A Critical Period for Learning to Pronounce Foreign Languages?

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This article discusses the Critical Period Hypothesis (CPH) as it relates to the naturalistic acquisition of foreign-language (L2) pronunciation by adults and children. An examination of the existing empirical and theoretical literature leads to the conclusion that there is no conclusive support for the existence of a critical period for human speech learning, and that assuming a critical period does exist may inhibit the search for testable hypotheses concerning the basis for observed adult-child differences in L2 pronunciation. These conclusions are based on the existence of direct counter-evidence, as well as on the observation that apparent adult-child performance differences may arise from many different confounding factors other than adult-child differences in neurological maturation or organization that cannot be adequately controlled in behavioral research.

1. INTRODUCTION
The results of many acoustic and perceptual experiments have provided empirical support for the popular belief that the earlier an individual begins to learn a foreign language (henceforth L2), the better will be his or her pronunciation of that language (e.g., Asher and Garcia 1969; Fathman 1975; Cochrane 1977; Williams 1979; Tahta et al. 1981; Oyama 1982a, b). Research has demonstrated that listeners are capable of detecting auditorily even subphonemic differences in sounds produced by native and non-native speakers (e.g. Flege 1984). Research has further demonstrated that foreign accent, the perceived effect of many discrete and general differences in pronunciation between native and non-native speakers, has serious detrimental effects such as diminished intelligibility and negative social evaluation (see Flege 1987 for a review). These findings have inspired research addressing the question 'Why do adults often—if not always—pronounce foreign languages with an obvious accent when children do not?'

Despite widespread acceptance that language-learning aptitude (see, e.g. Carroll 1963) and motor skills (e.g. Smith 1978) generally increase through late adolescence, there seems to be widespread agreement among L2 researchers that adults lose some important aspect of speech-learning ability that children still possess. This belief has found expression in what will be referred to here as the 'Critical Period Hypothesis' (henceforth, CPH). The CPH makes two important predictions concerning the pronunciation of foreign languages. First, to be entirely effective, speech acquisition must occur prior to the establishment of hemispheric specialization for language functions. Second, speech learning that occurs after the critical period has passed will proceed more slowly, and ultimately be less successful, than learning which occurs before the critical period has ended.

The literature abounds with statements in support of the view that adults are

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less able than children to learn new forms of pronunciation because they have passed a 'critical' period for language learning that is determined by neurological maturation or re-organization. Penfield and Roberts (1966) asserted that cortical centers important for language acquisition lose 'plasticity' by about the age of twelve years. Lenneberg (1967: 176, 377) concluded that 'language readiness ... begins around (age) two and declines with cerebral maturation in the early teens'. He speculated that adults 'inevitably' speak foreign languages with an accent if L2 learning begins after childhood, because the ability to learn new forms of pronunciation is inhibited as the result of the 'firm structuring' of neural processes through cerebral lateralization. Lamendella (1977: 165) argued that the 'immature neurolinguistic systems' of children give them 'intrinsically greater potential' for L2 learning than adults. Scovel (1969: 245, see also Scovel 1981) claimed that:

It is the nature of the human brain, not its nurture, that crucially affects (L2 pronunciation). The onset of cerebral dominance, which seems to occur around the age of twelve, inhibits the ability of a person to master the sound patterns in a second language without an impinging foreign accent.

Walsh and Diller (1981: 12) recently provided specific new arguments concerning a possible neurological basis for 'difficulty' in eliminating foreign accents after childhood. They noted (1981: 16) that although L2 learners may thoroughly acquire aspects of a foreign language other than pronunciation (e.g. vocabulary), complete success in pronouncing L2 is impossible because pronunciation is a 'lower order' linguistic function which is 'genetically specified and consolidated in early development'. They speculated that whereas patterns of pronunciation are based on early maturing 'neuronal circuits', the development of 'higher order' linguistic components (such as the lexicon) depend on information encoded in stellate cells, which are largely undifferentiated at birth and continue to develop long thereafter. According to Walsh and Diller, stellate cells play an important role in the establishment of new neuronal synaptic arrangements, are associated with the 'plasticity' discussed earlier by Lenneberg (1967) and Penfield (1965; Penfield and Roberts 1966), and are important to various aspects of learning and memory. These conclusions are consistent, they suggested (1981: 8), with the view that the identification of speech sounds depends on the existence of feature 'detecting' neuronal circuits which are established early in development and do not evolve with experience.

The possibility of a neurally-based loss of 'plasticity' finds prima facie support in the loss of ability for further song learning observed in certain avian species—a phenomenon known as 'crystalization' (Marler and Mundinger 1971; Studdert-Kennedy 1981)—as well as in the apparent superiority of children compared to adults in learning to pronounce foreign languages. However, Walsh and Diller's hypothesis concerning the role of innate neural 'feature detectors' would be accepted by few speech-perception researchers today, and is inconsistent with research pertaining to the perception of L2 phonetic contrasts by adult L2 learners. For example, native speakers of English require a longer VOT interval to judge prevocalic stops as voiceless than do native speakers of Spanish, whose labelling of stops which differ along the VOT dimension seems to be largely determined by psychophysical limits on judgements pertaining to the temporal order of two acoustic events. The
location of the phoneme boundary for native English speakers, moreover, continues to evolve throughout childhood and adolescence (Flege and Eefting 1986). The location of the phoneme boundaries of Spanish learners is known to shift to increasingly English-like VOT values as a function of age at first exposure to English and amount of English-language experience (Williams 1980). To take another example, the English /r/-/l/ contrast is known to represent an important learning problem for Japanese native speakers, owing to the absence of a phonemic contrast between /r/ and /l/ in Japanese. However, Japanese learners who have had sufficient conversational experience in English learn to label and discriminate the members of a synthetic /r/ to /l/ continuum just like English native speakers (MacKain et al. 1981).

The existence of a critical period is used frequently to rationalize empirical studies of L2 learning, and is often offered as an explanation for performance differences between adult and child L2 learners. For example, Mack (1984) performed an interesting series of experiments aimed at determining whether individuals who learned L2 long before puberty ('early childhood bilinguals', see McLaughlin 1978) differed from monolingual native speakers of L2. Having found differences between English monolinguals and French/English bilingual subjects, Mack concluded (pp. 172-3) that they did not ‘undermine the critical-period hypothesis’ because the differences may have stemmed from ‘non-intrusive’ interference arising from the existence of two linguistic systems rather than one, and not from ‘intrusive’ interference arising from differences in the sound systems of L1 and L2. Thus Mack—like many before her—appeared unwilling to interpret her evidence as possible counter-evidence against the CPH, because the CPH was accepted as a fact, rather than viewed as a hypothesis.

Given the importance of the CPH as a heuristic for designing and interpreting the results of L2 research, the aim of this article is to provide a discussion of the CPH as it relates to the ability of children and adults to pronounce L2. Most research influenced by the CPH has examined the production of L2 (but see Oyama 1982b for an exception). This is due largely to the fact that speech production differences between native and non-native speakers are more easily observed, and thus more frequently assessed and quantified, than perception differences. Production research has also undoubtedly been stimulated by the popular belief that adults and children differ in speech production, whereas a similar popular consensus regarding the perception of foreign languages does not appear to exist.

The discussion leads to the conclusion that existing evidence does not provide firm and conclusive support for the existence of a critical period for human speech learning, and that assuming the existence of a critical period may inhibit the search for testable hypotheses concerning the basis of observed adult-child differences in L2 pronunciation. These conclusions are based on the observation that the existence of adult-child differences may derive from confounding factors other than adult-child differences in neurological maturation or organization that cannot be adequately controlled in behavioral research.
2. ARGUMENTS AGAINST THE CPH

I believe that there are many good reasons to question whether a critical period for speech learning truly exists. First, the critical-period concept was not originally developed to describe human behavior, but was instead developed in ethological studies to account for animal behavior. A good example of a critical period for the learning of environmentally important stimuli is the imprinting seen, for example, in chickens, ducks, and geese (Hinde 1974). It is generally the case that a pattern of behavior which can be acquired only within a well-defined critical period exhibits the following characteristics:

a. it tends to appear under well-defined developmental conditions;
b. it cannot be forgotten or revised once it has been established;
c. it involves the recognition of species characteristics rather than individual characteristics; and

d. it may be learned long before it is manifested.

Of the four characteristics just mentioned, only the first seems to apply directly to human speech learning.

According to Oyama (1979), the critical-period concept cannot, in itself, explain characteristics of speech or other forms of observable behavior. In her view, the critical-period concept may serve to delineate developmental phases, to isolate specific mechanisms that regulate sequences of differentiation, and to pinpoint sources of environmental stimulation that influence behavior. Investigations of development in many different species, she observed, have supported the view that it is not a critical period which imposes a temporal limit on development, but rather the way in which developmental processes display themselves sequentially and interact with one another. In Oyama's view (1979: 88 ff.), the apparent superiority of early as opposed to late speech learning may support the existence of a broadly defined 'sensitive' period. A sensitive period may be regarded as a period of heightened responsiveness that is preceded and followed by periods of lesser responsiveness, or a 'period of competence' for specific exchanges with the environment. Shifts in responsiveness to various environmental stimuli may co-occur with the 'progressive elaboration of structures or schemata' which may affect how the organism engages the environment.

Second, despite the many studies which have shown superior performance by child subjects compared to adult subjects, several studies have provided evidence that in certain circumstances adults may produce or perceive L2 sounds as well as, or even better than, children (see Flege 1981). For example, Snow and Hoefnagel-Höhle (1978) found that English-speaking adults produced Dutch sounds more authentically than 8-10 year-old children after a small amount of L2 experience. Winitz (1981) found that native English adults were better able to discriminate Chinese tones and obstruent consonants than English-speaking 8-year-olds.

Third, a rigorous test of the CPH requires that converging behavioral and neurological evidence be provided. However, existing neurological evidence does not provide firm support for the existence of a critical period. There does not seem to be evidence for a discontinuity in neural development that could be reasonably regarded as coinciding with a clear change in speech-learning.
abilities. Most parameters of brain growth have reached adult or near-adult levels by five years of age (Whitaker et al. 1981), whereas other evidence has indicated that human cerebral functions and neuronal synaptic arrangements continue to develop, often as the result of specific environmental experience, long beyond puberty (Walsh and Diller 1981). Commenting on their finding that short-term conditioning was sufficient to affect adults' perception of the judged pitch of complex stimuli, Peters and Hall (1985) observed that 'behavior changes brain cells, sometimes briefly and sometimes forever'.

Probably the most important evidence offered by Lenneberg (1967) in support of a critical period was that children, unlike adults, are capable of complete recovery from certain types of aphasia as the result of shifting language functions from the dominant to the non-dominant hemisphere after a trauma has occurred. However, Snow (1986; see also Snow and Hoefnagel-Höhle 1982) has reviewed more recent evidence suggesting that complete recovery from aphasia does not occur, even in young children. There has been controversy regarding the age at which cerebral lateralization reaches completion. Arguments have been advanced that it occurs at the age of five or at the age of twelve. Both of these ages have, as a result, been proposed as marking the end of the critical period for speech learning. However, evidence reviewed by Studdert-Kennedy (1984) and Snow (1986) suggests that hemispheric specialization for the kinds of sequential processing important to speech production is evident at birth. In any case, it has never been clearly established that lateralization per se would impair language learning by either hemisphere (Oyama 1982a). Moreover, a recent dichotic listening experiment casts doubt on the assumption that degree of lateralization (as assessed by the magnitude of the right-ear advantage) is related to L2 proficiency (Schouten et al. 1985).

Fourth, the CPH leads to the expectation of a fairly abrupt difference in how authentically L2 is pronounced by individuals differing in age. This expectation was not supported in a study by Oyama (1982a), which examined the degree of foreign accent in the speech of native Italian men living in the United States. Degree of accent (as assessed by global ratings) increased linearly as a function of the age (between 6–20 years) at which the sixty subjects had arrived in the USA. There was no marked discontinuity which might serve to delineate the end of a critical period at the age of twelve or any other age. Data reported by Tahta et al. (1981) seemed to show a difference in the expected direction between individuals who were either less than, or more than, 12 years of age when they first began learning L2 in the United Kingdom. However, the significance of this apparent difference was not tested.

An essential aspect of human speech learning is the ability to perceive the acoustic distinctions between L2 categories accurately, and to implement those distinctions phonetically through finely controlled motoric patterns. Thus the CPH indirectly leads to the expectation that children will be able to imitate L2 sounds better than adults. This expectation was supported by Cochrane and Sachs (1979), who found that English-speaking 7-year-olds imitated Spanish words better than English-speaking adults. However, Politzer and Weiss (1969) reported a positive correlation between age and the accuracy with which American school children imitated French vowels. Snow and Hoefnagel-Höhle (1977, 1978, 1979) studied the imitation of Dutch words by native English
adults and children 5–17 years of age. They also found that the accuracy with which subjects imitated Dutch sounds was positively correlated with age.

3. POTENTIAL CONFOUNDING FACTORS
Perhaps the single most important reason for caution in accepting the CPH is that it presupposes an overly simple view of the speech learning process. Centuries of research in linguistics and phonetics has demonstrated that human speech is importantly influenced by 'mind, matter, and manners' (J. Ohala, personal communication). Speech is 'mental' in that it is directed by central category representations (of phones or phonemes) which contain sensorimotor information concerning production and perception parameters. Speech is 'material' in the sense that it is realized motorically by means of a mechanism with specific biomechanical constraints, and perceptually processed through sensory mechanisms having specific limits of resolving power. Speech is 'social' in that, within the physical limits just mentioned, linguistic experience affects the manner in which speech sounds are produced and how they are perceived. In addition to referential (i.e. categorical) information, sub-phonemic variations in segmental articulation also convey social and affective information.

A failure to consider all three aspects of speech is reductionistic, and apt to lead to misunderstanding of how speech is learned. In my opinion, such an oversimplification has led to an inappropriate acceptance of the CPH and this, in turn, has led to potentially erroneous conclusions regarding why children's speech performance might differ from adults'. More specifically, I believe that the existence of adult-child differences is likely to arise from a variety of factors other than (or in addition to) a critical period, because the age of L2 learners is inevitably confounded with other conditions that co-vary with chronological age.

3.1. Developmental factors
One obvious factor that may be confounded in studies comparing children and adults is differences in size and physiological functioning that may exist independently of differences in neurological maturation and/or organization. For example, a recent study by Flege et al. (1987) examined in detail the production of the contrast between /p/ and /b/ in the final position of English words by English adults and children, and by Chinese adults and children. An examination of two parameters (duration of the closure interval, duration of closure voicing) revealed that the Chinese adults differed from subjects in the three other groups. This suggested that the Chinese adults were less successful than the Chinese children in learning to realize a phonetic contrast which does not exist in their L1. However, the Chinese adults more closely resembled the English adults than the Chinese children as far as the minimum rate at which air pressure increased in the mouth. This indicated that in addition to speech learning that arises from specific linguistic experience, anatomical differences between children and adults (e.g. the amount of compliant tissue bounding the oral cavity) may also influence the nature of segmental articulation.

To take another example, Flege and Eefting (1986) recently examined the production and perception of /t/ and /d/ by Spanish adults and children (in Spanish) and English adults and children (in English). The study clearly showed an effect of previous linguistic experience. The Spanish subjects produced the
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/* in Spanish words with significantly shorter VOT values than the English subjects produced in English words, and showed a phoneme boundary between /* and */ at significantly shorter VOT values. The study also revealed clear developmental effects. The adult subjects produced /* with longer VOT values than the child subjects of the same native-language background, and manifested phoneme boundaries at significantly longer VOT values than the child subjects. Had production of English words by just adult and child native speakers of Spanish been examined, the existence of the developmental trend would probably have made it appear that the adults had more closely approximated the segmental phonetic norms of English than the child learners.

3.2. L2 input
It is possible roughly to control the length of time child and adult subjects have lived in an L2-speaking environment, but even then, the possibility exists that adult–child differences in pronunciation may derive from differences in the quality or quantity of L2 experience. Cochrane (1977) administered a detailed questionnaire on language background and usage to Japanese children and adults learning English in the United States. Compared to the adults, the children tended to speak English with a greater number of people outside the home, and were obliged to use English in a greater number of social contexts than the adults. Others have provided similar, subjective observations. Burling (1981) noted that other adults, by switching into English to promote a better exchange of ideas, impeded his progress in learning Swedish during his sabbatical year in Sweden. His children, on the other hand, were typically left to struggle in Swedish by their playmates, whose proficiency in English was probably less developed than that of most Swedish adults. Snow and Hoefnagel-Höhle (1978: 1116) observed that native English children learning Dutch in The Netherlands received more L2 input than adults:

The 3–15 year-olds were all attending Dutch schools and were therefore exposed to a Dutch language environment a minimum of 30 hours per week. The five adult men were all working in Dutch language environments; however, since most Dutch adults speak English well and readily, none of the men used Dutch regularly as a working language. The six adult women were all housewives who heard Dutch only in the context of shopping, social encounters, and contacts with their children’s schools, government offices, etc.

The quality of L2 input which adult and child learners receive may also differ. Burling (1981), among others, noted that children tend to use language more often in reference to ongoing events and objects near at hand than adults, who are more apt to discuss abstract concepts without tangible referents. Asher (1981) observed that child L2 learners, unlike most adults, inhabit an ‘acquisition-enriched’ environment in which much of the language addressed to them is immediately understandable from context (e.g. ‘Give Daddy a kiss’; ‘Let’s wash our hands’). Language addressed to adults, on the other hand, tends to be less easily understood from contexts (e.g. ‘Good morning’; ‘How are you?’).

A difference in the quality of L2 input may have important consequences. Children may understand a larger proportion of the L2 speech which is addressed to them than adults, which may in turn lead to a quantitative
difference in L2 ‘intake’. L2 words may also have a richer array of sensory associations for children than adults, making them easier to store and retrieve in speech processing. Asher and Price (1967) hypothesized that adult–child differences in pronunciation would disappear if L2 intake were truly equal for learners of different ages. In indirect support of this, they found that adults outperformed children in comprehending and executing commands spoken in a foreign language when exposed to physically demonstrated actions that were explained in L2 by the instructor.

3.3. Motivation and affective factors
Adult–child differences might also be due to differences in how subjects differing in age regard L2 or the need to modify previously established patterns of pronunciation. The degree of authenticity with which a learner pronounces L2 may be related to the extent he or she feels inclined—or obliged—to pronounce L2 like L2 native speakers. Hanlon (1971, cited by Cochrane 1977) found that children were more likely to imitate an individual’s accent if they identified positively with him or her. Mancanara (1973) suggested that children may pronounce foreign languages better than adults because they generally feel stronger pressure from their peers to conform to pronunciation norms. Perhaps children feel greater social pressure than adults to pronounce L2 authentically because they feel a greater need to participate fully in the culture associated with L2. Tahta et al. (1981) found that the amount of time adult and child L2 learners used English in the home accounted for a significant 9 per cent of variance in pronunciation scores. When subjects aged 7–12 years were considered separately, it accounted for 26 per cent of the variance. The authors speculated that this finding reflected the strength of subjects’ identification with L2 and its associated culture, rather than simply a difference in the amount of L2 input.

Schumann (1976, 1978) asserted that affective factors are more important than age in determining success in L2 pronunciation, and suggested that progress in L2 may be impeded by fear of making mistakes or being ridiculed for communicating ineffectively in L2. He outlined (1978) a wide range of factors that might potentially affect L2 learning. Under ‘social factors’ he included the socio-economic status of the L2 learner vis-à-vis native speakers of L2. ‘Affective factors’ included ‘language shock’ and ‘culture shock’. Schumann speculated that anxiety induced by the many differences between L1 and L2, along with concomitant cultural differences, may impede progress. ‘Personality’ factors included ‘degree of extroversion’, ‘tolerance for ambiguity’, ‘sensitivity to rejection’, and ‘degree of self-esteem’. These factors seemed likely to Schumann to affect the extent to which L2 learners seek practice in speaking L2, and thus the amount of L2 input.

Few if any previous studies examining the role of affective factors have directly compared adults to children, and few have been directly related to pronunciation. However, the possibility exists that affective factors influence the speech of adults and children differently, and that adults are more fearful of making mistakes than children. Guiora et al. (1972) examined the effect of alcohol to test a hypothesis regarding inhibitions against pronouncing foreign languages authentically. Perceptual evaluations indicated that adult subjects who imitated Thai speech material ten minutes after ingesting 1–1.5 oz of
alcohol did so better than subjects who received a placebo; these, in turn, did so better than subjects who consumed 2–3 oz of alcohol. Guiora (1972) provided a psychoanalytic interpretation of these results. He argued that L2 pronunciation patterns become a manifestation of personal identity once an individual develops a sense of 'language identity' and that, once this happens, an L2 learner may regard the prospect of modifying previously established patterns of pronunciation as threatening to his or her 'language ego'. Although other interpretations are possible, the finding by Guiora et al. (1972) seemed to show that adults are at least capable of pronouncing L2 better than they actually do. It is therefore possible that children pronounce L2 better than adults because they have fewer psychological inhibitions regarding the pronunciation of L2.

Attitudes and inhibitions may be related to motivation, which probably plays an important role in determining how successfully an L2 will be pronounced. Gardner and Lambert (1972) described motivation as having 'integrative' and 'instrumental' aspects. A learner who is integratively motivated wants to learn L2 in order to meet and communicate with native speakers of L2; one with an instrumental motivation desires to learn L2 in order to achieve professional or social advancement. Differences in motivational levels might reasonably be expected to lead to differences in amount of L2 input. To the best of my knowledge, no existing research has clearly shown whether these different types of motivation lead to differences in L2 pronunciation success, nor provided unambiguous information regarding motivational levels of adults compared to children.

Adults might become more easily discouraged regarding their L2 progress than children because the 'tolerance region' for adults' production of sounds is narrower than for children's, because adults are more able than children to note their own divergences from L2 phonetic norms, or both. One study showed that adults' accents were judged to be more authentic than children's after a short period of learning, but that the reverse was true after a longer period of learning (Snow and Hoefnagel-Höhle 1977, 1978). This suggests that young children continue to 'work on' their pronunciation longer than adults, perhaps because adults are more interested in communicating linguistic 'substance', whereas children are more interested in the 'form' that communication takes. If adult–child motivational differences do exist, they would provide another potentially confounding factor in developmental studies.

3.4. Social factors
L2 learning is generally not considered very important in the United States, as demonstrated by the relatively small number of students who study a foreign language beyond the minimum of 1–2 years. This attitude stands in contrast to that which prevails in certain other societies, where the ability to communicate in several languages is an important determinant of status. Hill (1970) observed that in cultures where L2 learning is a highly valued skill, even adults may manifest considerable success in L2 pronunciation. Segalowitz and Gatbonton (1977: 86) noted that L2 learners attempt to pronounce L2 authentically when their community regards mastery of foreign languages as 'prestigious and indicative of the speaker's superior intelligence and level of education'. Adults in Western society are well aware that 'adults cannot pronounce foreign languages without an accent', whereas children are apt to be told that they can...
do so. These expectations may represent self-fulfilling prophecies, and create yet another confounding factor which may contribute to better performance by children than adults.

Adults, moreover, may have more reason to retain an foreign accent in L2 than children. As mentioned earlier, foreign accent has a number of demonstrably negative effects, yet it possesses at least one advantage. Standard varieties of speech have 'overt' prestige (meaning that they elicit positive evaluations for dimensions relating to status, competence, power, etc.), whereas non-standard varieties of speech may enjoy 'covert' prestige (reflected by relatively high evaluations along dimensions such as friendliness, dependability, sense of humor, etc.). If foreign-accented speech can be thought of as a kind of 'non-standard' dialect, speaking with an accent may be perceived by the L2 learner as beneficial. For example, maintaining a foreign accent might help the L2 learner preserve his or her ethnic identity in a community where L2 is the dominant language. Gatbonton (1975, cited by Segalowitz and Gatbonton 1977) found that the frequency with which French Canadians correctly produced the difficult /θ/ and /ð/ sounds in English depended to some extent on how strongly they identified with the French-speaking population of Canada. Subjects who were most nationalistic in their political views correctly produced these sounds less often than learners whose ethnic identifications were not as strong. The L2 learner might attempt to avoid social censure by speaking with an accent that identifies him or her as not being a member of the community in the fullest sense. Social blunders which would be excused in an obvious 'foreigner' might not be so readily tolerated in a non-obvious foreigner. A foreign accent may represent a ready-made excuse for many minor social transgressions. Speaking without a foreign accent, on the other hand, might be regarded by the L2 learner as a kind of 'disloyalty' to other L2 learners of the same L1 background (Ryan and Carranza 1975).

3.5. Incomplete learning
Another potential difficulty in comparing child to adult subjects is that, all else being equal, differences in the rate of learning may be misinterpreted as representing a difference in the extent of learning. It takes any learner, child or adult, some finite amount of time to master the production of a new sound. Certain sounds (such as /θ/ and /ð/) are inherently more difficult to learn than others, even by children learning their first language (Macken and Ferguson 1981). Children may appear to outperform adults if they learn difficult L2 sounds at a faster rate than adults. Although a difference in rate of learning between adults and children would constitute support for the existence of a critical period (at least as formulated earlier in this article), it could in itself be the indirect consequence of differences in motivation, affect, social pressure, etc.

4. COMPETING HYPOTHESES
It would be difficult if not impossible to control for all of the potential confounding factors just mentioned, so it is probably impossible to provide unequivocal behavioral evidence in support of the existence of a critical period for speech learning. In my opinion, this reduces the CPH to an a priori assumption about the basis of adult–child differences rather than a testable
hypothesis. This in itself represents an important reason for discarding the CPH, at least as it was formulated above. A more important reason, perhaps, is that accepting the CPH may impede the development of specific hypotheses that can be tested. A discussion of such hypotheses falls outside the scope of this article (however, see Flege 1987), but several can be briefly outlined.

One hypothesis that could be tested is that children pronounce an L2 better than adults because they tend to process speech in an 'auditory' rather than a 'phonetic' mode more often, or to a greater extent, than adults, and that this enables them to develop more accurate perceptual 'targets' for L2 sounds. An auditory mode of processing makes use of the psychoacoustic capabilities with which all individuals are endowed. A phonetic mode of processing, on the other hand, imposes on sensory input patterns of perceptual processing that have been shaped by previous linguistic experience (see Redmond 1977; Repp 1981; Werker and Logan 1985). The development of an optimal representation for each L1 category depends, at least initially, on an auditory mode of processing. The L1 learner must establish which categories exist in L1, then go about determining the range of permissible allophonic variation for each category which has been identified.

Children may be more likely than adults to favor an auditory mode (or at least a pre-categorical auditory 'stage') in processing speech sounds because their central representations for sound categories are still evolving. Or children might be better able than adults to switch from a phonetic to an auditory mode when processing demands require doing so. If this is true, it might be more difficult for adult L2 learners than child L2 learners to assess accurately the acoustic characteristics of L2 sounds. Since the accurate production of an L2 sound surely depends on an accurate assessment of its acoustic characteristics, this should make it easier for children than adults to pronounce L2 sounds accurately.

A related hypothesis is that children may pronounce L2 sounds better than adults because they are more likely to develop new phonetic categories as a result of exposure to sounds in L2 which are acoustically non-identical to sounds found in L1. This hypothesis rests on the assumption that children's L1 categories are less firmly established or thoroughly elaborated than those of adults. Most instances of long-term learning, of which speech learning is just a particular instance, rely heavily on previous cognitive experience (Ausubel 1968). The learner brings the cumulative experience of her or his life to any new learning experience, including L2 learning. This leads to the expectation that adults may be more strongly inclined than children to identify phones occurring on the phonetic surface of L2 as belonging to already familiar L1 categories.

To illustrate how this might affect L2 pronunciation, let us consider the learning of English by Dutch native speakers. Some Dutch vowel categories are acoustically indistinguishable from English vowel categories (e.g. /U/, /a/); some resemble vowels found in English, but are none the less measurably different from them (e.g. /i/, /u/); and some English vowels have no direct phonological counterpart in Dutch (e.g. /æ/, /ʌ/; Disner 1983). All of the vowels encountered in English by Dutch learners will, of course, bear some degree of auditory similarity to Dutch vowel categories. However, we might expect that, in general, Dutch learners of English will produce English vowels that are 'identical' to Dutch vowels better than they produce vowels which are merely 'similar', and
that they will fare least well on 'new' vowels which have no phonological counterpart in Dutch. An issue that should be investigated is whether Dutch children are more likely than Dutch adults to recognize that vowels such as English /æ/ and /ə/ have no counterpart in Dutch, that is, they represent new vowel categories. If so, it would mean that Dutch children should be more likely to stop substituting the closest Dutch vowel category for English /æ/ and /ə/, and should ultimately be judged to be more successful than adults in producing these vowels.

To take an example from the temporal domain, let us consider the production of French /t/ by English learners. Native speakers of English who learn French must (among other things) learn to produce /t/ in the initial position of French words with short-lag VOT values of about 20 ms, rather than with the long-lag VOT values of 50–100 ms which are typical for English. It seems reasonable to think that English learners of French will judge the acoustically different phone occurring at the beginning of French and English words such as taille and tie as belonging to the same category. Flege (1981; Flege and Hillenbrand 1984) proposed that, in such instances, adult native speakers of English will be prevented from developing an accurate perceptual 'target' for French /t/ as the result of a mechanism he termed 'equivalence classification'. That is, the English learner of French (or the French learner of English) would tend to regard the many tokens of /t/ encountered in French as being 'allophones' of an already familiar category (i.e. English /t/). Although the English learner of French can detect auditorily the differences between French and English /t/, he or she will not develop a new phonetic category for French /t/, because of a general cognitive constraint.

This hypothesis seems to account for data (e.g. Caramazza et al. 1973; Flege and Hillenbrand 1984) which show that adult L2 learners typically produce stops with VOT values that are intermediate in value to those produced by monolingual native speakers of L1 and L2. This suggests a merger of the phonetic properties of French and English /t/ (a 'merged' system), rather than the establishment of a separate, co-existing category for French /t/ alongside that of the English /t/ (an 'enriched' phonetic system). One factor which makes this hypothesis plausible is that adults are generally more literate than children, and more likely to learn L2 through the intermediary of the written word. Reliance on an orthographic system which is at least partially phonemic is likely to encourage an L2 learner to interpret the sounds found in L2 words in terms of L1 categories.

The hypothesis has not yet been directly tested for child versus adult subjects (but see Williams 1979, 1980). It would be useful to determine in a study which controlled L2 intake whether English-speaking children who learn French are more likely than adults to develop a new category for French /t/. This could be done in two ways. First, the production and perception by adult and child subjects, in both French and English, should be examined. Second, adult and child subjects should be asked to choose stimuli they prefer (i.e. the 'prototypes') from a VOT continuum, in both a French and an English 'set'. If the L1 categories of adults are more 'all encompassing' than those of children, the 'tolerance region' of bilingual adults should be larger than that of child subjects, and the child subjects should show a greater tendency to identify two preferred ranges (prototypes) than adult subjects. This expectation is based on the
assumption that as adults gain experience in L1, they become increasingly familiar with the wide range of allophonic variants which serve as realizations for each category, and are therefore more willing than children to accept L2 phones as being realizations of an L1 category.

If the hypothesis just outlined is correct, it would mean the child L2 learners who come to recognize the existence of new categories in L2 would be more fully able to exploit the basic human ability to translate the sensory correlates of speech sounds into articulatory motor routines. Differences between adults and children, if observed, would therefore not be seen as arising from a difference in basic ability, so much as from differences in the extent to which that basic ability is tapped during the course of naturalistic L2 acquisition.

Neither of the two broad ‘cognitive’ hypotheses just outlined has been adequately tested to date, but both could be tested in a series of focused experiments comparing adults to children. Such a research programme would not be strongly motivated, however, if it were axiomatically accepted beforehand that adults’ basic speech learning ability was inherently inferior to that of children. Specific processing strategies such as those just mentioned might differentiate adults from children, as well as successful versus relatively unsuccessful L2 learners of any age. An interest in discovering the existence of processing differences, however, appears to be dampened by the CPH because it represents the assumption that adults’ production of L2 sounds is impeded by a diminished ability to realize articulatorily the (correctly) perceived sounds of L2.

5. SUMMARY

The critical period hypothesis (CPH) has been examined. The conclusion is reached that the CPH represents an assumption regarding inherent differences between L2 learners of different ages, rather than a testable hypothesis concerning the nature of speech learning. The primary reason for reaching this conclusion is that the results of several empirical studies are inconsistent with the expectations generated by the CPH; and there are many factors which are necessarily confounded when comparisons of adult versus child speech are made. It was further concluded that the CPH, while it represents an idea which is perhaps ‘good to think’, may in the long run impede progress in the field of L2 speech learning because it makes certain hypotheses which can be tested appear unwarranted.

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