, what is a "critical period" if not something that is biologically determined?

This is the reason for theoreticians to be concerned with the critical period for second language acquisition. Of course there is also a practical issue: is there a cutoff age for the acquisition of a second language? The practical applications of this question are reinforced by the fact that second language learning appears to be the easiest way to find out if there is a critical period for language. It is hard to ask whether there is a critical period for the acquisition of any language at all: that is to say, there are very few otherwise normal children in the world who have not been exposed to language at all and not learned to talk by age twelve. So the investigation of whether there is a critical period for the acquisition of *first* language is limited.

One could, however, do a number of interesting things that would bear directly on this question: suppose we hypothesize that the critical stage for language learning is puberty. We could compare development in one's native language before puberty and after puberty. We could try to show that the rate of acquisition of new types of language skills in one's native language undergoes a drastic reduction immediately as compared to the rate before puberty. Since puberty is definable biochemically and occurs across a range of ages, I.Q.'s and school grades, it would be possible to extract any independent effects of puberty. Furthermore, puberty is sometimes induced early in certain children for medical reasons (e.g., to stop abnormally fast bone growth). Such children might show specific independent effects of puberty on their language learning.

Similar studies could be carried out with respect to other independently defined developmental variables. For example, it is a frequent hypothesis that the "onset" of cerebral asymmetry (usually specialization of the left hemisphere for language processing) determines the critical period. This, too, could be studied systematically by closely examining the linguistic differences between children with and without independent objective signs of cerebral asymmetries.

Even social theories of the critical period can be tested on one's first language. For example, it might be the case that the critical change in language learning ability is due to a shift in motivation—younger children, *ex hypothesi*, are motivated to imitate the manifest behavior and common cultural skills of the adult world, while adolescents are more concerned with social skills relating to their peers. To study this hypothesis independently of the others is difficult, but possible. It would require scaling social interaction and peer dependence against rate and style of linguistic development (factoring out I.Q. and other measures separately).

In brief, there are certain things that one could study in first language learning if one had in mind a specific hypothesis about what it is biologically or socially that underlies the development of the first language. Nevertheless, most research has focused on second language learning because of its availability and because of the absence of a rich enough theory of first language learning that could make meaningful the notion of acquisition "rate" or "pattern." The result has been a number of dramatic declarations that language is "innate," but very little information useful for language teaching or anything else has resulted.

In this theoretical review, I first review and discuss the limitations of the prevalent theories of the linguistic critical period. I then review a model from biological research of what "critical period" could mean at a theoretical level for an understanding of the normal process of growth. I then present recent linguistic research and psycholinguistic studies that provide an understanding of the acquisition of grammar and language skills in first language learning. Finally, I show that the biological model can be directly transferred to an understanding of what the critical period may be in the case of language.

Some existing inadequate theories of a critical period for language

The first step in this discussion is to accept as a pretheoretic truth that there *is* a critical period for language learning. Scholars who claim that it is "unproven" that languages are harder to learn in middle age than childhood may be technically correct, in the sense that there is little "scientific" data demonstrating that relative difficulty. However, the claim is also disingenuous, since there is ample individual evidence that the older one is the harder it is to master a second language well enough so that a native speaker cannot detect that one is a foreigner. I think that there is very little argument about such facts: it clearly is the case that people who learn a new language after age twenty rarely do so with the proficiency of people who start learning before age ten. This difference persists even after many years of exposure to the language.

An important question from the standpoint of a biological interpretation of this loss in manifest language learning capacity is whether the loss of capacity is precipitous or whether it is gradual. If it is a gradual loss in capacity, then the evidence for a "critical period" would be quite weak. After all, a period of gradual decline that lasts for twenty years can hardly be called "critical." The difficulty in assessing this is that it is not clear how to scale the ease of learning a language at different ages without having that assessment placed in the context of the child's general learning capacity. We also lack thorough tests of the linguistic capacity of one's first language, never mind reliable techniques that scale the full linguistic mastery of a second language.

For purposes of discussion, let us assume that there *is* a critical period for second language learning; this is, that there is a relatively selective decline in

language learning capacity by age twenty. Beginning with this assumption, we can gain further insight in how to test its validity by consideration of alternative theories that might account for the existence of such a critical period. I consider three frequently proposed kinds of theories and discuss the deficiency of each. I then propose a new theory which combines the advantageous aspects of each of the previous deficient ones.

Traditionally, there are three classes of theories as to why there is a rapid loss of language learning ability with age; a precipitous loss of the neurological flexibility to learn a language (e.g., the permanent entrenchment of cerebral asymmetries in the brain); a "filling up" of the language-learning capacity simply due to the experience with the first language; and the superposition of an intellectualized self-conscious way of learning everything, which interferes with the elementary language learning processes.

The dependence of language learning on cerebral asymmetry expresses a direct mechanistic basis for the critical period. On this view, learning any language depends on the flexibility to represent linguistic capacity throughout the brain in such a way that the left hemisphere emerges as the dominant site of linguistic capacity. This interpretation reflects the fact that in virtually all adults (including most left-handers) language function is represented in the left hemisphere and not in the right. The age at which this specialization of the left hemisphere is firmly fixed is the subject of considerable discord in the literature. However, it is generally agreed that the plasticity of other areas of the brain to take over linguistic functioning is greatly impaired by age fifteen. That is, whether the left hemisphere for language is a *developmental* phenomenon: it emerges with a variety of manifestations, starting at birth. Secondly, there is no theoretical age (the original critical studies are those reviewed by Lenneberg (1967) in which children suffered lesions of the left hemisphere at different ages).

The difficulty with this hypothesis as an explanation of the critical period is that the emergence of left hemisphere specialization for language may be a correlated fact, not a causally related one. Firstly, the specialization of the left hemisphere for language is a *developmental* phenomenon: it emerges with a variety of manifestations, starting at birth. Secondly, there is no theoretical explanation of what the loss of plasticity of function means, particularly in relation to the acquisition of language. For example, one could easily argue that the loss of plasticity is itself due to the fact that by age ten, the child has stopped learning new aspects of his language. Thus, by age fifteen, the acquisition of *new* linguistic structures has not been taking place for several years, leaving the language learning system unused, and therefore, by hypothesis, hard to start up again. There are numerous other interpretations of the way in which cerebral dominance could be gradually imprinted. The main point is that it would be as easy to say that the loss of second language learning ability causes the cerebral dominance to become fixed as it would be to claim the reverse. They could also be unrelated contemporaries.

It should be noted as well that the specialization of the left hemisphere is an extemely crude and gross phenomenon, compared with the particular kinds of skills involved in the acquisition of language. There is no direct theoretical link between the specialization of the left hemisphere and the capacity to learn language in any case. One *could* postulate that the ability to learn language is biologically innate in the sense that there is a highly specific language learning neurological structure, which resides in the left hemisphere. This claim is extremely strong and bewildering in the light of gradual theories of evolution: however, even if it were true, it would not in itself explain the critical period.

The second theory draws on classical S-R learning theory. On this view, a second language is harder to learn than a first language because of "proactive inhibition." Since the learning theorists of this sort use behavior as the accumulation of S-R connections, the more such connections are accumulated in one's first language use, the fewer are available for a second language. Thus, by age fifteen, the child has spent twelve years talking in his first language and, in effect, has "used up" the mechanisms that underlie the formation of new S-R links in language.

There are a number of difficulties with this proposal. First, learning theory cannot in principle account for the acquisition of linguistic knowledge in the first language, and therefore, cannot be resorted to for an explanation of a critical period in a second language. Second, such a view would predict that learning a third language would be more difficult (and less possible with age) and learning a fourth language more difficult still. In fact, however, insofar as the anecdotal data are to be trusted at all, learning a third or fourth language before age fifteen appears to be *easier*, or certainly no harder, than learning the second. The learning theorists might claim that this is due to a "learning-to-learn" phenomenon; learning a third foreign language is easier because of the experience in how to learn a foreign language at all, which has been acquired in learning the second foreign language. This observation may correctly account for the phenomena, but is not theoretically rooted in the notion of proactive inhibition, which makes the opposite prediction.

A third sort of theory is that the critical period is caused by a shift in the way we learn *all* new skills. On one such view, by age ten, the child has acquired the habit of monitoring him/herself and learning new skills by way of conscious introspection. While such a style of learning may be adaptive to the acquisition of adult abstract concepts, the hypothesis is that this kind of strategy for learning is dysfunctional for learning a language. Thus, the critical period in learning a second language is due to a shift in how the language is acquired, due to a general shift in the way the child acquires everything.

Like the preceding theories, this view has a certain appeal, and would appear to be supported by certain kinds of facts. For example, it does seem to be the case that adults are much more self-conscious about their second language skill, in such matters as pronunciation or mastery of idioms. Also, it is presumably the case that adults are more skilled at the conscious learning of new abstract concepts, which could influence the way in which they approach the acquisition of a foreign language, even when they are not conscious they are applying abstract schemata to do so. However, like the theory that the onset of cerebral dominance causes the

critical period, this theory is observational at best, and not explanatory. We do not know whether adults learn a second language differently because they are introspective or whether adults learn a second language with a high degree of self-consciousness because they *must* do so in order to compensate for their inability to learn it in the natural way they applied to their first language.

Consider by way of example the acquisition of a new motor skill such as skiing. As adults, we can readily agree that a new skill is acquired with considerable intellectual mediation, perhaps even including some theoretical understanding of the physical nature of the phenomenon. There *may* be times at which such intellectualizing gets in the way of acquiring a new skill, but it hardly seems reasonable to claim that such intellectualizations are more than simple attempts to make up for the fact that we no longer have the sensory-motor plasticity of children. Furthermore, there is much evidence that even young children are quite conscious of themselves and their behavior; that self-consciousness is not something which emerges only in the acquisition of skills by adults. For example, the classic observations by Vigotsky (1962) and Piaget (1962,1968) attest to the fact that children between the ages of three and six may literally guide their behavior in complex tasks by talking to themselves out loud. Nothing could be more conscious in the acquisition and performance of complex tasks than this; yet if anything, it seems to be more characteristic of children than of adults.

These are the obvious theories concerning the existence of a critical period for second language learning. Each has certain virtues. The neurological interpretation offers a systemic basis for the phenomenon, one which refers to the loss of plasticity of function which, after all, is the biological basis of most critical periods. The second uses a theory of the normal acquisition of a skill to account for the loss of the ability to learn further skills: while the theory is in fact inadequate, it nevertheless has the virtue that the notion of the "critical period" is not itself grafted onto the theory of first language learning, but rather emerges as a by-product of it. The third theory allows for the learning of a second language after the critical age, but interprets the change in language learning ability as due to a difference in how the language is acquired, rather than simply arguing that it is acquired in the same way as the first language but with less capacity. In the following sections, I propose a theoretical interpretation of the critical period which includes the virtues of each of these theories, but none of the conceptual weaknesses.

An example of a critical period in biological growth

The notion of a "critical period" has its special force because it is rooted in biological science. To understand the concept of the critical period as defined within biology, we can profitably review the history of its application in an area of biology, for example, neuroembryology. Our review of the issues is cursory and unoriginal, but it does provide a paradigm from another science which will be useful for our understanding of the nature of critical periods in areas of cognition such as language.

A classical question in neuroembryology involves the process of cell differentiation and the specification, resulting in loss of plasticity for development. The puzzle of development is simple enough: millions of highly differentiated cells result from a single fertilized cell in interaction with a non-specific and non-directive environment. The empirical and theoretical question is, how does this differentiation of cell structure and function take place? There are two classical answers to this question. On the one hand, one could argue that each cell contains a representation of all possible final cells and of an overall organization which relates them: on this view, differentiation is the emergence of preprogrammed tuning laid down in each cell when it differentiates (i.e., when it first becomes a daughter cell). An alternative view is that each cell has a nonspecific capacity to be "directed" to a number of different special functions. The "director" that determines what each cell becomes might be a physical parameter such as the orientation of the entire embryo with respect to light, gravity or some other extrinsic force.

The primary tool for trying to resolve such questions resulted in the discovery of numerous "critical periods." There is an obvious technique to discover whether a particular cell is influenced by its position in the embryo as a whole: namely, to reposition the cell to another place in the embryo and observe if it differentiates into the same structure that it would have had originally. For example, a cell whose descendents would end up as an eye can be repositioned at various times in the development of a new embryo. If the destiny of that cell is determined, then the animal will develop an eye in the transplanted incorrect position (e.g., in an arm or stomach). The general result of various experiments in this line was that there is a certain amount of plasticity of function up to specific points in the development of the embryo. After these points an individual's cells' destiny is determined. That is, early in the development of an embryo a presumptive eye when moved to a different position in the animal will have daughter cells which are appropriate to that new position. At a slightly later time in the development of the embryo the destiny of the cell and its descendents is fixed: regardless of where it is placed in the body after that time it emerges as an eye. In the sense of the present paper, the cell passes through a "critical period," after which its morphological destiny is fixed.

Recently, the physical basis for such critical periods in cell differentiation has been explored in the case of the visual connections of the frog's eye and visual tectum. Jacobson and Hunt (1973) found that the cell membranes of individual cells are permeable to fluid from adjacent cells early in development: this allows for the passage of biochemical information influencing an individual cell's development as a function of its surrounding cells. The critical point in each cell is reached when, due to internal growth processes within the cell, an impermeable layer forms on the cell wall. From this point on, the cell is "on its own" so far as further differentiation is concerned.

Such discoveries have great implications for our understanding of the mechanisms of cell differentiation, a topic which is certainly far removed from the

question of critical periods in language learning. However, we can extract both a moral and a model from our sibling science that may lead to an understanding of the concept of critical period when applied to language. The essential moral is *the facts of a critical period are accounted for by the normal processes of growth*--that is, the critical period is not a special property of growth in its own right, but rather is the loss of plasticity of function which occurs as cells become more specialized and independent. The model can be articulated as the following.

1. Development initially proceeds within partially independent systems (e.g., cells). Each system differentiates internally and is influenced by the development and properties of adjacent systems.
2. Due to internal processes of growth, the adjacent systems "decouple," becoming independent of each other's influence with respect to further development. This decoupling is "critical" in the sense that under ordinary circumstances it is irreversible.

In order to apply this model of what a critical period is in second language learning, it is first necessary to construct a theory about the normal acquisition of a first language.

First language learning, behavioral systems and the psychogrammar

The outstanding puzzle of language acquisition in current discussions is how and why the child acquires a "grammar," in addition to acquiring the ability to speak and understand sentences. I start the analysis of this problem by defining the notion of a "psychogrammar." For purposes of this discussion, a psychogrammar refers to the psychologically real representation of grammatical knowledge. I use this term in order to avoid resting my arguments on any particular grammar as formulated within linguistic theory.

One basic question is: when does the child acquire the psychogrammar? A common view of language learning suggests that the psychogrammar is acquired at a relatively late age—around five years. On this interpretation, the younger child has no "need" for a grammar. It communicates by using primitive, but effective, "habits" of comprehension and talking. Since the adult environment is highly tolerant of mistakes and ungrammatical utterances, a grammar is not required. Around age five years, the child cannot refrain from using its abstracting capacities to construct a psychogrammar that represents what is shared between speech production and perception. It is useful in refining our linguistic capacities and simplifying the storage of linguistic knowledge. On this view, psychogrammar is one of the responsibilities of growing up and one of the joys of maturity.

While this is a traditional view, and appears to unify language acquisition with the development of cognitive capacities (e.g., the capacity for "abstraction"), it is exactly wrong. The theoretical difficulty with this hypothesis is that it is functionally unmotivated. There is no reason to believe that the presence of a psychogrammar actually improves one's ability to talk and understand sentences: indeed, as I shall point out below, the representation of sentences in a psychogrammar is sometimes at variance with what we can say and understand. Secondly, there is no clear explanation possible of how the "abstracting" process creates the existence of a psychogrammar out of the separate representations of linguistic capacity in the ability to talk and listen, without a prior representation of the psychogrammar intrinsic to each of the separate systems.

Also, there is a naive, but I think unsupportable, belief that the child at around seven starts "abstracting" structures having to do with every aspect of his/her daily life. That is, the child at this age is portrayed as a personal theoretician, applying his/her symbolic capacity to him/herself without extrinsic motivation to do so. I think this view is unreasonable, not only because it is unmotivated, but also because there does not seem to be any independent evidence for it. For example, one of the most common activities that children perform is to walk and run. I know of no evidence that any psychological representation of this skill is developed at an abstract level—for example, representing the physical knowledge that "walking" in fact is "organized falling." The kinds of abstract regularities which the child does seem to discover consciously without special training are extremely important, but extremely simple when compared with the formal structure of a language. For example, the class of constancies which a child painfully and slowly realizes must exist in the transformation of physical substances is acquired over half a decade (e.g., under the experimental rubric, "conservation"). Yet the formal complexity of such a symbolic relation is simpler than most grammatical rules.

The fact that this hypothesis about the emergence of grammar is unmotivated and unsupported, of course, does not prove that it is incorrect. What I shall do in the following discussion is suggest an alternative view as to why the psychogrammar develops, a view which has some positive evidence and which at least proposes that the psychogrammar is acquired because of its functional value, rather than *despite* the fact that it does not have any such value, as in the traditional hypothesis.

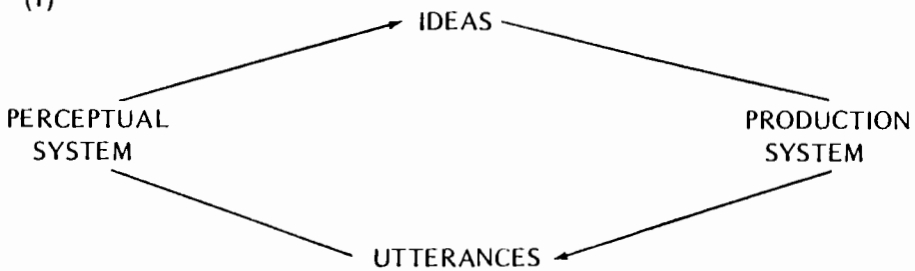
My proposal is this: the reason that a psychogrammar exists is because of the vital role it plays during language acquisition, much of which occurs during the first five years of life. The psychogrammar is needed during that period to mediate between the systems of speech production and perception. It is the internal translator that regulates conflicting capacities which arise as each of the two systems of speech behavior develop separately: if one system gets ahead of the other with respect to a structure, the psychogrammatical representation of that structure can be the basis for an equilibration of their capacities.

This interpretation of why a psychogrammar exists parallels economic interpretations of the emergence and persistence of the bureaucratic state. In that interpretation, the state emerges as the resolution of conflicting interests: even when the interests no longer conflict, the state may fail to "wither away" simply because it has become entrenched as a special structure. Similarly, I am suggesting that the psychogrammar comes into existence because of its role as an internal mediator in early language learning: although it is no longer needed for any purpose by the time a child is an adolescent, it remains as a functionally autonomous structure because it is so entrenched.

Accordingly, the psychogrammar is not a joy of adulthood, but a burden, an adventitious relic left over from a dozen years of language learning. It does not disappear after its usefulness is past because it is so entrenched as a mental system: the psychogrammar is the bureaucracy of linguistic life. In the next few pages, I outline the evidence demonstrating this, and attempt to explain why it should be so. The steps of the argument are first to demonstrate that the systems of speech perception and production are independent from each other in the adult, then to demonstrate an independent motivation for the claim that a psychogrammar exists in the adult, then finally, to demonstrate that the function of the psychogrammar can be to mediate between production and perception as those skills develop in early childhood.

Adult Speech Perception and Production: The fundamental mental activity in using speech is to relate inchoate ideas with explicit utterances. The direction of this mapping characterizes the difference between speech production and perception. The main question is whether the two systems are the same one, running in opposite directions, or whether they use different processes and are independently represented in behavior.

(1)



There are three kinds of considerations supporting the view that these two systems can operate independently of each other: the needs of the speaker are opposite to those of the listener; preliminary experiments suggest the systems use different kinds of behavioral processes; there are empirical examples of sentences that are unusable productively but not perceptually, and vice versa.

Consider first the conflicting needs of the speaker and listener. The listener optimally requires that the internal grammatical and semantic relations be explicitly marked in the surface sequence. This would make the perception of the sentence homonymous with the recognition of the surface elements—no further processing would be necessary. The needs of the speaker are the converse of explicitness: the optimal situation for the speaker would be one in which each utterance could consist of a single monosyllabic grunt, which the listener would always interpret correctly.

Actual utterances clearly strike a balance between these two extremes. It would be a mistake to draw direct conclusions about the nature of the psychogrammar from the behavioral balance between speech perception and production. However, the conflicting constraints on optimal utterances do suggest that the behavioral systems themselves could differ internally. This possibility is supported by the current empirically based theories of perception and production. The data on these systems are unfortunately meager (a few hundred published studies). However, the most salient difference between perception and production is that the major planning unit differs: for the speaker it is something close to the "surface structure clause," while for the listener it is something close to the "deep structure sentoid." The reason for this is not obscure: the speaker's problem is to find a mapping of a given, unconscious idea (relatively close in form to a deep sentoid) onto a compact but comprehensible explicit surface sequence. The listener's problem is to discover the underlying sentoids intrinsic to each utterance.

Thus, the different goals of speaker and listener lead to different organization of the mapping process. It follows from this difference that psychological processes of production and perception must differ, at least in part. That is, it is not the case that for every process of speech production there corresponds an isolable process of speech perception that is its inverse. It remains to be seen how much the two systems differ: even our current rudimentary knowledge indicates that there are some differences. That is, the systems are independent, at least in part.

Finally, we can isolate in our everyday speech behavior examples of sentences that we can understand but could not say ourselves, and sentences we can say but could not understand if somebody else said them. This, too, is prima facie empirical evidence supporting the behavioral distinctness of the two systems. Sentences that others say that we do not understand are all too common, and need no examples. But, by the same token, sentences that we utter that others do not understand are equally common. While this in itself does not prove that the systems are independent entities, it does show that running the idea-utterance mapping in one direction is not behaviorally equivalent to running it in the opposite direction.

These three kinds of arguments, general, technical, and anecdotal, support the claim that the systems of speech perception and production are independent entities in the adult mind. We understand utterances using one system, and speak using the other. This raises the question of the motivation to postulate a psychogrammar as part of the mental representation of language. There are already two systems for pairing ideas and utterances which combine to provide bidirectional mappings. Why, then, do we postulate a psychogrammar as a separate mental entity?

The Psychogrammar and Speech Behavioral Systems: There are three sorts of considerations supporting the distinction between a psychogrammar and the systems of speech behavior: it renders the distinction between linguistic knowledge and behavior; it combines with other linguistic systems to explain a

variety of facts about linguistic intuitions; there are critical examples of sequences that are intuitively well-formed but unusable, and vice versa.

Consider first the role of the psychogrammar in defining linguistic knowledge. The distinction between linguistic knowledge and language behavior arises initially out of the logical possibility that there is a distinction between what we "know" and what we "do." At first, such a distinction may seem obscurantist, especially to the empiricist. However, the postulation of this distinction is by no means unique to a "higher" abstract function like language. Rather, some of the most basic areas of psychological research find it necessary to postulate this distinction. For example, consider the T-illusion in which we "know" that the horizontal and vertical lines are equal in length, but we can "behave" as though the vertical line were longer (this extends both to the perceptual judgment and to the production of a drawing of the lines.) Indeed, it is characteristic of illusions that they involve this kind of contrast, and it is for this very reason that the study of illusions has been central to psychology.

We may take the position, as does Piaget, that the distinction is between two kinds of knowledge ("operative" and "figurative"). Or, like others, one could argue that the two ways of observing illusions are really due to two kinds of behavior (e.g., "measuring" vs. "estimating"). Whichever view one holds, the fact remains that the distinction is maintained, and that both ways of dealing with the stimulus are assumed to be psychologically real.

This in itself does not prove that there is such a distinction in the case of language. It does, however, establish a precedent in one of the most fundamental areas of psychological study: the postulated distinction is not unique to research in language. If one turns to this research one finds two kinds of empirical arguments supporting the claim that there are two kinds of representations of language—the behavioral systems governing speech behavior and the psychogrammatical representation of linguistic knowledge.

The first is a technical argument resting on the fact that assuming the existence of a psychogrammar allows us to explain a variety of facts about linguistic intuitions and aspects of language. It allows us to investigate and sometimes to answer which kinds of language universals are due to psychogrammatical constraints and which are due to other systems of speech behavior. Essentially, this argument is the claim that if one assumes a distinction between "competence" and "performance" (rendering the distinction between linguistic knowledge and language behavior), one can explain a variety of facts about language.

I think that the achievements of this approach have been prodigious and justify the distinction in themselves. I freely grant, however, that such an argument smacks of methodological sermonizing; the indirectness of the argument lacks full convincing power. A more direct argument for the distinction between a psychogrammar and speech behavior systems is the existence of empirical evidence that the two kinds of mental structures are independent. The crucial data are sequences which are unusable but intuitively well-formed and sequences which are usable but intuitively ill-formed. These cases illustrate that behavioral usability and intuitive well-formedness do not overlap completely, showing that each is accounted for by (at least partially) independent mental representation.

The significance of sentences that are unusable but intuitively well-formed has long been recognized. A classic example of this is a center-embedded sentence such as (2).

(2) The dog the cat the cricket chirped at meowed at barked at me.

Upon ratiocination one can appreciate the fact that such sentences are a combination of singly embedded ones like (3) and (4).

(3) The dog the cat meowed at barked at me.
(4) The cat the cricket chirped at meowed at the dog.

Thus (2) seems intuitively well-formed, but is obviously unusable. Furthermore, the fact that (2) is well-formed is demonstrated by the fact that a structurally parallel sentence like (5) is completely usable.

(5) The reporter everyone I met trusts had predicted Lance's resignation.

Something about (2) (perhaps the homogeneity of the nounphrases and verbphrases) is impossible for the behavioral systems to manage. Such cases show that the domain of structural well-formedness can exceed that of behavioral usability.

A separate set of cases shows that the domain of usability can exceed that of well-formedness. Consider the cases below, which are all taken from actual observations.

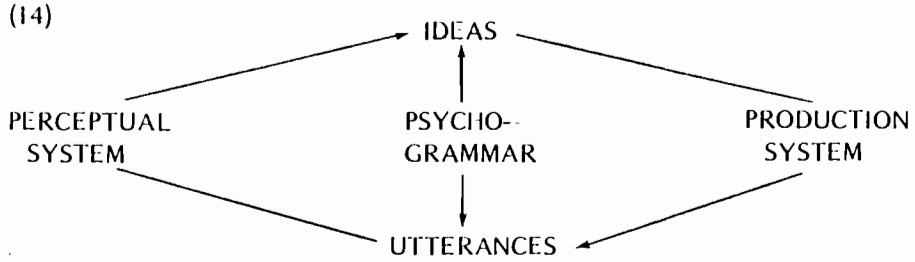
(6) That's the first time anybody ever sang to me like that before.
(7) I really like flying in an airplane that I understand how it works.
(8) Everyone forgot their coat.
(9) Either you or I am crazy.

Each example is perfectly usable, perfectly utterable, and comprehensible. But each is also intuitively ill-formed. This intuition can be backed up by showing that there are structurally identical sequences, differing only in a critical word, that are completely unusable (or at least would not be used) e.g.,(10)-(13). This demonstrates that the original intuition of structural oddness was correct, but that specific properties of (6)-(9) make them usable.

(10) *That's the second time anybody ever sang to me like that before.
(11) *I really liked flying in an airplane which I understand how it works.
(12) *Harry forgot their coat.
(13) *Both you and I am crazy.

These three arguments--general, methodological, and empirical--support the claim that the psychogrammar and the systems of speech behavior are independent in the adult mind. That is, the schematic outline of the representation of language is like that in (14), not (1).

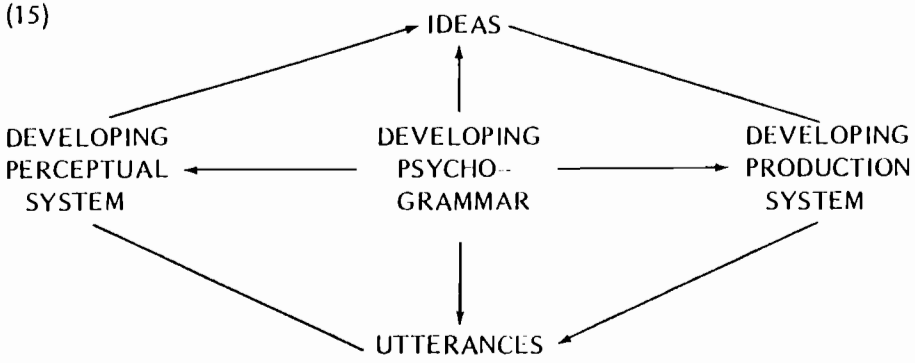
(14)



As adults, we have two separate ways of mapping ideas and utterances, through the psychogrammar, or through the conjunct of the systems of speech production and perceptions. Clearly the psychogrammar exists in the adult, and yet clearly it is redundant for adult language behavior. Why do we have it?

The Psychogrammar in Language Learning: The answer lies in the language-learning child. A child is acquiring two fundamental language abilities, the ability to talk and the ability to understand--that is, the child is acquiring a system of speech production and perception. Since these systems are behaviorally independent in the adult, we might expect them to be learned independently in the child: on this view the role of the psychogrammar is to translate internally between the systems of production and perception, and thereby to build up a representation of what is implied by their conjoint operation. That is, the schema of the language-learning child is like that in (15), rather than (13).

(15)



There are three kinds of arguments supporting this view of language acquisition. The psychogrammar provides the behavioral systems with an otherwise unavailable specification of linguistic universals and behavior-free record of what has been learned so far; there is evidence suggesting that the systems of speech perception and production are learned separately, thus requiring the psychogrammar to bring their capacities into alignment; anecdotal data suggest that young children are aware of the disparity between the way they talk and the way they think they ought to.

The first argument is primarily in the form of a formal justification of why the scheme outlined in (15) must be true of the language-learning child. The emerging psychogrammar serves two functions. First, it provides the emerging behavioral systems with an input vocabulary(e.g., "noun, distinctive feature, tree structure") which gives the behavioral systems a common set of objects to work with. The richness of the initial vocabulary is an open, hopefully empirical, question. Whatever the answer, there must be some initial internal language common to the systems of perception and production. Otherwise, they might never map the same kind of structures for the same kind of idea-utterance pairs.

A second role for the emerging psychogrammar is to record and simplify the amount of memorized material. Very early in language learning each new utterance can be memorized; but as the number of utterances increases, the load on memory can be eased by the application of a grammatical organization (given that humans are predisposed to develop grammars at all). Accordingly, the grammar can become a repository for accumulated perceptual and production patterns applying its own organization reductions to them.

It should be clear from these two proposed functions of the psychogrammar that I am suggesting that it develops in part because of its functional role in equilibrating the independently developing systems of speech perception and production. The heart of the problem is this. If a child learns to understand a new construction (however such perceptual "learning" occurs) how does this become transported to the production system? Conversely, if the child tries out a new speech production process (based on the schemata acquired thus far) and decides it is successful, how does that new knowledge become transported to the perceptual system? It is the role of the psychogrammar to maintain the perceptual and production capacities similar to one another.

Crucial evidence on this point is the fact that the perceptual and production systems develop separately and with different capacities: thus we have initial evidence that what the child says and understands can differ during language acquisition. For example, at around age three the (English-speaking) child shifts its perceptual strategies so that the first noun in a clause is regularly interpreted as the actor. (Earlier in life it was any noun immediately before the first verb.) This shift in a perceptual process is not accompanied by any marked change in what the child utters--indeed, that particular strategy characterizes the speech production pattern of the much younger child.

Considerably further study is needed to demonstrate that the perceptual and production capacities leapfrog one another during development. In particular, there are very few children who have been longitudinally followed with systematic investigation of both speech production *and* perception. Nevertheless, the preliminary evidence suggests that these systems do develop separately, thus requiring some internal mechanism to equilibrate them; by hypothesis that mechanism is the emerging psychogrammar.

The final argument supporting the schema in (15) is anecdotal evidence that children themselves are aware of the distinction between their own language behavior and what they "ought" to say. Consider the following true anecdote. It shows that the child says an incorrect form *(goed)*, that it recognizes to be "wrong."

(16) Child: Mommy goed to the store.
Father: Mommy goed to the store?
Child: No, Daddy; *I* say it that way, not *you*!
Father: Mommy wented to the store?
Child: No!
Father: Mommy went to the store.
Child: That's right, Mommy wen . . . Mommy goed to the store.

Since it cannot produce the right form (at this stage) and understands both correct and incorrect forms, where does the child "represent" the distinction between the "right" and the "wrong" way to say it? A psychogrammar is the repository of such knowledge. Such anecdotes are common enough to lend initial plausibility to this interpretation but obviously require further study.

These three arguments support the claim that the psychogrammar exists as a mediator between the emerging systems of language behavior: it provides linguistic universals and records accumulated linguistic knowledge; it equilibrates the systems of speech perception and production as they leapfrog one another; and it accounts for the anecdotal evidence that even the young child is aware of the distinction between linguistic knowledge and behavior.

In brief, the psychogrammar serves the function of being the internal mental "language" in which the speech perception system and the speech production system communicate: it provides a mental vehicle for translating a perceptual schema into a production capacity with the net inverse effect; when a new perceptual schema is learned, the psychogrammar essentially is a transducer which can translate from one domain of the child's capacity to another. In that sense, it regulates the conflicts between those two separable emerging capacities. The psychogrammar is the bureaucratic manager of the child's acquisition of language abilities. By the time we are adults, the systems of perception and production are in almost complete register: we no longer *need* the psychogrammar to serve the function of an internal mental language. But by that time it has become thoroughly entrenched as an independent representation of the mapping between ideas and utterances. Like the systems of perception and production, its internal structure leads to slightly differing mappings, although those differences are without negative consequences for adult behavior.

Decoupling of language systems and the critical period for language learning

This outline of the normal acquisition of the systems of language behavior and the formal representation of a grammar provides the basis for understanding what the internal nature of a "critical period" could be. Recall that the critical period for the differentiation of cells in the neuroembryological model was caused by the "decoupling" of adjacent cells and cell systems due to normal processes of individual cell groups. Once decoupling occurred, the possibility of influence from one system to another was cut off. While there is no hypothesis about the mechanistic substantiation of such a decoupling of systems in the case of language learning, our model of linguistic development allows for exactly the same kind of interpretation of a critical period in learning a second language.

Suppose that the developed systems of speech perception and production become functionally autonomous in the adult. That is, suppose the schema appropriate to the *adult* representation of language is that outlined in (14). On this view, the psychogrammar and the behavioral systems have decoupled (by age 15 years). It would be useful to understand the mechanism of decoupling, although it is not necessary to do so in order to maintain the schema in (14). A reasonable hypothesis is that when the speech production and perceptual system are well-aligned with respect to a linguistic property, then internal communication between them is no longer needed for that property. The communication channel falls into disrepair because of disuse. Learning a new language after this point may well be possible, but it now will proceed in a manner fundamentally different from that at a younger age. After this age, the problem of language learning is how to map each of the distinct and separate first language behavioral systems onto the corresponding systems in the second language, in partial independence of each other. This is not only likely to make the job of learning a language more difficult: it will certainly make it more disjointed.

This interpretation of the nature of a "critical period" for second language learning follows the nature of what a critical period is as isolated in biological research. Furthermore, it has the virtue of being predictable from *intrinsic* properties of the acquisition of language behaviors and linguistic knowledge. That is, the phenomena which are collected under the term "critical period" for second language learning themselves follow from the theory of language learning, rather than being a special set of phenomena which are tacked onto other aspects of language acquisition. Before turning to isolated experiments it is useful to consider a commonly reported fact about the critical period for language: it is often claimed that people who continue to learn new languages never experience an offset of the capacity to learn a new language. Such a phenomenon is incompatible with each of the three standard interpretations of the critical period discussed at the beginning of this paper. There is no reason for continuous

language learning to mitigate the effect of the critical period if it is caused by the onset of cerebral dominance or introspective modes of learning; the proactive inhibition model predicts the opposite—the more languages one learns, the harder to learn a new one.

The correct model predicts exactly the anecdotal finding—so long as one is *continually* learning a new language—the systems of production and perception never become fully autonomous, and closed off from each other. That is, continuous acquisition can stave off the independence of the systems, and therefore delay the apparent critical period.

In the following section, I review a number of disparate facts we have studied in the acquisition of a second language which are predicted by this view but not by other theories of the critical period. Although considerable further research is required, these initial demonstrations suggest that we are on the right track.

Some experiments related to the theory

The following summarizes some experimental work we have done that bears on this theoretical interpretation of the relation between first and second language learning. The particular results are chosen because they are either uniquely consistent with the present theory or inconsistent with one of the alternatives.

Age of starting to learn a second language correlates with measures of speech performance, but not with measures of linguistic consciousness

This prediction follows from the view that the critical period results from the decoupling of speech performance systems from each other. This implies that learning a second language after this decoupling takes place will be more disjointed--there can be a greater imbalance between the productive and perceptual capacity. We can expect that this difference will show up in measures of speech performance, but not in measures of linguistic knowledge—the ability to recognize the structural properties of the new language. The decoupling theory offers no basis for expecting any difference at this level of linguistic sensitivity.

This was tested (inadvertently) in S. Oyama's dissertation, carried out in our laboratory (see Oyama 1976). Oyama studied the linguistic capacity of Italian-Americans on a number of variables, including accent, speech comprehension, ability to detect ungrammatical sequences, ability to detect ambiguous sentences, and the ability to decode the meaning of short nounphrases. Her subjects were selected so that she could assess independently the effects of age-of-arrival in the United States (from six years to twenty) and number of years in the United States. She found no significant correlations between her linguistic sensitivity measures and the number of years in the United States. However, she did find significant correlations between the age-of-arrival and the measures of accent, comprehension, and recognition of syntactic errors. There was no correlation with the ability to detect ambiguities or to decode the semantic relations of short nounphrases.

Such a result is one of the first clear demonstrations that a critical age exists at all. Furthermore, it confirms the prediction that the critical age governs speech performance, and not linguistic competence as such. The more abstract tasks involving high degrees of conscious linguistic awareness were not related to the age at which the second language was started.

The critical age differs for different "levels" of linguistic skill

It is a common anecdotal report that foreigners can master certain aspects of a second language more easily than others. For example, pronunciation accent appears most persistent, even in foreign speakers who have manifest capacity to speak syntactically and semantically correct sentences. This could appear puzzling since there is a relatively small number of motor "habits" that differentiate one phonological system from another—while semantic and syntactic systems can differ in many intricate and abstract particulars. Why is a new syntactic and semantic system *easier* to learn?

The view that the role of the grammar is to translate between the systems of speech perception and production offers a rationale for this phenomenon. On this view, an aspect of the grammar is activated internally only when there is a mismatch in the capacity of the production and perception systems. Early in the child's linguistic development virtually all of the phonological system is learned, simply via resolution of conflicts in the perception and production of short sequences. This is not true, however, for the syntactic and semantic aspects of language: their mastery requires practice with long and varied sequences. Consequently, the phonological structure of a *grammar* as a mediating system becomes unused earlier than the semantic or syntactic structures. This is not to say that the phonological system is easier to learn—only that sufficient data for its complete acquisition are available to the child at an early age: once the speaking and identifying capacities are equilibrated, further phonological learning stops, and the constructed mapping system lies fallow. Semantic and syntactic differences between production and perception, however, continue even into adolescence.

The decoupling model of the critical period predicts the following: the critical age for phonological learning will be younger than for syntax and semantics. Oyama's dissertation (see above) did not test this directly, but it does afford the data for analysis of the critical age-of-arrival for each type of linguistic performance. I examined this by calculating the year-to-year *rate* of improvement on each measure as a function of decreasing age-of-arrival. This gives a measure of the effect of each year and allows us to assess, for example, whether the difference between arriving at age six and seven is the same as that between arriving at age eleven and twelve. A simple measure is the median age of the year-to-year transitions of greater-than-average improvement on a test. This median age is ten years for phonological accent and thirteen years for the syntactic-semantic measures which Oyama used. That is, the critical age does appear to differ for the different aspects of linguistic structure.

While habitual phonetic sensitivity may be lost very early, conscious sensitivity increases with age

A current standard theory of phonetic perception is the *motor theory*, the proposal that we learn to perceive fine phonetic discriminations as a function of our ability to produce them. This view, in itself, does not accord with the fact that second language learners often learn to discriminate sounds in the new language which they cannot distinctively produce. On the present theory, this is exactly because of the decoupling and independence of the ability to talk and listen.

For the first language learner, the systems are coupled (via the emerging grammar, by hypothesis). The first linguistic level at which production and perception should equilibrate is the phonetic level: as mentioned above, this prediction follows from the fact that the relevant stimulus information and motoric capacity are available to an infant, *even before it knows what the sounds mean.*

Recent research has explored a phonetic variable that is extremely basic to each language—the timing relation between the onset of voicing and of articulation, the so-called voice-onset-time (VOT). Research at Haskins Laboratory has established that there are discretely different categories in VOT, both in speech production and in perception. Eimas showed that young children (ca. three months) are also sensitive to such shifts (Eimas et al. 1971). L. Streiter (1976) used the same technique to study VOT in infants whose native language is Kikuyu. An interesting feature of her results is that the older Kikuyu infants in her study were selectively less sensitive to non-Kikuyu phonetic VOT transitions. That is, their sensitivity to Kikuyu VOT transitions was selected out and other possible VOT categories are dropped. Further study is required to establish the relation between this perceptual tuning and the development of the infant's babbling.

While the ability to respond to fine phonetic features may decrease with age, the ability to make conscious introspective judgments may increase. D. Pertz studied childrens' ability to assess the probability that different non-English consonant clusters would exist in some language (see Pertz and Bever 1975). She found that older children were better able to predict the actual probability than younger children. Interviews with the children suggested that the way they made these judgments was by introspecting about how hard it was for them to say each consonant cluster.

Speech comprehension is mastered with different stages after the critical age

In normal learning of a first language, the developing systems of speech perception and production can influence each other. This may explain why young children learning English pass through a period of interpreting all noun-verb-noun sequences as "subject verb object." The development of this comprehension pattern at age four can lead to *worse* comprehension than at age two of certain kinds of sentences (e.g., "It's the cow that the horse kisses").

First, we replicated this pattern of stages in comprehension with Spanish-speaking children (all under eight years of age) (see Bever & Denton, in press). The child's overall mastery of English correlated with its use of the "NVN-SVO" strategy in the same way as age in children learning English as their first language. That is, children with an intermediate overall mastery of English showed more reliance on that perceptual strategy than either children with very little or great overall mastery of English.

We then used the same procedures to test Spanish speakers learning English who were all over sixteen years of age. They showed no evidence of the stages of comprehension found in the younger children. This is consistent with the view that by age sixteen speech production and perception are learned in relative independence.

Conclusion — language universals and functional bases for grammar

These scattered results by no means provide monolithic support for the main hypothesis about the nature of the critical period. But the very fact that they are so different, and are not uniquely predicted by any of the other theories of the critical period, gives a special kind of initial confirmation to our proposal.

The theoretical analysis of a grammar as an internal mediator offers a functional basis for the mental incorporation of a grammar at all: the grammar is discovered in order to achieve the maximum mental consistency during childhood. I have suggested that this may be a characteristic functional basis for the discovery of many kinds of formal intuitive knowledge.

It is theoretically attractive to have a functional motivation for the discovery of the grammar by the child. But a sharp distinction must be made between the claim that there is a functional motivation for the discovery of grammar, and the claim that there is a functional basis for grammatical structures. I am *not* suggesting that grammars have the particular formal character that they do because of the way they are learned or the uses to which they are put. Rather, I have offered an explanation as to why it is functional to learn a grammar at all.

The determinants of its form are another matter entirely. Certain features that are true of all grammars may be functionally motivated by the uses of language—for example, the fact that all grammars allow for a modest amount of ambiguity. Other features may be directly related to the presently-proposed theory of grammar acquisition. For example, phonological systems may be generally "simpler" (in some intuitive sense) than syntactic or semantic systems, because they are mastered earlier, at a time when complex conflicts in representation can neither be generated nor reconciled. Furthermore, there may be properties of all internalized formal systems which grammars could differ only with respect to features in which perceptual/productive conflicts are likely to arise.

Finally, certain formal attributes may have no functional causes either in the way grammar is used or in the way it is learned. These formal universals would be the true core of a universal grammar.

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PART III

A PHILOSOPHIC VIEW