

Maturational Constraints on Language Learning

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This paper suggests that there are constraints on learning required to explain the acquisition of language, in particular, *maturational* constraints. First, empirical evidence for this claim is reviewed. The evidence from several studies of both first and second language acquisition suggests that normal language learning occurs only when exposure to the language begins early in life. With exposure beginning later in life, asymptotic performance in the language declines; the effects over age of first exposure are approximately linear through childhood, with a flattening of the function in adulthood. These outcomes argue that some type of constraints ensuring successful language learning exist early in life, and weaken with increasing maturation. Second, two hypotheses are considered as to the nature of these maturational changes. One hypothesis is that constraints on learning particular to language acquisition undergo maturational decay. A second hypothesis, which is considered in more detail, suggests that language learning abilities decline because of the expansion of nonlinguistic cognitive abilities.

As in other articles in this issue, I will argue that the type of behavioral development I study—namely, language learning—operates under a set of internal constraints, without which it would be impossible to achieve adult competence. Language acquisition has been perhaps the earliest arena in which it has been widely argued that constraints on learning are required (Chomsky, 1965; Wexler & Culicover, 1980). This argument has been based primarily on two bodies of evidence: First, the logic of the language learning problem requires that some type of internal constraint exists in humans. Formal demonstrations have shown that the learning of systems like human languages cannot be based solely on the type of input data children receive (Gold, 1967; Wexler & Culicover, 1980). Second, a vast body of evidence showing common universal patterns in human languages likewise suggests that humans must be biased in particular ways to induce such similar out-

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comes, and fail to induce many apparently possible (nonhuman) languages (Chomsky, 1965, 1981).

In the present article I will present a third type of evidence. In particular, I will present some of our evidence that language acquisition occurs under *maturational* constraints, operating successfully only during a maturationally bounded period. Given similar input, learners in different maturational states do not achieve the same outcome. This finding suggests that at least some of the constraints insuring successful language acquisition do not remain constant even within the human lifespan. While such findings argue that internal constraints must exist, they do not dictate their precise nature. However, the shape and character of the function relating success in language learning to the maturational state of the learner may help in pointing toward viable classes of explanation. For example, in much of developmental psychology, insofar as there are maturational effects, an uncontroversial generalization is typically that big kids are better than little kids. In language acquisition (and possibly in other domains as well), however, the child, and not the adult, appears to be especially privileged as a learner. The correct account of such a phenomenon must therefore explain not only why children are successful language learners, but also why adults, who have better capabilities than children at most things, are not.

I will begin by reviewing some of our evidence for the basic claim of a maturational effect, leaving aside the question of why this might be and whether the maturational constraint is particular to language or more general. After this review I will then suggest a possible account of the maturational constraints responsible for the findings, one which is rather different in character from most prior discussions of constraints on language learning.

EVIDENCE OF MATURATIONAL CONSTRAINTS IN FIRST LANGUAGE LEARNING

First, then, is the evidence that language learning is indeed subject to maturational constraints. Much of our work on this topic comes from studying the acquisition of American Sign Language (ASL). There are two main reasons why psycholinguists might study American Sign Language. One is that it is a language in a different modality than the usual one, and therefore offers the opportunity to examine the contributions of modality to the structure and acquisition of language. ASL has developed quite independently of English or any other spoken language, and has an entirely different grammar than that of English. At the same time, it is a natural language, in the sense that it has evolved within a human community of users rather than being devised or invented by technicians or educators. Linguistic research on ASL has demonstrated that it has the same degree of expressiveness and grammatical complexity as other languages of the world. Moreover, it dis-

plays the types of structural properties and developmental patterns shown by other natural languages (Klima & Bellugi, 1979; Newport & Meier, 1985; Supalla, 1982). These commonalities, despite independent evolution, thus suggest that such linguistic properties must not be linked in crucial ways to the particular modalities in which languages make their appearance.

The second reason why one might study ASL is that it is a language which is sometimes acquired under very different circumstances of time and input than the typical situation for spoken languages (Fischer, 1978; Newport, 1981). In particular, we have studied users of ASL to investigate whether there is a *critical period* for the acquisition of a first language. Although most profoundly deaf individuals in the United States use ASL as their primary language of communication (and are not highly fluent in any other language), they vary widely in when they were first exposed to the language. A small 5–10% of deaf signers are born to deaf parents and are exposed to ASL in the family from birth. The remainder of the deaf, signing community are born to hearing parents who, particularly until recently, did not know any sign language and were discouraged from learning any. These deaf children therefore often had no effective language exposure at all in infancy and early childhood. Although they may have been exposed to spoken English and even to training in lipreading and speech, for the congenitally and profoundly deaf this exposure is not highly effective and does not result in normal acquisition of English (Quigley & Kretschmer, 1982; Wilbur, 1979). Such individuals are then typically first exposed to ASL by being immersed with other deaf children in residential schools for the deaf, where ASL is not taught formally but is the language of everyday life among the children. Age of exposure to ASL is thus the age at which such children begin residential school: usually age 4–6, but sometimes much later, depending on whether the parents first sent the children to nonresidential schools where signing is often intentionally and successfully prohibited among the children. ASL is then the everyday and primary language, from the time of first exposure on. In short, then, the deaf population offers the opportunity to observe the effects of age of exposure to a first language on the competence one achieves in that language.

Arguing for a maturational basis for language acquisition, Eric Lenneberg (1967) first hypothesized that there was a critical period for language acquisition, extending from infancy to perhaps puberty.¹ However, his argument lacked direct evidence of effects of age of exposure on the acquisition of a first language, since virtually all normal humans are routinely ex-

¹ Lenneberg also proposed a neurological mechanism to explain the critical period. While this neurological mechanism has not received support from subsequent work (Krashen, 1975) and therefore will not be discussed in this paper, the critical period hypothesis itself can be considered independently.

posed to their first languages from birth. He therefore made his argument primarily by indirect evidence, particularly from data on the recovery of language after brain damage at varying ages: While children recover language quite well, adults do not. Although such evidence is certainly suggestive of a maturational constraint on language acquisition, it speaks most directly to a maturational change in the ability of nonlanguage areas of the brain to assume linguistic functions; it does not provide evidence concerning maturational changes in normal language learning abilities.

Since the publication of Lenneberg's important book, however, a number of other investigators have pursued his hypothesis. Most notably, studies of Genie, a girl isolated from linguistic input (and all other normal social and environmental stimulation) from around a year of age until after puberty, have suggested that first language acquisition during adulthood results in strikingly abnormal linguistic competence (Curtiss, 1977). A similar outcome has recently been reported for the case of Chelsea, a deaf woman isolated from linguistic input from birth to age 32, when her first exposure to spoken English was provided by successful auditory amplification (Curtiss, 1988). But, because of the (thankfully) rare occurrence of first language deprivation in otherwise normal individuals, little more has been discovered about the function relating age of exposure to linguistic competence.

Our own work on American Sign Language competence in the deaf community (Newport & Supalla, 1990; Newport, Supalla, Singleton, Supalla, & Coulter, 1990) has allowed us to investigate linguistic competence in a fairly large population of individuals who widely vary in age of exposure to their first full language, but who are socially, cognitively, and environmentally fairly normal. (See also Mayberry, Fischer, & Hatfield, 1983, for related findings on a measure of linguistic performance.) These studies, we believe, therefore approximate an experimental investigation of the effects of age of exposure on the acquisition of a first language.²

Our subjects for these studies have been congenitally or prelingually deaf adults whose primary language is ASL, and who have only limited skills in English. All of our subjects attended the Pennsylvania School for the Deaf (PSD), and interact socially with one another within the deaf community of

² Our studies only "approximate" the ideal study for several reasons. First, as already described, even profoundly and congenitally deaf individuals have some (limited) knowledge of spoken or written English; ASL is thus the first language to which they have been fully and naturally exposed, but not always the only language they are acquainted with by the time we test them in adulthood. Second, of course, the subjects are not assigned to experimental conditions entirely at random, but are sorted into these conditions by accidents of birth and parental choice of schooling. We believe these accidents in fact produce fairly random determinations of age of acquisition, but alternative accounts of our data as due to factors correlated with age of acquisition must be considered. See below, Newport & Supalla (1990), and Newport et al. (1990) for further discussion.

Philadelphia. At time of test all were approximately 35- to 70-years-old. All attended PSD at a time when signing was prohibited in the classroom; they acquired ASL naturally, by immersion in the language within the dormitories at PSD and (for the Native group only) within their family homes. They are therefore quite a homogeneous population, except in when they were first exposed to ASL.

Most of our work has been performed on 30 subjects, who fall into three groups of age of first exposure to ASL: *Native* learners (exposed to ASL from birth by their deaf signing parents in the home and from ages 4-6 by deaf peers at PSD); *Early* learners (first exposed to ASL by deaf peers at age 4-6, when they entered PSD); and *Late* learners (first exposed to ASL by deaf peers after age 12, when they entered PSD or when they met friends or married spouses from PSD). Late learners first attended strict "oral" schools where they were not exposed to ASL; they entered PSD because the family moved to Philadelphia, or because their previous school did not include a high school. In sum, the subjects fall into one of these three groups by relatively random assignment, due to accidents of birth or family choice of schools, and are otherwise a highly homogeneous population. All subjects had a minimum of 30 years of daily exposure to ASL.

Our first study (Newport & Supalla, 1990) examined their elicited production and comprehension of the complex morphology of ASL verbs of motion; a subsequent study (Newport et al., 1990), still in progress, included a battery of 15 tests, both production and comprehension, of a variety of structures in ASL syntax and morphology. Altogether, the test battery examines such structures as basic and topicalized word order; agreement between subject, object, and verb; the use of verbal classifiers and associated motion morphemes; verb inflections for aspect and number; and derivational morphemes which distinguish related nouns and verbs. The production tasks each present a series of short videotaped events which the subjects are asked to describe, in ASL; the events are designed to elicit one sign or simple sentence responses which, over the test, contrast in the set of morphemes or syntactic forms required in ASL. The comprehension tasks each present a series of short videotaped ASL signs or sign sentences, which, over the test, contrast as in the production tasks; the subjects are asked to manipulate an object or to choose one of two pictures in correspondence with the meaning of the ASL form.

For example, linguistic analyses of ASL have revealed that ASL verbs of motion are composed of several components of form which vary independently, in accord with particular aspects of the event of motion (Supalla, 1982). The tests of these structures are designed to evaluate whether deaf subjects produce and comprehend each of these components correctly, according to the standards of native ASL grammar. In the Verbs of Motion Production test (VMP), each item shows an object (e.g., a car or a person)

moving along a path (e.g., moving in a straight line or in a circle), with a manner of motion (e.g., bouncing or rolling). The subject is asked, in ASL, to say what happened. The appropriate response should include a verb with several morphemes, one for the category of the moving object, another for the path of motion traversed, and a third for the manner of motion used. In the Verbs of Motion Comprehension test (VMC), each item shows an ASL verb of motion, and the subject is asked to choose the appropriate object and make it perform the action. The response should involve making the correct object travel along the proper path, with the proper manner of motion. As another example, in ASL verbs "agree" in spatial location with their subjects and objects (that is, they move from the location of the subject to the location of the object). The Verb Agreement Production test (VAP) includes a series of events which vary in which of several videotaped participants is the subject, and which the object, of an action; signed responses should likewise vary in which participant the verb agrees with. The tests of the other linguistic structures are constructed similarly, in accord with analyses of native ASL usage. Scoring on each of the tests is performed by native signers, both quantitatively (with target responses predicted from linguistic analyses and verified by the test data from native signers) and qualitatively (internal analyses of the subject's responses, to determine the patterns of usage for non-native signers).

Figures 1a and 1b present the mean scores on 8 of the tests from the ASL Test Battery, for the three groups of learners who vary in age of first exposure to ASL. (The other tests are either still in the final scoring stages or are inappropriate for quantitative presentation.) The test scores fall into two types. First, Figure 1a shows the scores on *ASL basic word order*. As can be seen, control over basic word order does not show effects of age of acquisition; subjects in all groups score virtually perfectly. Figure 1b shows the scores on 7 tests of *ASL morphology*, with scores transformed into *z*-scores for comparability across the tests. In sharp contrast to the word order data, the scores on morphology all show consistent and significant effects of age of learning, with Natives outscoring Early learners, who in turn outscore Late learners; correlations between age of acquisition and test scores range around $-.6$ or $-.7$. The distinction between word order and other grammatical structures is in accord with results from the study of Genie (Curtiss, 1977), who after puberty mastered the basic word order of her language but did not control its morphology.

Individual morpheme scores, error patterns, and qualitative analyses of responses also show differences for early versus late learners. Native learners show highly consistent response patterns, in accord with grammatical descriptions of obligatory morphemes of ASL. In contrast, while late learners show some (well above chance) usage of the same forms, they also show several other types of usages which natives find ungrammatical in ASL. First, they show use of what we have called "frozen" lexical items; these are

a. Basic Word Order

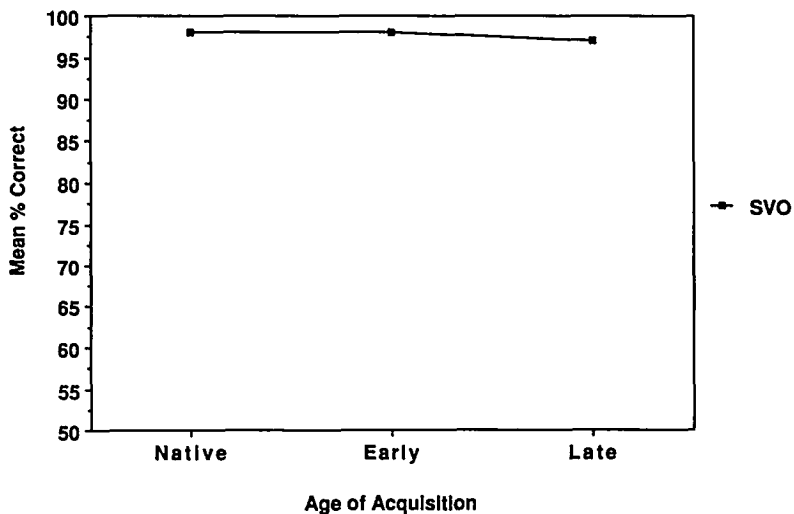


Figure 1a. Score on ASL Basic word order for Native, Early, and Late learners of ASL.

b. Morphology

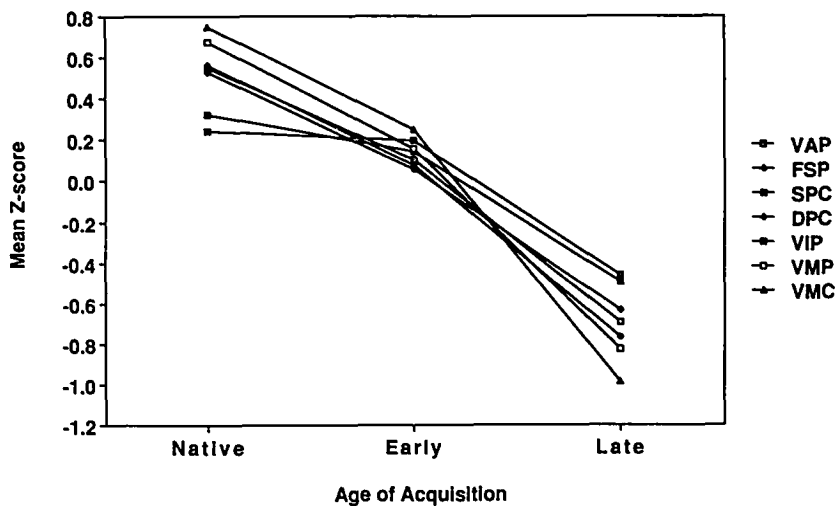


Figure 1b. Z-scores on 7 tests of ASL morphology for Native, Early, and Late Learners of ASL.

whole-word signs, without the internal morphological structure we were testing. They also show highly *variable* use of ASL morphology, with inconsistency in individual subjects' responses on items which should require the same morpheme. Occasionally, they also show omission of morphemes which are obligatory in the ASL context. These results provide strong evidence for an effect of age of acquisition on control over a primary language: The later the language is learned, the less its use is native (with crisp and grammatically consistent forms) in character.

We believe that our results are an effect of the maturational state of the learner, and not merely an artifact of variables coincidentally related to age of acquisition. For example, multiple regression analyses and an additional study of 21 new subjects show that the effects are not due to length of experience with the language. All of the subjects in the present studies have at least 30 years of everyday experience with ASL, and the precise number of years of use (either in this study, or comparing this study with the additional one using subjects with fewer years of experience) does not correlate with performance in our tasks. The data also do not accord with explanations on the basis of input differences, or intellectual or social deprivation differences, across the groups.

EVIDENCE OF MATURATIONAL CONSTRAINTS IN SECOND LANGUAGE LEARNING

To address a further part of the critical period hypothesis, we have also performed comparable studies on *second* language learners. Many prior investigators have studied age effects on second language learning because of the difficulty of obtaining a population for first language learning. In our view, however, the issue of age effects on second language learning versus first language learning are logically independent: In some nonlinguistic domains (though not all), maturational effects exist on *first* learning but not on *second* learning in the same domain (Scott, 1980). We therefore asked whether maturational state affects the learning of a second language, for subjects whose exposure to a first language occurred in infancy.

Surprisingly, although many prior studies had been done in the first year of second language acquisition (showing advantages for adults), few studies had been done on the competence ultimately achieved in the second language; and none of these directly examined grammatical competence in the second language (see Krashen, Long, & Scarcella, 1982, and Johnson & Newport, 1989, for a review of the literature). Our own research has examined syntactic and morphological competence in hearing subjects for whom English was a second language. One study (Johnson & Newport, 1989) tested subjects whose first language was Chinese or Korean (both languages typologically dissimilar to English). To insure homogeneous socio-economic backgrounds and extensive exposure to English, all subjects were

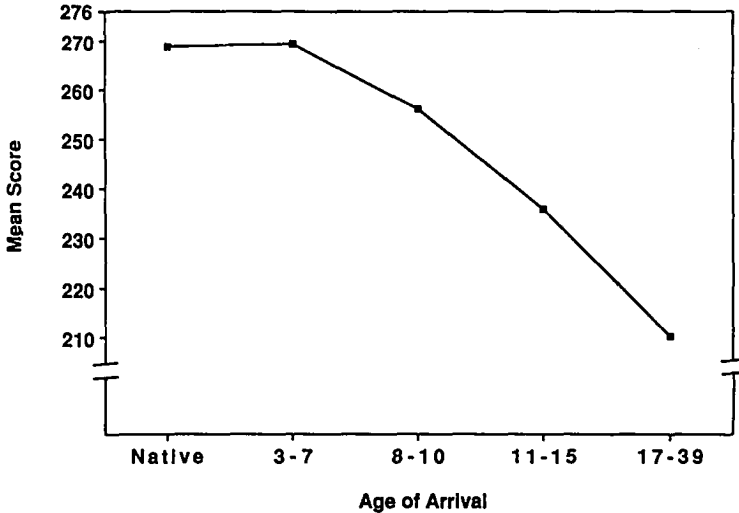


Figure 2. Total score on a test of English grammar in relation to age of arrival in the United States (redrawn from Johnson & Newport, 1989). Reprinted with permission from Academic Press.

students or faculty at the University of Illinois who were in the U.S. about 10 years prior to testing. We ran 46 subjects who varied in the age they first moved to the U.S. and became immersed in English (ages of arrival were age 3 to 39), plus 23 native speakers of English. This wide range of ages of arrival allowed us to examine the full function relating age of acquisition to performance in the language, from early childhood to well into adulthood.

Our measures of competence in English were scores on a grammaticality judgment test, devised by us, of 12 types of rules of English morphology and syntax. Subjects listened to a recording of 276 simple, short sentences of English, spoken one at a time at a moderately slow rate of speech. Half of these sentences were grammatical sentences of English; the other half, randomly interspersed, were each exactly the same as one of the grammatical sentences, except that they contained a single violation of an obligatory grammatical pattern of colloquial English. Subjects were asked to say whether each sentence was acceptable or not. The 12 rules thus tested included rules of English morphology (e.g., verb tense, noun pluralization, verb agreement) and syntax (e.g., basic word order, permutation of word order for forming *wh*-questions and yes-no questions, use of the determiners *a* and *the*, use of pronouns).

Figure 2 presents total test score as a function of age of arrival in the U.S. (i.e., age of first immersion in English). As this figure shows, there was a strong relationship between age of arrival and performance on our test, with performance declining as age of arrival increased ($r = -.77$, $p < .01$). Multiple regression analyses showed that these effects were not attributable

to formal instruction in English, length of experience with English, amount of initial exposure to English, reported motivation to learn English, self-consciousness in English, or identification with the American culture.

We further hypothesized that, if our effects were truly those of maturational state of the learner, the relationship between age of arrival and ultimate performance should hold only over the period in life during which maturational changes occur (that is, during childhood). In contrast, once the organism is fully mature (that is, during adulthood), there should no longer be a systematic relationship between age of arrival and ultimate performance. Figures 3a and 3b show the scattergrams of scores in relation to age of arrival, for subjects arriving during childhood (age 15 or below) versus after maturity (age 17 or after). The correlation between age of arrival and performance for the 23 subjects arriving before puberty (ages 3–15) was a whopping $-.87$ ($p < .001$). In contrast, for the 23 subjects arriving after puberty (ages 17–39), the correlation was $-.16$, NS. These results therefore support the claim that the effects of age of acquisition are effects of the maturational state of the learner.

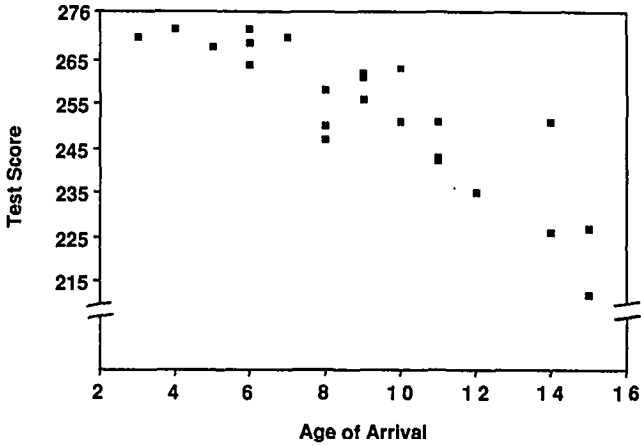
Finally, we examined the 12 rules individually for effects of age of arrival. Again these results were in accord with our findings for first language learning. Control over *word order* was very similar for native and late learners, as was control over the English morpheme *-ing*; both of these aspects of English were also acquired after puberty by Genie (Curtiss, 1977). In contrast, all other aspects of English morphology and syntax showed substantial differences between learners of different ages of acquisition.

We have also found effects of age of acquisition for learners with first languages other than Chinese and Korean, and for linguistic rules specific to English as well as those governed by universal syntactic principles (Johnson & Newport, 1990).

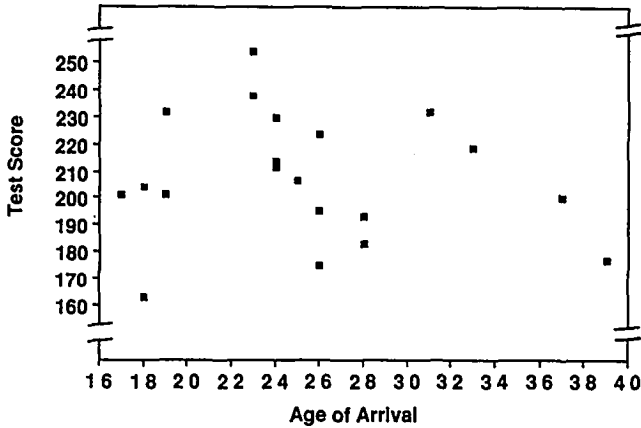
In sum, then, we have found evidence of the effects of age of acquisition on performance many years later in both a primary and a second language. In both cases the data support a maturational interpretation: Language learners who begin acquiring language at an early maturational state end up performing significantly better in that language than those who begin at a later maturational state; the effects over age are approximately linear through childhood, with a flattening of the function in adulthood. Finally, the fact that this function exists for second language learning as well as first language learning suggests that both instances of language learning are affected by maturational state; the ability to acquire language is not spared from maturational effects by exposure to another language early in life.³

³ It is possible, however, that early exposure to a first language has some quantitative effect on the degree to which maturational declines occur. While maturational changes occur in both first and second language learning, it is not clear whether these changes are of the same magnitude. Research is in progress to investigate this question.

a. Subjects Arriving Ages 3-15, $r = -.87$



b. Subjects Arriving Ages 17-39, $r = -.16$



* Note: The Y-axes are on different scales.

Figure 3. Scatterplots of total score in relation to age of arrival for subjects arriving in the United States before vs. after puberty (redrawn from Johnson & Newport, 1989). Reprinted with permission from Academic Press.

WHAT CHANGES OVER MATURATION: THE NATURE OF MATURATIONAL CONSTRAINTS ON LANGUAGE LEARNING

Having shown evidence of the effects of maturation on language learning, I will now turn to the question of what the underlying mechanism might be. What is it that undergoes maturational change, resulting in gradually declining language abilities over age?

As I mentioned at the beginning of this article, the finding itself is somewhat paradoxical. Apparently, learners of different ages (i.e., learners in different maturational states) show differing degrees of success in inducing the internal organization of their linguistic input, with greatest success achieved by the *least* mature learners. In contrast, in most cognitive domains, children are much less capable than adults, with competence increasing over age. There are two classes of explanation one might propose for such a paradox.

First, the traditional explanation in language acquisition for findings of such discrepancies between language and other cognitive abilities (cf. Chomsky, 1965, 1981) has been to posit a special *language faculty*, which includes innate knowledge of constraints on the forms of human languages may take. Such constraints might be present from birth (the "continuity hypothesis"), or unfold during early childhood on a maturational timetable (Borer & Wexler, 1987). To account for a maturational decline in language learning within this framework, one might suppose that this language faculty is entirely intact only early in life, and then undergoes decay or deterioration as maturation continues. On such a view, later language learners show less success in acquiring their language, and more variable mastery of its rules, because the constraints which permit successful acquisition are weakened.⁴

On this view, the inverse relationship between cognitive abilities and language learning (i.e., that the learner gets worse at language learning as he or she gets better at most cognitive tasks) is accidental, due to the fact that the language faculty happens to be at its peak early in life. The view would expect only that competence in language and competence in other domains are not necessarily the same, since they derive from independent faculties.

An alternative class of explanations, however, might suggest that language learning declines over maturation precisely because cognitive abilities increase. (Note that such an explanation might be agnostic on whether innate constraints particular to language also exist; it would merely hypothesize that these language-particular constraints are not the locus of maturational decline in language learning.) For example, I have proposed a view (called the "Less is More" hypothesis [Newport, 1988]) that the very limitations of

⁴ Given our data, it would be difficult to argue that these constraints are entirely absent after maturation, since even our latest learners (including late learners without any formal instruction in the language) do succeed in acquiring grammatical rules of the language to some degree of fluency; they simply do not acquire them as well, or use them as systematically, as earlier learners.

the young child's information processing abilities provide the basis on which successful language acquisition occurs. Before presenting this hypothesis in more detail, I will describe some of the data on which it is based.

The hypothesis derives from the differences we have observed in the character of errors made by late learners as compared with those of native learners. As described on pp. 16–18, the late learners' errors are predominantly of two types: First, they produce "frozen" structures, in which whole-word, unanalyzed signs are produced, in contexts where morphologically constructed forms are required. Most of these frozen signs are highly frequent morpheme combinations in ASL, but are used by late learners in contexts where the particular morphemes included are not grammatical. Such responses thus suggest that the late learner has acquired them as unanalyzed wholes, failing to perform the appropriate internal morphological analysis. Second, late learners produce highly variable and inconsistently used structures. While some of the morphemes may be used correctly, others are incorrect replacements for the correct morphemes; and which morphemes are correct and which replaced may vary over the same test. Both of these types of errors suggest that late learners have experienced problems in consistently and uniquely analyzing the complex structures of the language, and have either failed to analyze, or have learned more than one analysis for the same structure.

In contrast, native learners show very different patterns of performance. When they are at asymptotic performance, they show highly consistent, cleanly analysed, structures. A more revealing picture of how they got there, however, may emerge from examining native learners when they are at the same level of incorrect responses as the late learners described above (that is, during childhood, while they are still learning the language) (for further details, see Newport [1988]). In early stages of learning the language, native learners make very different types of errors from late learners: Theirs are predominantly componential errors, where structures are produced only in part, with whole morphemes omitted. Young signing children (like their hearing counterparts) typically produce only one or a few morphemes of a complex sign. This type of selective production and omission is characteristic of the child learner. Over time, native children add on more morphemes, while late learners either keep their holistic forms or broadly overgeneralize the patterns of a few of these forms. These differences in error types appear in the naturalistic studies of native versus late learners described above, in longitudinal studies of native versus late learners in early stages of acquiring ASL (Newport, 1981, 1988; Newport & Meier, 1985; Supalla, 1982), and in experimental studies of children versus adults in their first few minutes of exposure to ASL signs (Dufour, Newport, & Medin, 1990). We have hypothesized that these differences derive from differences between adults and children in the way linguistic input is perceived and stored, and perhaps not from differences in their knowledge of linguistic constraints or in their abilities to perform linguistic analyses once the input is stored.

In particular, the hypothesis assumes that children and adults differ in their abilities to accurately perceive and remember complex stimuli. The literature on cognitive development contains ample demonstrations, for example, that adults are capable of storing more items in short-term memory than are children, and that this ability increases regularly over maturation; on some measures the increase continues all the way up to adulthood. (See Dempster, 1981, and Kail, 1984, for reviews. As these authors discuss, there is controversy in this literature about whether the developmental change is due to maturational increases in STM capacity, or rather to changes in the ability to make more effective use of the available capacity; but the hypothesis under discussion is indifferent to this distinction.) The "Less is More" hypothesis suggests, paradoxically, that the more limited abilities of children may provide an advantage for tasks (like language learning) which involve componential analysis. If children perceive and store only component parts of the complex linguistic stimuli to which they are exposed, while adults more readily perceive and remember the whole complex stimulus, children may be in a better position to locate the components.

As an example, let us consider the way this hypothesis would work for the acquisition of morphology. The acquisition of morphology is basically a problem of analysis. The learner must find, in the linguistic input data, the particular components of word forms which map consistently onto components of meaning (these are the morphemes of the language). The learning procedure must therefore involve storing words, plus the nonlinguistic events to which they refer, and then computing for a large set of such data the consistent cooccurrences of the components of form and the components of meaning. With words that have even a small number of components of form and meaning, figuring out the right sized units of the linguistic pairing (that is, which components of form, or combination of components of form, consistently map onto which components, or combination of components, of meaning) is a surprisingly complex computational problem. Boris Goldowsky and I (Goldowsky & Newport, 1990) have been working out the mathematics of such computations, as well as a computer simulation of the procedures; the description that follows is an informal summary of our results thus far.

If the learner stores whole words, with all of their components of form, plus a reasonable number of components of meaning that might be extracted from the nonlinguistic setting, the job of figuring out the best mappings is large. (This is what the hypothesis assumes an adult learner might do.) With a single word of only 3 components of form (let's call them *a*, *b*, and *c*) and 3 components of meaning (*m*, *n*, and *o*), there are 49 possible pairings to examine. Form *a* by itself could mean *m*, *n*, *o*, *mn*, *no*, *mo*, or *mno*; likewise, form *b*, *c*, *ab*, *bc*, *ac*, or *abc* could have any of these meanings.

In contrast, suppose a more limited learner (that is, the child) on each exposure to a word perceives and stores only a limited number of the component pieces of form and meaning. For example, suppose on exposure 1

the child stores only *a* and *mn*, on exposure 2 the child stores *bc* and *o*, and so on. Under these circumstances at least two important advantages occur.

First, even if the selection of form and meaning components on each exposure is random, the number of possible computations to perform is greatly reduced, and is also substantially focused on morphological rather than whole-word mappings. If the system to be learned actually is morphological (that is, if the system is one with morphemes smaller than the whole word, e.g., *a-m*, *b-n*, *c-o*), it will be learned more readily with limited storage than with full storage of the whole word and its meaning. If the system to be learned actually is a whole-word system (e.g., *abc-mno*), the more limited learner will not learn it as well, but instead may interpret it (incorrectly) as a morphology. These outcomes are true despite the fact that selective storage will also sometimes eliminate relevant data; the loss of data is far outweighed by the reduction and focus in the number of computations (Goldowsky & Newport, 1990).⁵ To continue with our example, exposures 1 and 2 above will each permit 3 (rather than 49) possible pairings to be examined, one of which is the correct one; with reasonable assumptions about the form and likelihood of performing such computations over a large data base, the child will learn morphology more with more consistency than the adult.

Second, if the form and meaning components selected are precisely those of the morphology (e.g., if *a*, *b*, and *c* are morphemes, and these are independently stored or omitted), an even greater advantage may accrue to the learner, by perceptually highlighting the particular units which a less limited learner could only find by computational means. This second advantage may sound implausible: how could the learner know in advance the units which will turn out to be the morphemes of the language? This could occur, however, even without advance knowledge of the morphology, if the units of perceptual segmentation are (at least sometimes) the morphemes which natural languages have developed. Since human languages have presumably evolved their structural principles at least in part under the constraints of information processing and learning abilities, this advantage may not be as implausible as it sounds. Indeed, our studies of imitation of ASL signs by hearing children who have never been exposed to ASL before (Dufour et al., 1990) do show that young children tend to extract and reproduce, or selectively omit, ASL morphemes. (In the ASL morphology under study, handshapes, motions, and manners of motion are independent morphemes [see pp. 15-16 for a brief description of this morphology]; these are likewise

⁵ There are several crucial caveats in the proposed hypothesis concerning the relationship between character of these limitations and the nature of the system to be learned. In general, one can demonstrate that limitations in perception and memory only reduce the information on which learning must be based, and therefore will result in the possibility of more errors and the need for greater innate preprogramming to avoid learning failures (Osherson, Stob, & Weinstein, 1986; Wexler & Culicover, 1980). In order for the hypothesis to work, the limitations must be such that they more than compensate for this reduction of information.

the components into which naive young children segment their imitations.) We are currently investigating the extent to which such perceptual segmentation maps onto morphological structure in imitating foreign spoken languages, such as Turkish, where the morphology is predominantly syllabic (Goldowsky & Newport, 1990).

Note that these advantages occur for only certain aspects of language learning, particularly those that require some type of componential analysis. For these kinds of structures, adults should have more difficulty locating the right analysis (i.e., they will have more computations to perform, and will find more potential analyses which are partially supported by their input data); they should therefore produce more inconsistent and less componential forms (in accord with our research findings). On the other hand, Less is not always More: for aspects of language (or other skills) that require integration and/or complex wholes, adults should perform better than children. As described above, the hypothesis predicts that adults should excel at whole word learning. We are still working out other similar predictions.

In short, the hypothesis suggests that, because of age differences in perceptual and memorial abilities, young children and adults exposed to similar linguistic environments may nevertheless have very different internal data bases on which to perform a linguistic analysis. The young child's representation of the linguistic input will include many *pieces* of the complex forms to which she has been exposed. In contrast, the adult's representation of the linguistic input will include many more whole, complex linguistic stimuli. The limitations of perception and memory in the child will make the analysis of at least certain parts of this system easier to perform. The adult's greater capabilities, and the resulting more complete storage of complex words and sentences, may make the crucial internal components and their organization more difficult to locate and may thereby be a counterproductive skill. Furthermore, this difference alone may help to explain why language learning is different in these two groups; whether there are also differences between adults and children in other aspects of language learning (for example, in the ways in which they perform linguistic analyses on the data bases they store, processes which themselves may be constrained by either nonlinguistic or inherently linguistic factors) is as yet unclear.

To repeat, this type of hypothesis suggests that the very limitations of the child in many nonlinguistic domains are the ones which insure more successful language acquisition. More generally, the hypothesis suggests that children should have the advantage in many learning tasks other than language, particularly those that involve componential analysis, at the same time that they show a disadvantage in tasks that require early integration or control over complex stimuli. Similar notions, though different in detail, have been suggested by other investigators; see, for example, a suggestion by Krashen (1982) and Rosansky (1975) that adults are worse at language learning because the emergence of formal operational abilities interferes with implicit learning strategies more suitable for language acquisition. In studies of

quite different domains than that discussed here, Turkewitz & Kenney (1982) have pointed out that humans have evolved a strikingly longer period of infancy than other species, and have suggested the possibility that this period is not just a temporary state of incompetence, but may have adaptive value for the achievement of the more complex skills of the adult. The hypothesis I have suggested for language learning is one example of this type of notion.

SUMMARY

In sum, a wide variety of studies demonstrate that language acquisition occurs successfully only under the operation of certain internal constraints or predispositions in the learner. Our own studies reviewed herein suggest that certain of these constraints undergo maturational change, such that learners who begin the task in childhood reach more systematic levels of asymptotic performance in the language than those who begin in adulthood. At least two types of mechanisms appear to be compatible with these results. One of these suggests that the crucial constraints needed for language acquisition are those of a special language faculty, equipped in advance to expect only certain types of structures to occur in human languages. Maturational change may occur in these constraints, leading the older language learner to less success in inducing the linguistic systems to which she is exposed. A second possibility is that at least some of the constraints crucial to success in language acquisition are nonlinguistic, and that the maturational changes which lead to more difficulty in language learning occur in these nonlinguistic constraints on perception and memory. Whatever the correct account, however, it is clear from our empirical evidence that some significant internal constraints are required to account for why children, and only children, uniformly succeed in learning language.

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