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THE CRITICAL PERIOD HYPOTHESIS: SOME PROBLEMS

DAVID SINGLETON
TRINITY COLLEGE, DUBLIN

1. Introductory

In this paper I shall claim that to speak in terms of *the* Critical Period Hypothesis (CPH) is misleading, since there is vast variation in the ways in which the critical period (CP) for language acquisition is understood. I shall in addition point out that such variation also relates to the ways in which the purported CP is interpreted in terms of its practical implications for L2 instruction. My contention is that such variation fatally undermines the status of the CPH as a scientific hypothesis.

2. The notion of critical period

The notion of CP has its origins in the biological sciences. One example of a CP that is often cited is behaviour exhibited by ducklings whereby they follow the first moving object they perceive after hatching:

This following behavior only occurs within a certain time period after hatching, after which point the ducklings develop a fear of strange objects and retreat instead of following. Within these time limits is the *critical period* for the following behavior.

(De Villiers & De Villiers 1978: 210)

Another example is the development of binocularity:

A critical period for the development of binocularity may begin when central nervous system cells driven by each eye grow and compete for cortical synapses (Wiesel & Hubel, 1963). This critical period may end when the degree and extent of competitive synaptogenesis diminishes and stabilizes, perhaps regulated in part by the amine system (Kasamatsu & Pettigrew, 1979). The critical period for development of binocularity may take place between weeks 4 and 12 in the cat; 1 and 9 in certain monkeys; and years 1 and 3 in man.

(Almli and Finger 1987: 126)

On the basis of the above examples, CPs can be characterised as being of limited duration within well-defined and predictable termini and as being related to very specific capacities or behaviours. We shall see that the precise termini proposed for maturational constraints on language acquisition by CP advocates vary across quite a wide range and that there is no consensus either regarding the particular acquisitional capacities that are deemed to be affected by such constraints. We shall further see that researchers diverge markedly in respect of their identification of the underlying causes of maturational constraints on language acquisition.

3. CP Termini

Penfield is widely seen as at least a proto-CP theorist and so let us begin our discussion of the termini of the CP with him. Penfield suggests that 'for the purposes of learning languages, the human brain becomes progressively stiff and rigid after the age of nine' (Penfield and Roberts 1959: 236) and that 'when languages are taken up for the first time in the second decade of life, it is difficult ... to achieve a good result ... because it is unphysiological' (Penfield and Roberts 1959: 255).

Lenneberg, for his part, proposes (1967) not only an end point for the CP (puberty), but also a point at which it supposedly has its onset (age two), the intervening period purportedly coinciding with the lateralization process - the specialization of the dominant hemisphere of the brain for language functions. Lenneberg further suggests (1967: 142) that the developmental stage on which language acquisition is predicated 'is quickly outgrown at the age of puberty,' the point at which he posits the lateralization process to be complete. With respect to L2 acquisition, he asserts (*ibid.*: 176) that after puberty 'the incidence of "language-learning-blocks" rapidly increases', 'foreign languages have to be ... learned through a conscious and labored effort, and '[f]oreign accents cannot be overcome easily'.

There has been a great deal of debate about lateralization, much of it focusing on the completion point. Molfese (1977: 206f.), for example, suggests that the lateralization of certain 'low-level' functions of phonetic and/or phonological character may in fact be 'complete by the first year of life,' while the sensorimotor cognitive structures underlying the child's early use of syntax and semantics may be 'represented in both hemispheres,' in which case 'his meaningful linguistic utterances will be mediated by both hemispheres, although perhaps not to the same degree.' This approach predicts a multiplicity of CPs, with the phonetic/phonological CP being posited as coming to an end very early.

Other researchers propose an earlier end of the phonetic/phonological CP on different grounds. Seliger (1978) argues that as well as a lateralization process there is a localization process within the dominant hemisphere. He suggests that phonetic/phonological functions are localized by puberty and that syntactic functions are localized subsequently, thus remaining acquirable until later in life. Yet another advocate of the multiple critical periods perspective is Diller (1981: 76), who notes that pyramidal cells, which he associates with phonetic/phonological acquisition, develop by age 6/8, whereas stellate cells, which he links with higher order functions, mature over two to three decades; he infers that authentic L2 accents can be acquired only by young children whereas cognitive aspects of L2s can be learned by relatively mature people.

Scovel (1988: 101) also distinguishes pronunciation from other areas of language, claiming that it shows maturational effects because it has a 'neuromuscular basis.' He suggests that acquiring other aspects of language is fundamentally different from learning pronunciation, because vocabulary, morphosyntax, etc. do not, unlike phonetics/phonology, have a 'physical reality.' He claims that those who begin to be exposed to an L2 after age 12 cannot ever 'pass themselves off as native speakers phonologically' (Scovel 1988: 185; cf. Scovel, 2000, 2006).

Other L2 researchers claim that the offset of the CP is progressive, this process beginning around age 6 or 7. Johnson and Newport (1989) infer from their research that there is a specific maturational phase - up to about 7 years - which is particularly favourable for language learning and a second phase - from about 7 years to about puberty - during which the language learning capacity declines gradually but subsequent to which there is a very abrupt deterioration. Long (1990) accepts Johnson and Newport's evidence in relation to an early beginning to the decline of the language acquiring capacity and agrees with Scovel's suggestion that age 12 constitutes the point beyond which a native-like L2 accent cannot be acquired. He also asserts that the prerequisite for the acquisition of L2 morphology and syntax to native levels is exposure to the L2 before age 15.

Rubén (1997) takes a more radical line. On the basis of studies of the effects of very early temporary hearing impairment, he concludes that the CP for phonetics/phonology ends around the twelfth month of infancy. Rubén further reads the research literature as indicating that the CP for syntax ends in the fourth year of life, and for semantics in the fifteenth or sixteenth year of life. Hyltenstam and Abrahamsson also favour a very early CP offset. Their review of evidence of differences between even very early L2 acquirers and native speakers, leads them to a certain dubiousness about the CPH, and to state in one publication that the CP may be 'une chimère' (2003b: 122). Elsewhere they speculate that the language learning mechanism may be 'designed

in such a way that it ... inevitably and quickly deteriorates from birth' (2003a: 575), and for this reason 'natelike proficiency in a second language is unattainable' (*ibid.*: 578).

A succinct comment on the state of the evidence regarding CP termini comes from Aram *et al.* (1997): 'the end of the critical period for language in humans has proven... difficult to find, with estimates ranging from 1 year of age to adolescence' (p. 285). The foregoing survey, though brief and selective amply suffices to confirm the well-foundedness of this comment.

4. Capacities affected by the CP

As we have seen, whereas Lenneberg (1967) and others see the CP as applying to language acquisition across the board, Scovel (1988) limits its application to the phonetic/phonological sphere. The notion that maturational constraints impact only on the acquisition of phonetics/phonology has a long history. Thus, for example, Dunkel & Pillet (1957) found that adult L2 beginners outperformed elementary school pupils in comprehension tests, but that younger beginners' pronunciation was 'superior to that achieved by older beginners' (p. 148), concluding that pronunciation is 'the most rewarding aspect' of early L2 learning. Fathman (1975) and Fathman & Precup (1983) reached similar conclusions in studies of immigrants acquiring English in the US.

Other researchers have hypothesized constraints of a different nature on the operation of the CP. For instance, Martohardjono & Flynn (1995) claim that, whereas aspects of L2 proficiency unrelated to innate elements may be subject to age-related degradation, aspects supported by biological endowment (Universal Grammar – UG) are likely to resist such degradation. Other researchers (e.g. Bley-Vroman 1989; Schachter 1988) claim that post-pubertal language learning has *no* access to UG, explaining L2 learning without UG in terms of general problem solving mechanisms (seen as not constrained by maturation) plus L1 knowledge (Bley-Vroman 1989). There is also a 'partial access' position on this issue. Thus, Hawkins (2003; Hawkins & Yuet-hung Chan 1997) suggests that some features of UG are inaccessible to late L2 learners, resulting in mental representations which diverge from those of the native speaker.

A further – non UG-based - distinction is proposed by DeKeyser (2000, 2003a). In his (2000) study, the adult beginners who scored within the range of the child beginners evinced higher levels of verbal analytical ability, an ability which, according to him, played no role in the performance of the child beginners. DeKeyser concludes that maturational constraints apply only to implicit language learning mechanisms - that 'somewhere between early childhood and puberty children gradually lose the ability to learn a language successfully through implicit mechanisms only' (DeKeyser 2003a: 335).

As in the case of the survey of proposed termini for the CP, the above *tour d'horizon* of proposals with respect to the domains affected by the CP is very far from exhaustive. However, once again, even a very brief survey of this kind reveals quite a range of different points of view in this matter.

5. Causes of the CP

As is already clear from previous discussion, many of the widely cited proposals regarding causes of the CP refer to neurobiology. Penfield (Penfield and Roberts 1959) talks about decreasing cerebral plasticity; Lenneberg (1967) and Molfese (1977) refer to the process of lateralization of language functions; Seliger (1978) evokes the localization of specific language subfunctions within the dominant hemisphere; and Diller (1981) bases his arguments on the maturation timetables of different types of brain cell. A further perspective is offered by Pulvermüller and Schumann (1994), who note that, as the brain matures, the axons of neurons are progressively wrapped by glial cells – a process labelled myelination – after the substance myelin

contained in the glial cells. Pulvermüller and Schumann claim that myelination reduces plasticity in the language areas of the brain until around puberty, that plasticity then remains low, and that this is what explains age effects in language acquisition.

Other treatments of the neurobiological dimension of this issue have derived from studies using brain-imaging techniques. Thus, Kim *et al.* (1997) investigated spatial representation of L1 and L2 in the cortex of early and late bilinguals during a sentence-generation task. What they found was that in respect of Broca's area late bilinguals showed two adjacent centres of activation for L1 and L2, whereas in the early bilinguals a single area of activation for both languages emerged. Similarly, Wattendorf *et al.* (2001) looked at subjects (i) exposed to two languages before age 3 and to a third after age 10, and (ii) exposed to only one language up to age 10 and had then to two further languages. In the early bilinguals the zones in Broca's area activated by the use of the first two languages overlapped, whereas in the late multilinguals the pattern of activation was more diffuse. Whether such effects are related to age of onset or to degree of proficiency is still a matter of dispute.

In sum, there is 'no consensus' (Hyltenstam & Abrahamsson 2003a: 563) regarding neurobiological interpretations of age effects. Nor, of course, are other varieties of explanation exempt from neurobiological implications; the issue is that of directionality. Recent work in the neurosciences (see e.g. Bialystok and Hakuta 1999; Gazzaniga 1992; Robertson 1999) shows that brain structure and organization are as likely to reflect different kinds of experience as to determine these experiences, which means that features of structure and organization may result from rather than cause different cognitive, affective and other aspects of language acquisition – including level of proficiency (see e.g. Perani *et al.* 1998; Abutalebi *et al.* 2001).

Some researchers' explanations for the CP have focused not on neurobiology but on Piagetian psychology, and in particular on the impact of the onset of 'formal operations' (FO) during adolescence. Krashen (1975) homes in on the development of an interest in general 'systems' and 'theories' rather than ad hoc solutions, suggesting that this 'general tendency of adolescents to construct theories' (Inhelder and Piaget 1958: 336) might inhibit the 'natural' and complete acquisition of an L2. Rosansky (1975) focuses on the awareness of contradictions associated with FO, which she sees as being deleterious to language acquisition. Felix (1981) sees the 'problem-solving cognitive structures' associated with FO as competing with the language-acquiring structures of the language faculty.

A more recent perspective on the role of general cognitive factors in relation to the age question is provided by DeKeyser (2000, 2003a, 2003b, 2006), who posits an inescapable decline in language acquiring capacity because of cognitive maturation. He suggests that there a diminishing capacity for the implicit learning of complex abstract systems – including language but not excluding other complex systems. (cf. Bialystok (1997, 2002; Bialystok & Hakuta 1994, 1999; Hakuta, Bialystok & Wiley 2003).

Explanations for the CP also refer to affective-motivational factors. For example, Krashen (1982: 216) claims that the 'affective filter' (cf. Dulay and Burt 1977) is strengthened at puberty thanks to the onset of formal operations. His view (1985: 13) is that '[w]hile the filter may exist for the child second language acquirer, it is rarely, in natural informal language acquisition situations, high enough to prevent native-like levels of attainment,' whereas '[f]or the adult it rarely goes low enough to allow native-like attainment.'

Another batch of explanations are Freudian in inspiration. An early Freudian account of age effects in L2 acquisition is that of Stengel (1939) account, in terms of – *inter alia*: *identification*, the desire to be like others, which he sees as underlying the phenomenon of 'echolalia' in children, which plays no role in normal adult language learning (pp. 471f.); the *super-ego*, which, he says plays an inhibiting role in the adult but is relatively undeveloped in the child (p. 473); and *narcissism* which Stengel claims occasions the 'sense of shame' many adults feel when they start to use a new language (p. 476). Another concept borrowed from Freud is that of hardening ego-boundaries. Taylor's (1974: 33) approach to maturational constraints is

informed by this perspective but it is particularly emphasized in the work of Guiora, who (1972, 1992; Guiora, Brannon and Dull 1972; Guiora, Beit-Hallahmi, Brannon, Dull and Scovel 1972) introduces the construct of *language ego*, Guiora's proposals claim that learning an L2 requires the taking on of a new identity and that in order for this to happen language ego boundaries have to be permeable, which, typically, they are not in the adult.

Schumann also takes affective-motivational factors into account in his discussion of the CPH. In his earlier work indeed (e.g. 1975, 1978) he related post-pubertal L2 learning difficulties principally to 'social and psychological changes' (Schumann 1975: 229) and to social and psychological distance. In his more recent discussion of these issues he continues to see affective-motivational factors as playing a countervailing role in respect of neurobiological maturational constraints (Schumann 1994; cf. Moyer 1999, 2004).

Once again it is worth emphasising that the above short account of relevant research, like those in the previous sections, could be extended significantly (see, e.g. Singleton & Ryan 2004: Chapter 5). However, despite its curtailed and partial nature, the foregoing overview reveals a wide variety of opinions on the matter of causes of the CP.

6. The CP and early L2 instruction

We come now to the question of practical implications of the CPH. We can begin by noting that advocacy of early L2 instruction in the 1950s-60s was much influenced by the ideas of Penfield regarding the difficulty of acquiring a language in the second decade of life (Stern 1983: 132). It is clear then that the notion of a critical period had a major impact on decisions concerning early L2 instruction.

Some present-day CPH theorists take essentially the same line as Penfield. Spada, for example, recently made the following assertion in an interview:

If the goal for learning/teaching a foreign language is to obtain the highest level of second language skills ... there is support for the argument that 'earlier is better.' This support, found in the critical period hypothesis literature, is based on the claim that biological and maturational factors constrain language learning beyond a certain age.

(ReVEL 2004)

However, this is by no means a unanimous view among those who favour the CPH. Johnson & Newport (1989) conclude that 'the learning which occurs in the formal language classroom may be unlike the learning which occurs during immersion, such that early instruction does not necessarily have the advantage for ultimate performance that is held by early immersion' (p. 81). DeKeyser takes a rather similar line:

Rather than suggesting the importance of starting early, [age differences] indicate that the instructional approach should be different depending on age: full-scale immersion is necessary for children to capitalize on their implicit learning skills, and formal rule teaching is necessary for adults to draw on their explicit learning skills.'

(DeKeyser 2003a: 335)

Contrariwise, there are CPH *sceptics* who energetically *support* the early introduction of L2s into the curriculum. For example, Ekstrand (1971) Genesee (1978) and Hatch (1983) all argue for early L2 instruction, but not because they accept the idea of maturational constraints, but rather on the basis of their belief in the importance of factors such as the desirability of as long an exposure to the L2 as possible and the importance of laying an early foundation to L2 learning to maximise the ground that can be covered.

In other words, the consensus which is lacking with regard to the termini, the domains of operation and the causes of the CPH is also completely absent in respect of what implications it might or might not have for L2 instruction.

7. Concluding remarks

The variety of propositions to be found under the CPH heading mean that the CPH cannot plausibly be regarded as a scientific hypothesis. Nor does the option of reducing the various versions of the CPH to a single summary form help. Such a summary form would look something like this: 'for some reason, the language acquiring capacity, or some aspect or aspects thereof, is operative only for a period which ends some time between perinatal and puberty.' This is not a hypothesis either; it is at best an extremely vague promissory note.

In the context of research into social and emotional development, the child psychologist Ross Thompson voices the following conclusion about the CP concept.

While the metaphor of critical periods in the organization of neural systems in the visual cortex or of imprinting in lower species may offer an attractive heuristic to students of human development, the complexity of the behavioral systems to which these concepts are applied in young children makes it difficult, if not impossible, to identify the parameters of sensitive periods with appropriate specificity.

(Thompson 2001: 87)

These seem to me to be words that CPH theorists would do well to ponder on.

References

- Abutalebi, Jubin, Stefano Cappa and Daniela Perani (2001). The bilingual brain as revealed by functional neuroimaging. *Bilingualism: Language and Cognition* 4: 179-190.
- Almli, C. Robert and Stanley Finger (1987) Neural insult and critical period concepts. In *Sensitive Periods in Development: Interdisciplinary Perspectives*, Marc H. Bornstein (ed.), 123-143. Hillsdale, NJ: Lawrence Erlbaum.
- Aram, Dorothy, Elizabeth Bates, Julie Eisele, Judi Fenson, Ruth Nass, Donna Thal and Doris Trauner (1997). From first words to grammar in children with focal brain injury. *Developmental Neuropsychology* 13: 275-343.
- Bialystok, Ellen (1997). The structure of age: In search of barriers to second language acquisition. *Second Language Research* 13: 116-137.
- Bialystok, Ellen (2002). On the reliability of robustness: A reply to DeKeyser. *Studies in Second Language Acquisition* 24: 481-488.
- Bialystok, Ellen and Kenji Hakuta (1994). *In Other Words: The Science and Psychology of Second Language Acquisition*. New York: Basic Books.
- Bialystok, Ellen and Kenji Hakuta (1999). Confounded age: Linguistic and cognitive factors in age differences for second language acquisition. In *Second Language Acquisition and the Critical Period Hypothesis*, David Birdsong (ed.), 161-181. Mahwah, NJ: Lawrence Erlbaum.
- Bley-Vroman, Robert (1989). What is the logical problem of foreign language learning? In *Linguistic Perspectives on Second Language Acquisition*, Susan M. Gass and Jacquelyn Schachter (eds.), 41-68. Cambridge: Cambridge University Press.
- DeKeyser, Robert (2000). The robustness of critical period effects in second language acquisition. *Studies in Second Language Acquisition* 22: 499-533.

- DeKeyser, Robert (2003a). Implicit and explicit learning. In *The Handbook of Second Language Acquisition* (eds.), Catherine Doughty and Michael H. Long (eds.), 313-348. Malden, MA: Blackwell.
- DeKeyser, Robert (2003b). Confusion about confounding: The critical period and other age-related aspects of second language learning. Paper presented at ELIA VIII (Encuentros de Linguística Inglesa Aplicada), El factor edad en la adquisición y enseñanza de L2, Seville.
- DeKeyser, Robert (2006). A critique of recent arguments against the critical period hypothesis. In *Age in L2 Acquisition and Teaching*, Cristián Abello-Contesse, Rubén Chacón-Beltrán, M. Dolores López-Jiménez, M. Mar Torreblanca- López (eds), 49-58. Bern: Peter Lang.
- De Villiers, Jill and Peter De Villiers (1978). *Language Acquisition*. Cambridge, MA: Harvard University Press.
- Diller, Karl (1981). 'Natural methods' of foreign language teaching: Can they exist? What criteria must they meet? In *Native Language and Foreign Language Acquisition*, Harris Winnitz (ed.), 75-91. New York: The New York Academy of Sciences.
- Dulay, Heidi and Marina Burt (1977). Remarks on creativity in language acquisition. In *Viewpoints on English as a Second Language*, Marina Burt, Heidi Dulay and Mary Finnochiaro (eds), 95-126. New York: Regents.
- Dunkel, Harold B. and Roger A. Pillet (1957). A second year of French in the elementary school. *Elementary School Journal* 58, 142-151.
- Fathman, Ann (1975). The relationship between age and second language productive ability. *Language Learning* 25: 245-53.
- Fathman, Ann and Lois Precup (1983). Influences of age and setting on second language oral proficiency. *Second Language Acquisition Studies*, Kathleen M. Bailey, Michael H. Long and Sabrina Peck (eds.), 151-161. Rowley, MA: Newbury House.
- Felix, Sascha (1981). Competing cognitive structures in second language acquisition. Paper presented at the European-North American Workshop on Cross-Linguistic Second Language Acquisition Research, Lake Arrowhead CA, September. Cited and discussed in Birgit Harley (1986) *Age in Second Language Acquisition*. Clevedon: Multilingual Matters, 12.
- Gazzaniga, Michael S. (1992). *Nature's Mind: The Biological Roots of Thinking, Emotions, Sexuality, Language, and Intelligence*. New York: Basic Books.
- Genesee, Fred (1978). Is there an optimal age for starting second language instruction? *McGill Journal of Education* 13: 145-54.
- Guiora, Alexander (1972). Construct validity and transpositional research: Toward an empirical study of psychoanalytic concepts. *Comprehensive Psychiatry* 13: 139-150.
- Guiora, Alexander (1992). Notes on the psychology of language – the Gent lectures. *Scientia Paedagogica Experimentalis* 29 (Supplement): vii-62.
- Guiora, Alexander, Benjamin Beit-Hallahmi, Robert Brannon, Cecelia Dull and Thomas Scovel (1972). The effects of experimentally induced changes in ego states on pronunciation ability in a second language: An exploratory study. *Comprehensive Psychiatry* 13: 421-428.
- Guiora, Alexander, Robert Brannon and Cecelia Dull (1972). Empathy and second language learning. *Language Learning* 22: 111-130.
- Hakuta, Kenji, Ellen Bialystok and Edward Wiley (2003). Critical evidence: A test of the Critical Period Hypothesis for second-language acquisition. *Psychological Science* 14: 31-38.
- Hatch, Evelyn (1983). *Psycholinguistics: A Second Language Perspective*. Rowley, MA: Newbury House.

- Hawkins, Roger (2003). 'Representational deficit' theories of (adult) SLA: Evidence, counterevidence and implications. Paper presented at the 13th Annual Conference of the European Second Language Association (EUROSLA), Edinburgh.
- Hawkins, Roger and Cecelia Yuet-hung Chan (1997). The partial availability of Universal Grammar in second language acquisition: The 'failed functional feature hypothesis'. *Second Language Research* 13: 187-226.
- Hyltenstam, Kenneth and Niclas Abrahamsson (2003a). Maturational constraints in SLA. In *The Handbook of Second Language Acquisition*, Catherine Doughty and Michael H. Long (eds.), 539-588. Malden, MA: Blackwell.
- Hyltenstam, Kenneth and Niclas Abrahamsson (2003b). Âge de l'exposition initiale et niveau terminal chez les locuteurs du suédois L2. *Acquisition et Interaction en Langue Étrangère* 18: 99-127.
- Inhelder, Barbel and Jean Piaget (1958). *The Growth of Logical Thinking from Childhood to Adolescence*. Translated by A. Parsons and S. Milgram. London: Routledge and Kegan Paul.
- Jacqueline S. Johnson and Elissa L. Newport (1989). Critical period effects in second language learning: The influence of maturational state on the acquisition of ESL. *Cognitive Psychology* 21: 60-99.
- Kasamatsu, Takuji and Jack D. Pettigrew (1979). Preservation of binocularity after monocular deprivation in the striate cortex of kittens treated with 6-hydroxydopamine. *Journal of Comparative Neurology*, 185: 139-162.
- Kim, Karl H.S., Norman R. Relkin, Lee Kyoung-Min and Joy Hirsch, J. (1997). Distinct cortical areas associated with native and second languages. *Nature* 388: 171-174.
- Krashen, Stephen D. (1975). The critical period for language acquisition and its possible bases. In *Developmental Psycholinguistics and Communication Disorders*, Doris Aaronson and Robert W. Rieber (eds.), 211-224. New York: New York Academy of Sciences.
- Krashen, Stephen D. (1982). Accounting for child-adult differences in second language rate and attainment. In *Child-Adult Differences in Second Language Acquisition*, Stephen D. Krashen, Robin C. Scarcella and Michael H. Long (eds.), 202-226. Rowley, MA: Newbury House.
- Krashen, Stephen D. (1985). *The Input Hypothesis: Issues and Implications*. London: Longman.
- Lenneberg, Eric H. (1967). *Biological Foundations of Language*. New York: Wiley.
- Long, Michael H. (1990) Maturational constraints on language development. *Studies in Second Language Acquisition* 12: 251-285.
- Martohardjono, Gita and Suzanne Flynn (1995). Is there an age factor for Universal Grammar? In *The Age Factor in Second Language Acquisition*, David Singleton and Zsolt Lengyel (eds.), 135-153. Clevedon: Multilingual Matters.
- Molfese, Dennis (1977). Infant cerebral asymmetry. In *Language Development and Neurological Theory*, Sidney J. Segalowitz and Frederic A. Gruber (eds.), 22-37. New York: Academic Press.
- Moyer, A. (1999). Ultimate attainment in L2 phonology: The critical factors of age, motivation and instruction. *Studies in Second Language Acquisition* 21: 81-108.
- Moyer, A. (2004). *Age, Accent and Experience in Second Language Acquisition*. Clevedon: Multilingual Matters.
- Penfield, Wilder and Lamar Roberts (1959). *Speech and Brain Mechanisms*. Princeton, NJ: Princeton University Press.
- Perani, Daniela, Eraldo Paulesu, Nuria Sebastian Galles, Emmanuel Dupoux, Stanislas Dehaene, Valentino Bettinardi, Stefano F. Cappa, Ferruccio Fazio and Jacques Mehler (1998). The bilingual brain: Proficiency and age of acquisition of the second language. *Brain* 121: 1841-1852.

- Pulvermüller, Friedemann and John H. Schumann (1994). Neurobiological mechanisms of language acquisition. *Language Learning* 44: 681-734.
- ReVEL (2004). Interview. *Revista Virtual de Estudos de Linguagem* 2 (2). http://planeta.terra.com.br/educacao/revel/edicoes/num_2/interview_l2.htm.
- Robertson, Ian (1999). *Mind Sculpture*. London: Bantam.
- Rosansky, Ellen (1975). The critical period for the acquisition of language: Some cognitive developmental considerations. *Working Papers on Bilingualism* 6: 93-100.
- Ruben, Robert J. (1997). A time frame of critical/sensitive periods of language development. *Acta Otolaryngologica* 117: 202-205.
- Schachter, Jacquelyn (1988). Second language acquisition and its relationship to Universal Grammar. *Applied Linguistics* 9: 219-235.
- Schumann, John H. (1975). Affective factors and the problem of age in second language acquisition. *Language Learning* 25: 209-35.
- Schumann, John H. (1978). *The Pidginization Process: A Model for Second Language Acquisition*. Rowley, MA: Newbury House.
- Schumann, John H. (1994). Where is cognition? Emotion and cognition in second language acquisition. *Studies in Second Language Acquisition* 16: 231-242.
- Scovel, Thomas (1988). *A Time to Speak: A Psycholinguistic Inquiry into the Critical Period for Human Language*. Rowley, MA: Newbury House.
- Scovel, Thomas (2000). A critical review of the Critical Period Hypothesis. *Annual Review of Applied Linguistics* 20: 213-223.
- Scovel, Thomas (2000). Age, acquisition, and accent. In *Age in L2 Acquisition and Teaching*, Cristián Abello-Contesse, Rubén Chacón-Beltrán, M. Dolores López-Jiménez, M. Mar Torreblanca- López (eds), 31-48. Bern: Peter Lang.
- Seliger, Herbert W. (1978). Implications of a multiple critical periods hypothesis for second language learning. In *Second Language Acquisition Research: Issues and Implications*, William C. Ritchie (ed.), 11-19. New York: Academic Press.
- Singleton, David and Lisa Ryan (2004). *Language Acquisition: The Age Factor*. Second Edition. Clevedon: Multilingual Matters.
- Stengel, Erwin (1939). On learning a new language. *International Journal of Psycho-Analysis* 20: 471-479.
- Stern, Hans H. (1983). *Fundamental Concepts of Language Teaching*. Oxford: Oxford University Press.
- Taylor, Barry, P. (1974) Toward a theory of language acquisition. *Language Learning* 24: 23-35.
- Thompson, Ross A. (2001). Sensitive periods in attachment? In *Critical Thinking about Critical Periods*, Donald B. Bailey, Jr., John T. Bruer, Frank J. Symons, and Jeff W. Lichtman (eds.), 83-106. Baltimore: Brookes.
- Wattendorf, Elise, Birgit Westermann, Daniela Zappatore, Rita Franceschini, Georges Lüdi, Ernst-Wilhelm Radü and Cordula Nitsch (2001) Different languages activate different subfields in Broca's area. *NeuroImage* 13: 624.
- Wiesel, Torsten N., and David H. Hubel (1963) Single-cell responses in striate cortex of kittens deprived of vision in one eye. *Journal of Neurophysiology*.