wide range of readers. By its balance of competing views, the book should allow people to judge for themselves which arguments and what data are most compelling, thereby enabling an informed decision on the merits of the CPH–L2A.

I felt it was important to compile recent and largely unpublished research, and to expedite its publication. In this respect as well, the volume has inherent appeal to serious researchers and students of age-related linguistic development and the limits of bilingualism. Consequently, it is tempting to bill the collection of papers in this book as "state of the art." However, it would be presumptuous to maintain that, for this particular issue, there is a "state" of intellectual discourse. In this area of vigorous research and debate, the discourse is almost too fluid to pin down. This is not the first time the CPH–L2A has been visited, nor will it be the last.

There are dozens of individuals who have pushed the envelope of critical period inquiry. Were the world a perfect place, they would all be contributors to this volume. Reducing the number was not easy, and if there are conspicuous absences, it is the judgment of the editor alone that should be faulted. (At least it can be safely said that I didn't invite just my old buddies. Many of the people I met for the first time in Finland, and others I have yet to lay eyes on.)

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Finally, with great earnestness I applaud the contributors to the volume for their reasonableness and good cheer. These fine scholars are also fine human beings.

—David Birdsong

CHAPTER ONE


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The facts of adult second language acquisition (L2A) contrast sharply with those of first language acquisition (L1A). Whereas the attainment of full linguistic competence is the birthright of all normal children, adults vary widely in their ultimate level of attainment, and linguistic competence comparable to that of natives is seldom attested. A reasonable explanation for the facts of L1A and L2A is given by the Critical Period Hypothesis (CPH). In its most succinct and theory-neutral formulation, the CPH states that there is a limited developmental period during which it is possible to acquire a language, be it L1 or L2, to normal, nativelike levels. Once this window of opportunity is passed, however, the ability to learn language declines. Consistent with the CPH are the morphological and syntactic deficits of Genie, who was largely deprived of linguistic input and interaction until age 13 (Curtiss, 1977), as well as the desultory linguistic achievements of most adult L2 learners.

With a focus primarily on L2A, the present volume explores reasons why humans might be subject to a critical period for language learning. It also examines the adequacy of the CPH as an explanatory construct, the "fit" of the hypothesis with the facts.

To both of these dimensions, the contributors offer cutting-edge thought and experimentation. In examining the possible causes of a
critical period for L2A, the researchers bring the CPH into line with specifics of recent linguistic theory (Eubank & Gregg, chap. 4), discern neurofunctional differences between early- and late-learned language (Weber-Fox & Neville, chap. 2), and suggest sources of limits to language learning that are accommodated in modern evolutionary thinking (Hurford & Kirby, chap. 3). In questioning the explanatory suitability of the CPH-L2A, contributors bring new empirical data and argumentation to bear on matters once thought to be settled, such as the heuristic utility of the CPH-L2A (Flege, chap. 5), the shape of the age function, in theory and in fact (Bialystok & Hakuta, chap. 7), and the possibility of nativelike attainment in L2 pronunciation (Bongaerts, chap. 6).

These two approaches—one that ponders the etiology of a critical period for L2A and the other that disputes the adequacy of the CPH-L2A—are representative of current intellectual discourse. In according equal time to each of the approaches, this volume aims at a balance of scholarship pro and contra the CPH in the L2A context.

As a prolegomenon to these chapters, it is instructive to examine a few of the more prevalent formulations of the CPH-L2A, looking in particular at the proposed mechanisms of age-related effects. The introduction will also situate this book within the current intellectual climate of questioning the received wisdom relating to the CPH-L2A.

1. WHY'S AND WHY NOT'S OF THE CPH–L2A

kindred proposals not mentioned in the chapters—this section offers sketches of some of the mechanisms that researchers have proposed as underlying age-related declines in language learning ability.

Loss of Neural Plasticity in the Brain

Because of progressive lateralization of cerebral functions and ongoing myelination in Broca's area and throughout the cortex, the neural substrate that is required for language learning is not fully available after the closure of the critical period. This formulation was originally proposed by Penfield and Roberts (1959), and later popularized by Lenneberg (1967), who postulated that the end of the critical period was marked by "termination of a state of organizational plasticity linked with lateralization of function" (p. 176). Variations on this line of thinking have been advanced for the L2A context (e.g., Long, 1990; Patkowski, 1980; Pulvermüller & Schumann, 1994; Scovel, 1988).

Lenneberg (1967) directed most of his argumentation to primary language acquisition. However, he made a brief foray into L2A and pointed to learners' progress as well as their shortcomings. Here, Lenneberg moved from brain-based to mind-based commentary, alluding to an appendix in his book—written by Chomsky—that outlines Universal Grammar (UG)-based formal similarities among natural languages. For adults learning an L2, Lenneberg (1967) invoked the presence of this mental "matrix for language skills" to square the facts of (partial) L2A success with closure of the critical period:

Most individuals of average intelligence are able to learn a second language after the beginning of their second decade. ... A person can learn to communicate in a foreign language at the age of forty. This does not trouble our basic hypothesis on age limitations because we may assume that the cerebral organization for language learning as such has taken place during childhood, and since natural languages tend to resemble one another in many fundamental aspects (see Appendix A), the matrix for language skills is present. (p. 176)

For related thinking about the linkage of neurological development and the mental representation of UG, see Eubank and Gregg (chap. 4, this volume) and Jacobs (1988).

Loss of (Access to) the Language Learning Faculty

The closure of the critical period entails a loss of UG, a mental faculty consisting of innately specified constraints on the possible forms that natural language grammars may take. A weaker version of this approach suggests that UG continues to be mentally represented but for various reasons is no longer available or accessible to the language learner. It should be noted that, because the L1 grammar is an
instantiation of UG (see previous section), one can plausibly account for at least some of the headway that learners do make in L2A.

With the offset of the critical period, there may also be a loss of innate learning strategies presumed specific to the learning of language. These include the Subset Principle, which guides the learner to posit the most conservative grammar consistent with the linguistic input. By hypothesis, these epistemological components are the sine qua non of language acquisition; their absence essentially guarantees failure to attain nativelike competence. Thus the Fundamental Difference Hypothesis (Bley-Vroman, 1989) attributes the divergent end states of early L1A and late L2A to loss of, or lack of access to, UG and associated learning principles.

Principled inquiry concerning the role of UG in both the initial and end states of adult L2A comes in many forms (for a recent selection, see Flynn, Marahardjono, & O'Neil, 1997). One prominent line of thinking holds that invariant principles of UG are not lost in adult L2A; rather, what is problematic is the acquisition of L2 parameters: “Parameter values become progressively resistant to resetting with age, following the critical period” (Towell & Hawkins, 1994, p. 126). Simplistically, the difficulty in resetting parameters resides in having to “unlearn,” in the sense of relinquishing the representation of a parameter having a unique, L1-based setting, and establishing in its stead a biunique setting compatible with both the L1 and the L2 (for elaboration on parameter resetting, see Eubank and Gregg, chap. 4, this volume). In a later section, I summarize a contrasting approach to unlearning under the connectionist model of acquisition.

Maladaptive Gain of Processing Capacity with Maturation

As children develop, they are increasingly capable of processing linguistic input. However, Newport (1990, 1991) argued that cognitive immaturity, not cognitive maturity, is advantageous for language learning. Young children's short-term memory capacity allows them initially to extract only a few morphemes from the linguistic input. Working within these processing limits, children are more successful than adults, whose greater available memory allows for extracting more of the input, but who then are “faced with a more difficult problem of analyzing everything at once” (Newport, 1991, p. 126). The benefits of starting small have been demonstrated in simulations of the acquisition of English morphology (Goldowsky & Newport, 1993). Similarly, Elman's (1993) connectionist model starts with limited memory, then undergoes maturational changes (incremental increases in memory capacity). Training of networks under this condition succeeds in processing complex sentences. If the starting point is a fully formed adult-like memory, however, the complex sentences are not successfully processed by the network.

This "less is more" formulation of the CPH is apparently not confined to the domain of language acquisition: “The more limited abilities of children may provide an advantage for tasks (like language learning) which involve componential analysis” (Newport, 1990, p. 24; italics added). Nor is any loss of an innate language learning faculty implied: “the language acquisition capacity remains intact, but as children mature beyond the ages of four or five its function is impeded by the child's increasingly sophisticated cognitive abilities” (Meier, 1995, p. 613). In a similar vein of thought that specifically targets L2A, Felix's Competition Model (e.g., Felix, 1985) posits the coexistence of an intact UG and advanced domain-general cognition, and maintains that competition between the two systems results in victory for the latter. Mature domain-general cognition is thought to be ill-suited to the narrow, modularized task of acquiring language, hence the lack of success typically associated with adult L2A. The inappropriateness of certain mature cognitive mechanisms in the L2A context was explored by Birdsong (1994) and Bley-Vroman (1989).

Rosansky (1975) appealed to a Piagetian developmental model of cognition and argued that the emergence of Formal Operations during adolescence might forestall language learning. Although Rosansky's theoretical constructs differ from those of Newport, the reasoning of the two researchers is remarkably similar. For Rosansky (1975),

initial language acquisition takes place when the child is highly centered [i.e., in stages prior to Formal Operations]. He is not only egocentric at this time, but when faced with a problem he can focus (and then only fleetingly) on one dimension at a time. This lack of flexibility and lack of decentration may well be a necessity for language acquisition. (p. 96)

Use It Then Lose It

After childhood, unneeded neural circuitry and the language learning faculty it underlies are "dismantled" because the relevant neural tissue incurs metabolic costs (Pinker, 1994). This reasoning, whereby early language learning is biologically favored over later learning, is rooted in modern evolutionary thinking. Early learning of language is preferred in order that we may reap the benefits of linguistic communication over a longer stretch of our lifetime. So whereas our use of language continues through adulthood, the language learning faculty has served its purpose early on. To retain it would be uneconomical.

The evolution of our species has taken account of this one-shot utility. As Pinker (1994) argued:
Language-acquisition circuitry is not needed once it has been used; it should be dismantled if keeping it around incurs any costs. And it probably does incur costs. Metabolically, the brain is a pig. It consumes a fifth of the body's oxygen and similarly large portions of its calories and phospholipids. Greedy neural tissue lying around beyond its point of usefulness is a good candidate for the recycling bin. (pp. 294–295)

Hurford (1991) similarly accommodated the "use it then lose it" version of the language learning faculty within an evolutionary model: "The end of the critical period at around puberty is ... a point where the selection pressure in favour of facilitating factors ceases to operate, because of success at earlier lifestages. ... The 'light' goes out for lack of pressure to keep it 'on'" (p. 193).

Pinker (1994) speculated that the critical period for language acquisition is evolutionarily rooted in the more general phenomenon of senescence. Natural selection asymmetrically favors young organisms over older ones, assigning to youth the emergence of the lion's share of genetic features, which deteriorate at differing rates with increasing age. Using the example of lightning striking and killing a 40-year-old, Pinker noted that if a bodily feature had been designed to emerge after the age of 40, it would have gone to waste:

Genes that strengthen young organisms at the expense of old organisms have the odds in their favor and will tend to accumulate over evolutionary timespans, whatever the bodily system, and the result is overall senescence. Thus language acquisition might be like other biological functions. The linguistic clumsiness of tourists and students might be the price we pay for the linguistic genius we displayed as babies, just as the decrepitude of age is the price we pay for the vigor of youth. (p. 296)

Use It or Lose It

On the mental muscle metaphor, the language learning faculty atrophies with lack of use over time. Paltry progress in postadolescent L2A is clearly compatible with this view. Further, deriving from "use or lose" the inference that if the language learning faculty is used it will not be lost, this "exercise hypothesis" can also accommodate anecdotal accounts of individuals who start L2 acquisition early and continue to acquire foreign languages successfully into adulthood.

The exercise hypothesis was elaborated in greatest detail by Bever (1981). Under Bever's view, for acquisition of a given linguistic structure to take place, the systems of speech production and speech perception should work in tandem. In the absence of ongoing language learning activity, however, the two systems become progressively independent (with perceptive abilities outstripping productive abilities), because the psychogrammar, which normally mediates production and reception, ceases to function. (Bever's psychogrammar may be likened to a combination of UG, plus an organizer of acquired linguistic knowledge, plus an equilibrator of production and reception capacities at the moment of acquisition of a given structure.) Under conditions of continual use, however, the psychogrammar does not cease to function, and production and perception do not dissociate:

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, continued acquisition can stave off the independence of the systems, and therefore delay the apparent critical period. (Bever, 1981, p. 194)

Whereas the use it or lose it formulation predicts that critical period effects can be skirted under conditions of continued language learning, the "use it then lose it" version would seem to imply inevitable loss of language learning ability at the offset of the critical period. The two conceptions also differ in terms of the postmaturational fate of language learning circuitry. For Pinker, natural selection eliminates the metabolically hungry but functionally obsolete language learning mechanism. For Bever (1981), the psychogrammar "does not disappear after its usefulness is past because it is so entrenched as a mental system"; rather, it hangs around, taking an enormous metabolic toll: "The psychogrammar is not a joy of adulthood, but a burden, an adventitious relic left over from a dozen years of language learning" (p. 188).

Learning Inhibits Learning

In connectionist networks, learning is a matter of progressively accumulating and strengthening input–output associations. The strength of an association is functionally a probabilistic weighting corresponding to the likelihood that a given output of the system is correct. One downside to this kind of learning is that it is difficult to undo. As Elman et al. (1996) noted, "across the course of learning ... the weights within a network become committed to a particular configuration. ... After this 'point of no return' the network can no longer return to its original state" (p. 389).

Consider the example of the word-final phonemic sequence /oral vowel + n/ in French, which is strongly correlated with feminine gender in nouns and adjectives. Under the connectionist model, an adult native French speaker develops a high weighting for the cooccurrence of this sequence with feminine gender. Once the weighting has become stable, it is difficult to perform the unlearning required for representational reorganization. So, if the French native encountered word-final /oral vowel + n/ in a foreign language, the learner's initial assumption would be that the gender of the word is feminine. This functional state would persist despite input to the system about the inadequacy of its output.
This scenario was summarized by Elman et al. (1996):

All things being equal, the weights will be most malleable at early points in learning. As learning proceeds, the impact of any particular error declines. . . . If a network has learned the appropriate function, occasional outlier examples will not perturb it much. But by the same token, it may be increasingly difficult for a network to correct a wrong conclusion. Ossification sets in. The interesting thing about this phenomenon, from a developmental viewpoint, is that it suggests that the ability to learn may change over time—not as a function of any explicit change in the mechanism, but rather as an intrinsic consequence of learning itself. (p. 70)

For the context of language learning, Marchman (1993) produced critical period effects in her connectionist simulation. When a neural net becomes so "entrenched" with linguistic information that reorganization is too "costly," then it can be said that "it is the act of language learning itself that constrains the ability of the system to recruit new resources for solving linguistic problems" (p. 218).

Under this model, to attain success in L2A, the neural representation of a new language would in some sense have to supplant that of an earlier-learned language. That is, the idea that later language might be acquired alongside the old one is not explored. However, it is well known that the addition of an L2 does not imply subtraction of an L1, except to a modest extent in instances where continued use of the L1 is minimal (see Flege, chap. 5, this volume). This matter of ecological validity aside, such a model—or any other model that assumes inhibition of late learning by prior learning—is a reasonable point of departure for dealing with crosslinguistic (L1–L2) effects in syntax. (See MacWhinney’s Competition Model (e.g., Liu, Bates & Li, 1992; MacWhinney, 1987), which examines the ways that L1 knowledge may influence L2 learners’ representations of the relation between constituent position and semantic function in L2 sentences.) Something akin to inhibition may likewise underlie a learner’s failure to develop new phonetic categories that properly distinguish L2 sounds from related L1 sounds, thus resulting in a foreign accent (see Flege, 1995; chap. 5, this volume). However, it would be inappropriate to apply an inhibition model straightforwardly to age effects in the L1: Despite having little or no language to unlearn, late learners of L1 such as Chelsea (Curtiss, 1989) or Genie (Curtiss, 1977) are unable to attain full linguistic competence.

Other Factors in Nonnativelike Outcomes

Any number of learner variables may contribute to nonnativelikeness at the end state of L2A. There is little doubt that exogenous factors, such as variations in the amount and type of target language input, play a role in determining the final product. Similarly, one cannot discount pressures of a psychosocial nature, especially learners’ motivation to learn an L2 and their attitude toward assimilating within the foreign culture. Perhaps reflecting a conspiracy of several of these factors, the amount of use of the target language influences degree of foreign accent (Flege, Frieda, & Nozawa, 1997), as does phonetic training (Bongaerts, chap. 6, this volume). Thus, the CPH–L2A is not to be thought of as a unitary account of non-nativelike outcomes. For further discussion of the range of factors that may influence ultimate attainment in L2A, see Klein (1995), Bialystok & Hakuta (chap. 7, this volume), Flege (chap. 5, this volume), Birdsong (1998), and Bongaerts (chap. 6, this volume).

THE WHY NOTS:
REASONABLY DOUBTING THE CPH–L2A

On the face of it, the CPH–L2A is eminently plausible. We know that as humans mature, an earlier-is-better rule of thumb applies to any number of skills. Further, the case for the CPH–L2A is founded on a number of well-known studies, some of which we touched on earlier, others that are cited later. Moreover, until recently, there were few L2A success stories that would constitute counterevidence. Indeed, the case for the CPH–L2A is sufficiently solid that I am on record elsewhere as a staunch supporter (Birdsong, 1991).

The CPH–L2A would still have my support were it not for the unexpected findings of a study I carried out a few years ago (Birdsong, 1992). Two distinct sets of results gave me pause. First, among the 20 native speakers of English who began learning French as adults, 15 fell within the range of native speaker performance on a challenging grammaticality judgment task, and several of these 15 participants deviated very little from native norms. This rate of natiivelike attainment was unprecedented in the literature at the time. Second, I found that performance on the task was predicted by age of arrival (AOA) in France, even though the participants had moved to France as adults. Why should age effects continue to be found after the end of the presumed critical period?

Now that I am on the other side of the fence, it would be disingenuous of me to offer a neutral account of the CPH–L2A debate. Readers seeking the "pro" side will find it more than ably represented in this volume by Eubank and Gregg, Hurford and Kirby, and Weber-Fox and Neville. The following review is not meant to be exhaustive, because the book’s "anti" chapters (those of Bialystok and Hakuta, Bongaerts, and Flege) cover the terrain thoroughly. Rather, I will  

\(^2\)I should point out that the study was not designed to test directly the CPH–L2A but to see if some areas of grammar might be less subject to age effects than others. Some of the more peripheral results turned out to be of enduring interest.
concentrate on two types of evidence I already alluded to—the nature of the age function and numbers of nativelike attainers—that have led me to reconsider my original position. In so doing, I hope to convey a sense of why the case is not closed on the CPH–L2A, and thus to justify the collection of papers in this volume.

The Age Function

In L2A research on ultimate attainment, no single study has contributed more to the case for critical period effects than that of Johnson and Newport (1989). The Johnson and Newport participants were 46 Korean and Chinese learners of English, all of whom had lived in the United States for 5 years or more, but who varied in terms of their AOA in the United States. Participants were asked to provide grammaticality judgments of some 276 English sentences, roughly half of which were grammatical and the other half ungrammatical. The stimuli were presented on an audiotape, and participants provided binary judgments of acceptability by circling "yes" or "no" on an answer sheet. The stimuli exemplified basic surface contrasts in English, for example, regular verb morphology (Every Friday our neighbor washes her car; *Every Friday our neighbor wash her car), irregular noun morphology (Two mice ran into the house this morning; *Two mouses ran into the house this morning), and article placement (The horse jumped over the fence yesterday; *The horse jumped the fence over yesterday).

Of the many findings in Johnson and Newport (1989), perhaps the most revealing is the age function, that is, the distribution of participants’ scores on the instrument plotted against their AOA in the United States. For participants arriving in the United States prior to the presumed closure of an age-related window of opportunity, there was a linear decline in performance that began after AOA of approximately 7 years. However, after the window of opportunity closed, at AOA of about 17 years, the distribution of performance was essentially random (r = -.16). This outcome suggests that postmaturational AOA is not predictive of ultimate attainment; in other words, the L2 asymptote is determined not by a general age effect, but by one that operates within a defined developmental span. Consistent with critical period thinking, neurocognitive developmental factors are at work early on and cease when maturation is complete. Indeed, the asymmetry found by Johnson and Newport (1989), along with a similar finding by Patkowski (1980), may be straightforwardly interpreted as evidence for a biologically based critical or sensitive period in L2A (e.g., Long, 1990; Pulvermüller & Schumann, 1994).

Understandably, the age function evidence in Johnson and Newport (1989) is a cornerstone in the CPH–L2A edifice. However, since that study, several researchers have found age effects among participants who began learning their L2 as adults. For example, Birdsong (1992), in a study of English-speaking learners of French (AOA varying from 11.5–28), found a −.51 correlation (p = .02) of AOA and performance on a grammaticality judgment task. Other researchers (see Bialystok & Hakuta, chap. 7, this volume) have shown age effects for both early and late AOA. In a variety of domains, including pronunciation, both late and early AOA effects have been found (Oyama, 1976; Fleige, chap. 5, this volume). Contrary to the premises of the CPH–L2A, AOA is predictive of success, even when the AOA is later than the presumed end of maturational effects.

In the wake of these findings, the original Johnson and Newport (1989) results have been subjected to considerable scrutiny. For example, Bialystok and Hakuta (1994) reanalyzed the data from Johnson and Newport (1989) and found significant correlations of scores with age for both groups if the cutoff point was set at 20 years instead of 17. In addition, Birdsong and Molis (1998) conducted a replication of Johnson and Newport (1989), using the same materials, procedures, and tasks as the original. Our participants were 62 native speakers of Spanish. In contrast to Johnson and Newport (1989), we found a strong age effect among the 32 late arrivals (AOA ≥ 17 years). The correlation between age and performance on the grammaticality judgment task is significant (r = -.69, p < .01). The results of our study further suggest that earlier is better across the lifespan; for early and late arrivals together, the correlation (r = -.77) is likewise significant (p < .01). Consider, too, that the scores of the late arrivals are fairly closely clustered about the regression line; with an r² accounting for nearly half of the variance, the distribution is a far cry from the randomness found by Johnson and Newport.

Pulvermüller & Schumann (1994) maintained that "there is no clear evidence that after puberty the age of learning onset influences either mean or variance of grammaticality judgment scores" (p. 684). The present results constitute a direct and unambiguous challenge to this assertion. They should be sufficient, presumably, to prompt Pulvermüller and Schumann to revisit their neurobiological account of language acquisition: "If the decrease in grammatical proficiency with greater age in postpuberty starters could be confirmed, the present proposal would have to be modified" (p. 723).

Although these recent results are not consonant with the predictions of the CPH–L2A, they should not be interpreted as suggesting that

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3 "Ultimate" is not used here to suggest "nativelike." Ultimate attainment is to be understood as synonymous with the end state or asymptote of L2A, however close to or far from nativelike that state may be.
maturational factors are not at play at all. Birdsong & Molis (1998) pointed out that there is an inevitable confound of AOA and development prior to the end of maturation, in the sense that, for early arrivals, age effects cannot be dissociated from maturational effects. It is not inconceivable that the attested straight-line age function in L2A over the lifespan is the product of different causal mechanisms along the way, that is, the result of developmental factors up to the end of maturation, and of nondevelopmental factors thereafter.\footnote{A few candidate variables were mentioned previously. Note too that neurophysiological factors after the completion of maturation are not to be overlooked in late AOA age effects. For example, myelination and dendritic pruning take place over the lifespan. Precisely what these processes might contribute to late L2A is still a matter of speculation, however. One direction of inquiry to consider is the possibility that different neural substrates are variably affected by senescence. Thus, for example, if the basal ganglia area that is responsible for the processing of regular morphology were less (or more) affected by aging than the temporal and parietal regions that subserve irregulars (see Ullman et al., 1997), we would expect to see a dissociation between regulars and irregulars in the ultimate attainment of late L2 learners (see Flege, Yeni-Komshian, & Liu, 1998; other dissociations are discussed by Weber-Fox & Neville, chap. 2, this volume, and Eubank & Gregg, chap. 4, this volume).}

Rate of Nativelike Attainment

Estimates of rate of success in adult L2A (defined in terms of attainment of nativelike competence) typically range from virtually nil (Bley-Vroman, 1989) to 5\% (Selinker, 1972). Much has been made of the scarcity of nativelike attainers. Bley-Vroman (1989) spoke of "ineluctable failure" in L2A: if there are exceptional L2 learners, they are so rare as to be "pathological," comparable to instances of failure in early L1A (p. 44). Bley-Vroman (1989)—along with Selinker (1972)—suggested that whatever successes there are "could perhaps be regarded as peripheral to the enterprise of second language acquisition theory" (p. 44).

To establish the adequacy of the CPH–L2A, however, the rate of success must be taken into account. For Long (1990), falsifiability of the CPH–L2A hinged on this type of evidence: "The easiest way to falsify [the CPH] would be to produce learners who have demonstrably attained native-like proficiency despite having begun exposure well after the closure of the hypothesized sensitive periods" (p. 274). Indeed, for Long, a single such learner would suffice to refute the CPH–L2A (p. 253).

At the time this criterion was suggested, there was little reason to suspect the CPH–L2A would be falsified. For example, Patkowski (1980) had found only 1 participant out of 34 late learners who performed in the native range. Johnson and Newport (1989) had found none. Moreover, not one of the adult learners in Coppieters’s (1987) study had even come close to native performance in judgments of sentence acceptability in French. However, since 1990, several researchers have attested nativelikeness among their late-learning participants.

For example, Van Wuijtswinkel (1994) tested Dutch native speakers who had begun learning English after 12 years of age. Their task was to judge the grammaticality of a subset of the Johnson and Newport (1989) items, along with an assortment of other syntactic structures in English. Van Wuijtswinkel attested nativelike performance among 8 of 26 participants in one group of learners and 7 of 8 participants in another group. In a study of American Sign Language (ASL) as a second language, Mayberry (1993) found that late ASL–L2 learners (mean age of acquisition = 11) varied little from native ASL users on several tasks, including immediate recall of complex sentences and grammaticality judgments. White and Genesee (1996) studied the acquisition of English by French native speakers in Montreal. Some 16 of the 45 participants who appeared nativelike on various screening measures had had their first significant exposure to English after age 12. Participants were asked to make questions involving wh-extraction and to judge the grammaticality of 60 exemplars of various wh-movement structures such as "What did the newspaper report the minister had done?" and "What did you hear the announcement that Ann had received?" The researchers found no significant differences between near-natives (including the 16 late learners) and native controls on any task.

As mentioned above, Birdsong (1992) looked at the acquisition of French by 20 native speakers of English who had been exposed to French postpubertally (range 11–28 years, M = 14.9), who had been residing in France for at least 3 years, and whose mean age of arrival was 28.5 years (range = 19–48). On scalar grammaticality judgments of seven French syntactic structures exemplifying parametric variation (e.g., Diane a placé des fleurs dans sa chambre/*Diane a placé dans sa chambre des fleurs—Diane put flowers in her room/*Diane put in her room flowers) and highly French-specific constraints (e.g., Le très-commi Marcel Proust vient d’arriver/*Le commi romantier vient d’arriver—The well-known Marcel Proust just arrived/*The known novelist just arrived), the performance of 6 of the 20 experimental participants (30\%) was well within the range of performance of native controls.

Cranshaw (1997) investigated the acquisition of English tense–aspect features by 20 Francophone and 20 Sinophone participants, all of whom had begun studying English after age 12. Over a variety of production and judgment measures, and using stringent criteria for comparison, 3 (15\%) of the Francophones were indistinguishable from native English controls, as was 1 (5\%) of the Sinophones. Birdsong (1997) studied the acquisition of the distribution of the clitic se in
French intransitive constructions (e.g., Les nuages se dissipent/*dissipent après l’orage—'The clouds dissipate after the storm'; Les doigts bleuissent/*bleuissent de froid—'One's fingers turn blue from the cold'). Participants were 20 English natives (average AOA = 23; average age of first exposure to French = 13; residence in France ≥ 5 years). The distribution of se is highly idiosyncratic; it was therefore felt that L2 acquisition to nativelike levels in this domain would be unlikely. As groups, natives and learners differed significantly. However, 4 (20%) of the non-natives scored above the native mean of approximately 95% accuracy. Finally, in the Birdsong and Molis (1998) replication of Johnson and Newport (1989), 3 of the 32 late-arriving subjects had scores that were above 95% accuracy, and 13 of these late arrivals performed at or above 92% accuracy.\(^5\)

In the domains of phonetics and phonology, Bongaerts and his colleagues (see Bongaerts, chap. 6, this volume) showed in several experiments that native speakers of Dutch are able to attain a level of pronunciation in English and in French that is indistinguishable from that of native speakers, even though their study of the L2 began in late adolescence. Birdsong (1997) examined the acquisition of constraints on realization of liaison consonants in French, using the same participants from the se experiment. Although the group overall had an error rate of 22.5% (in contrast to the native controls, whose error rate was 0%), 4 of the nonnative participants, or some 20%, performed at 100% accuracy. Two of these participants were among the 4 who had performed at nativelike levels in the SE experiment.\(^6\)

Note that, in bringing falsifying evidence to bear on the CPH–L2A, the rate of success should be based on the relevant population of learners. That is, to determine the proportion of nativelike attainments, we should look only to those learners with exogenous circumstances-favoring language acquisition, not at any and all who have had some exposure to an L2 or who have tried to learn a foreign language. (I suspect that many long-held beliefs about the insignificant rate of success in L2A are based on the latter, much larger population.)\(^7\)

\(^5\)Other studies attesting nativelike attainment include Juffs and Harrington (1995), Ioup, Boustagui, El Tigi, and Moselle (1994), and White and Juffs (1997).

\(^6\)Flege, Munro, and MacKay (1995) found that 6% of their late L2A participants performed at nativelike levels. However, no participant with AOA > 16 was found to have authentic pronunciation. Together, these findings suggest that nativelike pronunciation is possible but infrequent among late-arriving participants, and that age effects persist past the presumed end of maturation.

\(^7\)To get an idea of how small the relevant population might be, let us construe "a fair chance of success" in terms of bringing L2 input into rough comparability with L1 input. It has been estimated that in the first five years of life a child has 9100 hours of exposure to L1 input; multiplying this figure by the average number of utterances that are directed to a child each hour (670), we arrive at a figure in excess of 6 million (see Birdsong, 1998). Were the relevant L2A population to be restricted to learners with such massive input, they would constitute a small fraction of the universe of "second language learners." In all likelihood, the rate of nativelike attainment within such a population would surpass insignificance.
from the processing of semantic aspects (e.g., open-class words and semantic anomalies). The two processing subsystems are differentially affected by delays in the onset of language learning, suggesting the operation of different sensitive periods (see Seliger, 1978). Weber-Fox and Neville also review other applications of neural imaging techniques to bilingualism and L2A, underscoring the specific areas of linguistic competence in which differences between late and early bilinguals are to be found. These differences are viewed as being consistent with a Lennieberg-type conception of the CPH.

From an evolutionary perspective, Hurford and Kirby consider two components of restricted language learning capacity. First there is language size, the sum of all the complexities of a given language. Given our speed of acquisition, there is an upper limit on how much language can be acquired prior to puberty (biological selection favors attainment of maximal language size before the onset of sexual maturity). However, it is not the entrenchment of an acquired language that inhibits late learning (see the earlier discussion of Marchman, 1993). Instead, the attainment of maximal language size coincides with the decline of a second component, a facility for acquiring new linguistic knowledge. Like Elman and like Newport (see previous sections), Hurford and Kirby argue that this facility is optimized by starting small, in the sense of initially having a limited linguistic processing capacity. With development of increased processing capacity, this advantage is lost. For normal individuals, the upper limit of linguistic attainment is reached by the time the ability to learn language is lost. Thus, by virtue of the coincidence of these two developmental milestones, language size could be thought of as being predictive of the offset of the critical period, but it is clearly not its cause. In the L2A context, knowledge of the L1 can be recruited to the benefit of L2 attainment when the two languages are sufficiently similar. Success in L2A will nevertheless be limited, however, because the adult’s linguistic processing resources are no longer well suited to the task.

Eubank and Gregg’s chapter is broad in scope. First the authors seek to pin down the concept of plasticity as it relates to critical periods, detailing the interaction of input, neurophysiology, and neurochemistry in the processes of long-term potentiation and long-term depression. This section culminates in the outlines of distinct neurofunctional mechanisms whose decreased plasticity could be linked to the passage of a critical period for language learning. Eubank and Gregg then cite several critical periods in other animal species that could be compared in their domain specificity to humans’ critical period for language acquisition. They go on to examine the evidence for critical periods in L1A, and contrast this with the case for the CPH in L2A. Casting the debate in terms of modern linguistic theory, Eubank and Gregg refine the notions of language, modularity, and access to UG.

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stressing the need for precision in use of these terms in discussing the CPH. A number of relevant L2A studies are reviewed and are found to offer only equivocal evidence for or against the role of UG in post-critical period L2A. However, Eubank and Gregg find the research of Weber-Fox and Neville promising, as it aims to identify precisely which aspects of language might be subject to a critical period. The authors conclude with speculations as to why (a) critical period(s) might exist.

On the anti side of the ledger, there are likewise three chapters. Flege is interested in the CPH as it pertains to L2 pronunciation. First, he shows that L2 pronunciation accuracy declines linearly with age (see Bialystok & Hakuta, chap. 7, this volume), and does not display a trademark discontinuity that Patkowski (1990) and others associate with the passing of a critical period. After reviewing the adequacy of several variants of the CPH, Flege proposes that nonnativelike accents do not result from a loss of ability to pronounce; rather, they are an indirect consequence of the state of development of the L1 phonetic-phonological system at the time L2 learning is begun. This conclusion is supported by the negative correlations of L1 pronunciation with L2 pronunciation, and of L1 use with L2 pronunciation. He goes on to adduce evidence that undermines Bevery (1981) formulation of the CPH, which depends crucially on the assumption of a loss of isomorphism between production and perception capacities in adults. For Flege, the difficulties associated with late learning of L2 pronunciation are not sufficiently captured by the CPH but are much more consistent with his Speech Learning Model. On this view, nonnativelike pronunciation results from learners’ increasing difficulty in establishing new, distinct representations of L2 phonetic categories. This difficulty is exacerbated when a given target phonetic segment is perceived by the learner to be highly similar to a segment in the L1 repertoire.

Bongaerts likewise tackles the area of L2 pronunciation, which, of the various linguistic domains, has been identified as the most vulnerable to critical period effects (Long, 1990; Scovel, 1988). Reporting the results from three experiments, Bongaerts brings disconfirming evidence in the form of late learners who are able to attain nativelike accents. The first two studies involved Dutch native speakers learning English as adults. Native English controls and two groups of Dutch participants were asked to read aloud a set of English sentences containing phones both similar to and different from Dutch sounds. Their pronunciations were rated for nativelikeness by a panel of judges. Under a variety of different analyses and by stringent criteria for comparison, a significant proportion of late learners in both studies were judged to have nativelike English pronunciation. The third study tested Dutch natives’ late acquisition of French. This
target language was chosen because, unlike English and Dutch, it is not a Germanic language, and because it is less often encountered over the Dutch airwaves than English. Over a range of performances, and again using strict criteria for nativelikeness, 3 of 9 highly proficient late learners of French were judged to be indistinguishable from natives.

Bialystok and Hakuta grant that for L2A, earlier is better, but stake out the position that it is misguided to infer a causal relation between age and attainment. Rather, Bialystok and Hakuta liken age to an intervening variable in a design; were it to be controlled for experimentally or partialed out of a regression equation, then one would find linguistic factors and cognitive factors at play. The linguistic variable is exemplified in native-language transfer. If there is a change in the language acquisition mechanism over time, then what is transferred from the L1 to the L2 should also change: Early on, more abstract UG constraints should transfer, while later learning should be characterized by relatively more transfer of L1-specific surface features. A review of the relevant literature suggests that this is not the case. With respect to cognitive factors, Bialystok and Hakuta argue that literate versus nonliterate populations differ in ultimate attainment. This, along with the authors' demonstration of proficiency differences as a function of educational level, cannot be captured by a simple maturational account of L2A. Bialystok and Hakuta also argue that the declines in general cognitive abilities that come with aging, being gradual and linear, are a better fit with the L2A data—which include the authors' report of a large-scale survey of immigrants to the United States—than is a critical-period-type function which, arguably, should exhibit some form of discontinuity.

Each of these chapters, whether anti- or pro-CPH-L2A, illustrates the richness, depth, and breadth of critical period inquiry. Collectively, they testify to the unmistakable centrality of the CPH in L2A research.

REFERENCES


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**Chapter Two**

**Functional Neural Subsystems Are Differentially Affected by Delays in Second Language Immersion: ERP and Behavioral Evidence in Bilinguals**

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**Age of Immersion and Neural Subsystems in L2A**

Our aim has been to test the hypothesis that the age of immersion in a second language has differential effects on the neural subsystems involved in language processing. This hypothesis arises from consideration of studies of the development and organization of visual, auditory, and somatosensory systems. Within these systems, the nature of sensory input significantly affects the development of specific neurophysiological and behavioral processes (Freeman & Thibos, 1973; Kaas, 1991; Knudsen, 1988; Patkowski, 1980; Wiesel & Hubel, 1963, 1965). Moreover, different functions within a system display distinct vulnerabilities to altered timing of input during development. For example, within the visual system, the timing of abnormal visual experience differentially affects the development of stereopsis, monocular spatial resolution, and spectral sensitivity (Harwerth, Smith, Duncan, Crawford & von Noorden, 1986). Although plasticity has been shown to characterize sensory and motor maps even in adult mammalian brains (Kaas, 1991; Kaas, Merzenich, & Killackey, 1983),