

THE NEUROSCIENTIFIC PERSPECTIVE IN SECOND LANGUAGE ACQUISITION RESEARCH: A CRITICAL SYNOPSIS

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The question of whether the findings coming out of the research in the neurosciences have produced any valuable insights for applied linguistics has been a topic of considerable debate in the last few decades. Such findings have been enlisted to examine such important issues as, for instance, the existence of differences between primary language acquisition and secondary language acquisition, the notion of a "critical period" for the acquisition of languages, and the role of experimental vs. analytical processes in second language acquisition (SLA).

The purpose of this review essay is to provide an overview of the main issues that the neuroscience/SLA interface has dealt with, including how neuroscientifically-shaped SLA theories have been translated into specific instructional proposals and models. The present synopsis will attempt to answer, in effect, if the foray into the territory of neuroscience has produced any insights of value for applied linguistics.

INTRODUCTION

If anything now marks the increasingly-sophisticated field of applied linguistics it is the lack of a profession-wide consensus on how second languages (SLs) are acquired. This is perhaps why a growing number of second language acquisition (SLA) researchers have, for several decades now, been looking to neuroscience for insight and guidance, believing perhaps that knowledge about the brain will provide an empirical basis upon which to construct a truly comprehensive and coherent theory of SLA or, at the very least, will provide a template for assessing and interpreting theories and models of SLA. Indeed, since Eric Lenneberg's widely influential 1967 study, in which he proposed a "critical period" for the lateralization of language, applied linguists have frequently looked to the neuroscientific domain in the hope of being able to extract relevant insights on SLA itself and on how to make the instruction of SLs more "brain-compatible."

In 1986, I put forward in *Lenguas Modernas* a construct, designated the *bimodality* model, that attempted to correlate the work in neuroscience with models and theories of both SLA and second language teaching (SLT). Since then, various aspects of the bimodality model have been applied both to the teaching of languages to children in Italy with various kinds of brain lesions (e.g. Danesi 1988a, 1988b) and to typical SL learners in a high school setting (e.g. Danesi and Mollica 1988) with a modicum of success. Encouraged by such empirical experiences, in this essay I will now "stand back theoretically," so to speak, and look at the main issues that the neuroscience/SLA interface has dealt with, including how neuroscientifically-shaped SLA theories have been translated into specific instructional proposals such as Suggestopedia, Total Physical Response, and the Natural Approach.

The idea of seeking insights from neuroscience is, in my view, a sustainable one. From a biological perspective, language acquisition, be it primary (PLA) or secondary (SLA), can, in fact, be thought of as a reorganization of the structure of some, if not most, parts of the brain. In other words, the acquisition of any language can be conceived as entailing a reconfiguration of neuronal-synaptic structure, and this can have implications for assessing, interpreting, or constructing theories and models of SLA. Using techniques such as lateral eye movement, dichotic listening, tachistoscopic viewing, visual field tasks, electric stimulation mapping, etc., neuroscientists have been putting together a rather substantive profile of how language is acquired and organized in the brain. Some evidence has emerged, for instance, that bilinguals and advanced SL learners are equally lateralized in each of their languages; that there might be a greater right hemisphere (RH) involvement in the early stages of SLA; that there is greater left hemisphere (LH) involvement in formal learning tasks; and so on. However, I should alert the reader to the fact that, in their enthusiasm, neuroscientifically-inclined applied linguists have perhaps not always been judicious and cautious in applying neuroscientific theory to SL teaching practice. I cannot but agree with Spolsky (1989: 86) when he remarks that "the body of hard data on the neuroscience of second language learning comes nowhere near matching the enormous amount of speculation or the large number of studies."

The present synopsis of the work in applied linguistics that has been shaped by a neuroscientific mindset will attempt to answer if the two-decade-old foray into the territory of the brain sciences has produced any insights of value for applied linguistics and if it is worthwhile for applied linguistics to pursue this line of inquiry in the future. I will start with an overview tracing the history of the neuroscientific study of language. Then I will survey the three main issues that have emerged from the neuroscience/SLA interface: namely, the neurofunctional differences that inhere between PLA and SLA; the critical period issue; and the purported role played by the RH in SLA. Needless to say, within the space limitations

of the present essay this critical synopsis can only be of a highly schematic and selective nature.

NEUROSCIENTIFIC THEORIES OF LANGUAGE: AN HISTORICAL SYNOPSIS

For the purposes of clarity, I will use only the term *neuroscience* in this essay. This covers any study of the brain/mind nexus (neuropsychology, neuroanatomy, neurolinguistics, etc.). The roots of this branch of the contemporary cognitive sciences lie in the birth of neuropsychology as a field investigating the relation of any kind of mental operation to brain anatomy, physiology, and functioning. These can be traced to 1861, when the French anthropologist and surgeon Pierre Paul Broca published his classic study of a patient who had lost the ability to articulate words during his lifetime, even though he had not suffered any paralysis of his speech organs. Noticing a destructive lesion in the left frontal lobe of the LH at the autopsy of this patient, Broca was thus able to present concrete evidence to link the articulation of speech to a specific cerebral site. By making a direct connection between a psychological function and the neural substrate from which it arose, Broca had, *ipso facto*, established a new field of scientific inquiry. Incidentally, Broca was also responsible for suggesting that there existed an *asymmetry* between the brain and the body by pointing out that right-handed persons were more likely to have language located in the LH. As an historical footnote, it is important to note that the military surgeon Marc Dax had already presented observations in 1836 at the Congrès Méridional de Montpellier relating destructive lesions in the LH to language loss. However, his paper was never officially published (see Joannette, Goulet, and Hannequin 1990: 1-2).

This "first period" of neuroscience came into sharp focus when, in 1874, the work of the German neurologist Carl Wernicke brought to the attention of the medical community further evidence linking the LH with language. Wernicke documented cases in which damage to another area of the LH consistently produced a recognizable pattern of impairment to the faculty of speech comprehension. Wernicke's work was followed in 1892 by Jules Déjerine's demonstration that problems in reading and writing resulted primarily from damage to the LH alone. So, by the end of the nineteenth century the research evidence that was accumulating provided an empirical base to the emerging consensus among neuroscientists that the LH was the biological locus for language. Unfortunately, it also contributed to the unfounded idea that the RH was without special functions and subject to the control of the LH.

The work of Broca, Wernicke, and other nineteenth-century neuroscientists made good, paradoxically, on the unfounded "phrenological" perspective of Franz Joseph Gall (1795-1820), who was probably the first to attempt a mapping of all the parts of the brain according to function. The difference between phrenology and the work of Broca and the others was

essentially one of method –Broca established a link between a neural substrate and a psychological function in a clinical, scientific manner; the phrenologist speculatively linked a “bump” on the skull, and its cerebral area underneath, to a psychological function.

The first period of neuroscience was grounded on what has come to be known as “localization” theory –the view that specific mental functions had precise locations in the brain. A corollary to this was the notion of “cerebral dominance”, or the idea that the LH was the dominant one for generating the higher forms of cognition. Although the origin of this term is obscure, it grew, no doubt, out of the clinical research connecting language to the LH and out of the conceptual link that has always existed in Western culture between language and the higher mental functions. As Springer and Deutsch (1985: 13) aptly note, it nicely captured “the idea of half a brain directing behavior.” The RH, in contrast, came to be designated as the “weak” or “minor” hemisphere. As Roger Sperry (1973: 209) remarked two decades ago, the appeal of the dominance model of cognition was such a powerful one that it took the research in neuroscience most of the first half of this century to dispel the notion that only the verbal part of the brain was crucial for the higher forms of mentality, and to establish the fact that the brain was structured anatomically and physiologically in such a way as to provide for “two modes of thinking, verbal and nonverbal, represented rather separately in left and right hemispheres respectively.”

Actually, the nineteenth-century British neurologist John Hughlings Jackson (1874, 1878) –initially one of the congeners of the dominance notion– was already casting doubts on the extreme view inherent in strict localization and dominance theory by pointing out that patients suffering from Broca’s aphasia were nonetheless able to carry out basic communicative interactions, and by suggesting that nonverbal perception might be located in the RH. But during the first half of the present century, it is safe to say that localization theory continued to dominate the mindset and research agenda of neuroscience. There were, however, some notable exceptions. In 1929, the American psychologist Karl Lashley questioned the significance of positing specific neural zones and connections for mental operations and, therefore, of the strict version of localization theory. He suggested, as an alternative, that the brain processed stimuli in an integrated fashion and that any part of a functional area had the potential capacity to carry out a particular behavior. In the thirties, the Russian psychologist Vygotsky (1931) argued that language in a restricted sense –i.e., as sounds, words, and meanings– did indeed have a primary locus in the LH; but as a more encompassing communicative-expressive modality it was most likely to arise from the synaptic connections that were distributed throughout the brain. Vygotsky also suggested that the brain was endowed at birth with a unique kind of “plasticity” that rendered it highly sensitive and adaptive to environmental stimuli during childhood. Therefore, he put forward the intriguing proposal that the innate structure of the mind –arising from the interaction of smaller functional units interconnected

synaptically throughout the brain— was constantly subject to modifications from sociocultural influences.

This hypothesis became the point-of-departure for the work of another Russian psychologist, Alexander Luria, who in 1947 went even further in suggesting that there existed an interconnectivity in functional task distribution that spanned the entire brain. Adopting Jakobson's (1942) idea that the selection of linguistic *units* and their *combination* were neurologically complementary, Luria showed that combinatory processes were traceable to the anterior areas of the language centers, whereas selectional ones were locatable in the posterior areas of the same centers. Luria thus argued that although a single linguistic function (articulation, comprehension, etc.) could be safely located in specific areas of the LH, the overall phenomenon of language as an expressive and ideational phenomenon resulted from the interaction of several cooperative cerebral structures that were connected by a network of synaptic processes. And, indeed, recent work on so-called parallel distributed processes (Rumelhart and McClelland 1986) has been shedding some light on how Luria's idea of connectivity might actually generate the higher cognitive functions such as language.

It was during the late thirties and early forties that the term *neurolinguistics* crystallized from attempts to investigate aphasias in terms of linguistic theory (Ombredane, Alajouanine, and Durand 1939, Jakobson 1942). But it has been only since the publication of Eric Lenneberg's widely-quoted 1967 book that this term has come into functional usage to designate a vast field of research which encompasses any kind of investigation on how the language functions are organized and processed by the brain. In this relatively short span of time, the proliferation of work in neurolinguistics proper has been mind-boggling. A little more than a decade ago Dimitrijevic and Djordjevic (1980) listed 1,609 titles of studies dealing with language and its relation to neural structure and function. Today, neurolinguistic research proper has become a kind of empirical template for assessing theories and models of language, as well as a source of ideas for drafting research agendas in many of the language sciences.

The second landmark event in the history of neuroscience came almost a century after Broca's ground-breaking 1861 discovery. During the 1950s and 1960s, the studies conducted by Roger Sperry and his associates (e.g., Myers and Sperry 1958, Gazzaniga, Bogen, and Sperry 1963, Gazzaniga and Sperry 1967, Sperry 1968, 1973, Sperry, Gazzaniga, and Bogen 1969, Levy, Trevarthen, and Sperry 1972) on epilepsy patients who had their two hemispheres separated by surgical section of the *corpus callosum*—the cable of nerve fibers that connects the two hemispheres— showed rather conclusively that both hemispheres, not just a dominant one, were needed in a neurologically-cooperative way to produce complex thinking. In other words, the commissurotomy, or so-called "split-brain," research established the fact that the cerebral hemispheres worked *in tandem* in processing incoming stimuli. Sperry's work changed the course and nature of

neuroscience in a permanent way (Trevarthen 1990 contains studies that both assess and pay homage to Sperry's pivotal work).

By the 1960s, the commissurotomy research provided neuroscience both with a breakdown of the main psychological functions according to hemisphere (e.g., Boger 1975, Geschwind 1979), and with a new experimental focus. Techniques such as dichotic listening (Kimura 1961, 1967), electroencephalographic analysis (e.g., Galin and Ornstein 1972), magnetic resonance imaging, tachistoscopic analysis (e.g., Marcel, Katz and Smith 1974), lateral eye movement (e.g., Bakan 1969, Gur 1975), and others were devised by the 1960s and 1970s in order to provide neuroscience with a repertory of nonclinical methods for investigating the mind/brain nexus. And by the early 1980s, neuroscientists started to work more and more on the development of computational models of neurological processes as a means of gaining knowledge of how thought is processed by the brain (e.g., Arbib 1982).

In the area of language, the neuroscientific research of the last four decades has documented several crucial facts (see, for example, Bouton 1984, Caplan 1987 for in-depth historical accounts). By stimulating specific areas of the brain electrically, Wilder Penfield (e.g., Penfield and Rasmussen 1950, Penfield and Roberts 1959) discovered a "supplementary" area several decades ago that appeared to control various functions previously thought to be distributed in Broca's and Wernicke's areas. In 1967 Eric Lenneberg published his classic work suggesting a critical period for the lateralization of speech. On the basis of a large body of clinical studies, Lenneberg noticed that most aphasias—the partial or total loss of speech due to a disorder in any one of the brain's language centers—became permanent after the age of puberty. This suggested to Lenneberg that the brain lost its capacity to transfer the language functions from the LH to the nonverbal RH after puberty, which it was able to do, to varying degrees, during childhood. Lenneberg concluded that there must be a biologically-fixed timetable for the lateralization of the language functions to the verbal LH and, consequently, that the critical period for the acquisition of language was before adolescence. Although his time frame has been disputed—e.g., after reviewing the same clinical evidence used by Lenneberg in his work, Krashen (1973, 1975) inferred that the period of lateralization was completed by around five or six—Lenneberg's hypothesis that there is a fixed time period during which the brain organizes its division of labor remains, to this day, a plausible hypothesis and a target for much debate.

So, by the early 1970s, neuroscience had charted out a flourishing field of inquiry for language scientists. Above all else, it had started to question some of the traditional notions, and especially the idea that the LH alone was responsible for language. Neuroscientists were beginning seriously to entertain the possibility that even if specific language functions were concentrated in the LH, the possibility existed that some of the functions related to discourse were controlled by the RH. In such an "interhemi-

spheric" model, language is considered to have a "double modality." Its *form* and *motor functions* are programmed in specific centers of the LH; but its *content* and *expressivity* are controlled by the synthetic functions of the RH. The phenomenon of "discourse" is now conceived to span the entire cortex of the brain.

One of the more significant findings to emerge in the early 1980s has been the likelihood that the RH is a crucial "point-of-departure" for processing novel stimuli: i.e., for input for which there are no preexistent cognitive codes or programs available. In their often-quoted review of a large body of experimental literature, Goldberg and Costa (1981) suggested that the main reason why this is so is because of the anatomical structure of the RH. Its greater connectivity with other centers in the complex neuronal pathways of the brain makes it a better "distributor" of new information. The LH, on the other hand, has a more sequentially-organized neuronal-synaptic structure and, thus, finds it more difficult to assimilate information for which no previous categories exist. If this is indeed the case, then the discussions on comprehensible input (e.g., Krashen 1985, Gass and Madden 1985) can be seen to have supporting neurofunctional correlates. The brain research suggests, in fact, that for any new input to be comprehensible, it must occur in contexts that allow the synthetic functions of the RH to do their interpretive work. In the case of tutored, or classroom, SLA this has rather far-reaching implications. Above all else, it suggests that the brain is prepared to interpret new information primarily in terms of its contextual characteristics. The whole pedagogical movement towards "contextualization" (e.g., Omaggio 1986) will certainly find a highly supportive theoretical framework in such neurolinguistic work.

Today, neuroscientists have at their disposal a host of techniques for the collection of data on brain functioning –e.g., electrical stimulation mapping techniques (Ojemann 1983), methods for determining the dendritic correlates of cortical functions (e.g., Scheibel, Paul, Fried, Forsythe, Tomiyasu, Wechsler, Kao, and Slotnick 1985), etc.–; several major journals, such as *Brain and Language* (which is nearly four decades old) and the *Journal of Neurolinguistics*; and several monograph series (such as the *Studies in Neurolinguistics* one published by Academic Press). Work by Marcus Raichle and his associates on the technique known as positron emission tomography (see Kandel, Schwartz, and Jessell 1991) has become a particularly powerful investigative tool for neuroscientists, since it provides images of local changes to cerebral blood flow and metabolism which accompany a mental activity such as language. For applied linguists, the domain of brain research has become, without doubt, a source of knowledge which, if Spolsky (1989: 84) is right (and I believe that he is), they can ill afford to ignore, given that it provides valuable information on "the central physiological organ underlying language, the brain."

THE PRIMARY VS. SECONDARY LANGUAGE ACQUISITION ISSUE

Lenneberg's (1967) notion that there must be a biologically-fixed timetable, or a critical period, for the lateralization of the language functions to the LH has also generated a different, but related, controversy in applied linguistics –the PLA vs. SLA issue. For Lenneberg, the period from birth to puberty was the one during which the brain organized its division of labor (see Marcotte 1990, for a recent confirmation that such a period does indeed seem to characterize PLA).

The intensive and substantive neuroscientific study of SLA started in the 1970s when Krashen (e.g., Krashen and Harshman 1972, Krashen 1973, 1975) set out, as a matter of fact, to reexamine much of the aphasiology data Lenneberg had analyzed in his 1967 book. Krashen concluded, in contrast to Lenneberg, that PLA occurred in the first five years of a child's life. This reevaluation of Lenneberg's clinical data, which Krashen bolstered by conducting dichotic listening experiments, had, as an underlying intent, the purpose of vitiating the idea that the loss of neuroplasticity was to be considered as the primary cause for language learning difficulties past the age of puberty.

Krashen's work was followed by that of Lamendella in the late 1970s (1977, 1979, Selinker and Lamendella 1978). Lamendella put forward a testable definition of the PLA vs. SLA dichotomy. For Lamendella, PLA refers to the child's acquisition of one or more languages from 2 to 5 years. SLA is defined as both foreign language learning in formal classroom environments and the natural acquisition of another language after age 5. Lamendella's essential claim is that PLA takes advantage of innate neural systems which are available up to the critical period, but that after this period it involves somewhat different systems. In other words, for Lamendella there are different neurofunctional systems operating for PLA and SLA.

Lamendella posits two "hierarchies" as crucial components of neurological language programming: (1) the communication hierarchy, which is responsible for language and other forms of interpersonal communication; (2) the cognitive hierarchy, which controls cognitive processing activities that intersect with language use. For Lamendella, PLA and natural SLA are marked by the deployment of the communication hierarchy, whereas tutored SLA (foreign language acquisition) is marked by the utilization of the cognitive hierarchy. These two hierarchies are purported to belong to different neurofunctional systems composed of different levels which, however, are not specified by Lamendella. So, for instance, the acquisition of SL forms enlists higher-level systems which can be stored as automatic subroutines at lower levels of the communication hierarchy. In actual language performance, lower-level subroutines can be enlisted without calling upon higher-level ones. So, according to Lamendella, the SL learner is faced with the task of identifying the functional hierarchy best suited to a task, and then establishing the appropriate

level and subsystems within the hierarchy with which to initiate the learning process.

To the best of my knowledge, there has emerged no evidence to suggest the presence of differentiated systems in the brain for PLA or SLA before or after the critical period (see also Genesee 1982, and Scovel 1982, on this point). Tollefson, Jacobs, and Selipsky (1977) have convincingly argued, however, that Lamendella's model is compatible with Krashen's Monitor Model, and thus that it constitutes a powerful integrated theoretical construct. But I cannot but agree with Ellis (1986: 273) when he remarks that neurofunctional accounts of SLA are more useful in providing "additional understanding about SLA," rather than constituting explanations of it.

At about the same time that Lamendella was proposing his model of PLA vs. SLA, Michel Paradis was starting his own work in the same area (e.g., 1977, 1985, 1987, 1989, 1991, Paradis, Hagiwara, and Hildebrandt 1985), offering another kind of perspective on the PLA vs. SLA issue. Paradis started out by attempting to make sense of the voluminous and amorphous body of data on bilingual aphasiology in order to formulate an approach to the classification of language impairment in bilinguals and polyglots. He organized the data into six categories: (1) parallel (the impairment and recovery of both languages occurs at the same rate), (2) differential (the impairment is of a different degree in each language), (3) successive (one language is recovered only after the other), (4) antagonistic (one language regresses as the other progresses), (5) selective (one of the languages is never recovered), (6) mixed (features of the two languages are mixed in an inappropriate fashion). Paradis' taxonomy suggests that any diagnostic procedure employed must not only take into account language-specific abilities, but must also be sensitive to the culture-specific modalities associated with each language.

Paradis' work on bilingual aphasiology has allowed him to construct a neurofunctional model of bilingualism that is of obvious relevance to SLA research. To paraphrase Ellen Perecman's (1989: 227) recent assessment of this line of work, Paradis has attempted to determine to what extent the bilingual's two languages are functionally independent and to what extent they constitute a unitary functional system. Carefully examining cases of non-parallel recovery, Paradis argues for both neurofunctional independence and neurofunctional overlap or integration, since the organization of the bilingual's two languages in the brain appears to depend on a host of factors ranging from degree of structural similarity between the two languages to the degree of environmental stimulation received in one or the other of the two languages. None of these factors *in themselves* can account for the non-parallel recovery patterns observed.

For Paradis there are four ways to explain why two structurally-unrelated languages may appear to be organized differentially, as opposed to two structurally similar ones: (1) they may be stored in different ways, with similar languages sharing the same neural substrate to a greater degree

than languages with highly-differentiated subsystems (phonology, syntax, etc.); (2) two structurally-different languages may have fewer strong associations, which, in terms of their subsystems, translates into less related neural systems; (3) highly-differentiated writing systems associated with each language may not only affect the areas involved in the processing of reading and writing, but also the ways in which the two languages are organized; (4) in closely related languages, when only comprehension seems to be less impaired or better recovered, it may be because of the fact that comprehension in the recovered language is better due to its resemblance to the other language.

So, on the one hand, Paradis rejects interpretations of the aphasic data which posit separate neural systems for each language. On the other, he also rejects the view that the bilingual brain is organized in the exact same way as the unilingual one in PLA. Paradis' "integrative" model is best summarized in his own words (1989: 131): "languages are subserved by different circuits intricately interwoven in the same language areas, so that both are represented in the same area at the gross anatomic level, while still being independently subserved by different neural circuits at the micro-anatomical level." Calling it a "subsystem hypothesis," Paradis argues that his explanatory framework is compatible with all patterns of recovery as well as with the bilingual's ability to mix languages at each level of linguistic structure. Each language is susceptible to selective pathological inhibition. In the intact brain, elements of one or the other, or of both, are available to the speaker. This model thus claims to account for switching and mixing phenomena in bilinguals, and SL learners for that matter. Paradis also claims that his framework makes it unnecessary to postulate such constructs as a special language tag specific to bilinguals, or models which posit that comprehension and production are subserved by different and separable systems.

To the best of my knowledge, there exists no evidence in the clinical or experimental neuroscientific literature to validate or invalidate Paradis' subsystem model. It has been used by some, however, to set up various experimental situations. Guided by Paradis' model, Ojemann and Whitaker (1978) combined word tests with electrical stimulation of two surgical patients –an English-Spanish and an English-Dutch bilingual. These two researchers were thus able to map the actual areas of the LH where each of their languages was represented. They found that within the center of the language area of each patient there were sites common to both languages. In other words, they found that the two languages shared some brain space, but that each also had areas of its own, as Paradis' model predicted. Paradis' explanatory framework also seems to enclose the idea that implicit and explicit knowledge (e.g., Bialystock 1981) might be subserved by different cerebral memory systems (e.g., Cohen 1984, Schacter 1987, Lewandowsky, Dunn, and Kirsner 1989).

Paradis' general view is shared by Perecman (1989), who posits the neurofunctional independence of the conceptual level from the lexico-

semantic one. For Perecman the conceptual level reflects general properties of the human mind, being comparable to Paradis' gross anatomic level, whereas the lexico-semantic one is differentiated according to language, being thus comparable to Paradis' microanatomic level. Both argue for a distinction between a conceptual memory storage system for multisensory images independent of language (and therefore of languages), and a linguistically-constrained semantic system for lexical meanings and relations. Bilinguals would seem to have one conceptual system as do unilinguals, but two distinct semantic ones. The general theoretical thrust of the "Paradis-Perecman view" seems to have a wide consensus among neuroscientists (e.g., Mendelsohn 1988, Grosjean 1989, Solin 1989, Vaid and Hall 1991), and it is also being borne out by recent empirical findings: e.g., Fabbro 1990, Green, Nicholson, Vaid, and White 1990, Fabbro, Gran, and Gran 1991 found few significant neurofunctional differences between monolingual and bilingual simultaneous interpreters. As Vaid and Hall (1991: 105) aptly write, "the bulk of the evidence to date, from both clinical and normative populations, appears to converge on there being no clear differential neuropsychological implications of the bilingual experience."

The work on primary bilingualism raises a basic question for SLA research. Does the addition of a language after the PLA period entail a reorganization of brain structure? An answer to this question is still elusive. But the work on bilingualism suggests that there may be some similarities and some differences. It suggests that the PLA = SLA hypothesis, which seems to have gained a foothold on much of the thinking in the SLA domain, is only partially true. Adult and adolescent SL learners do indeed manifest the same kinds of processes that children do when they are developing their primary language(s). It is a self-evident fact that learning a language, whether it be in the primary or in the secondary periods of life, will enlist many of the resources of the brain in the same ways. But it is also true that the learning of a second language in adulthood will entail other processes associated with maturation.

The discussion of PLA vs. SLA has, in my view, also put into a realistic perspective the innatist vs. experientialist debate that is still raging on in the PLA field. As Jacobs (1988) has also argued, the available neuroscientific evidence indicates that when separated by time and context of learning, PLA does not always equal SLA. There must, on the one hand, be a universal neural substrate for the conceptual space encompassed by language in its most fundamental form, but, on the other hand, there are experiential events encoded by different semantic systems that affect the "detail" of brain organization.

THE CRITICAL PERIOD HYPOTHESIS

It is obvious from the above discussion that, rather than discouraging SLA researchers, the implications of Lenneberg's critical period hypothesis

initiated a meaningful debate in 1967 that is still going on today. Perhaps the most exhaustive critique of this hypothesis comes from the pen of Thomas Scovel who, in 1988, reviewed the extensive body of research evidence assessing the critical period and came to the conclusion that there are no clear-cut findings to suggest biological constraints on language acquisition, but rather psychological ones such as motivation, cognitive style, and affective variables. Lenneberg, as Scovel points out, simply assumed that language acquisition was easier for children. Scovel also remarks (as he did previously in 1969) that the critical period applies mainly to the acquisition of pronunciation. This suggests that the hypothesis probably should be recast in order to account for the loss of the ability to acquire native-like pronunciation after puberty. As Seliger (1978) and Walsh and Diller (1981) have suggested, perhaps there are many critical periods corresponding to the various levels, or subsystems, of language.

The critical period hypothesis also bears directly on the theory of universal grammar (UG) and its recent applications to SLA (e.g., Broselow 1988, Pinker 1990). According to this paradigm, there exists a "language organ" in the brain that equips humans by the age of two with the ability to use the rules of a "universal" grammar to develop the specific languages that cultures require of them. The child only has to "set" a few language-specific "parameters" on the basis of parental input, and the full richness of grammar will ensue when those parametrized rules interact with one another and with universal principles. The parameter-setting view has been put forward to explain the universality and rapidity of language acquisition.

There seems to be nothing in the neuroscientific research literature, outside of the fact that language acquisition occurs during a critical period, that would support the idea of a "language organ" (however, for a supportive neuroscientific view of UG theory see Obler 1988). For one thing, the very same critical period hypothesis seems to answer negatively the question of whether the learning of a second language can still involve fixing parameters in the UG. Some (e.g., Travis 1988, White 1990, Clahsen 1990, Carroll and Meisel 1990, Comrie 1990) have argued that universal principles continue to play an important role in SLA. Whether or not this is the case will have to be seen. At present, the theory of UG, by and large, excludes the possibility of SLA ever equaling PLA. But, in my view, to ascribe the inability to master a SL in adulthood to the accessibility of language universals rules out too many other possibilities—life experiences, previous training, etc.—which have nothing to do with biology. As Jacobs (1988: 330) aptly puts it, any theory of SLA "will have to consider what the environment brings to the brain, including both the input itself (e.g., structure, intonation, morphology) and the surrounding situational variables (e.g., gestures, discourse context); and, just as importantly, must also consider what the brain does to this information."

THE ROLE OF THE RIGHT HEMISPHERE

In the early 1970s, neuroscientists were beginning to entertain the idea that, although certain language functions were located in the LH, the possibility existed that the neurological programming of discourse was controlled in part by the RH. Moreover, as mentioned above, in the early 1980s the idea that the RH is a crucial "point-of-departure" for processing novel stimuli became a testable hypothesis.

A general caveat is in order when considering the role of the RH in cognition, given the fact that the currently fashionable, but artificial, RH vs. LH dichotomy was brought about by the media popularization of the split-brain experiments. From the 1960s onward, these have been ascribed great sociophilosophical importance that extends well beyond the actual perimeter of the research findings. The "discovery" of the RH by neuroscience was interpreted by many representatives of the media as vindicating the view that Western culture was biased in favor of the LH, i.e., in favor of analytical, deductive, and rational thought at the expense of creative, imaginative, and intuitive thinking. Now, while all this may have some validity—sociocultural institutions do indeed reflect and incorporate the notions emanating from the domain of science—it is also true that this interpretation of the commissurotomy findings has led inevitably to various misconceptions and to what Gardner (1982: 266-267) aptly characterizes as "the temptation to tamper with the work of scientists," and consequently to the tendency to put forward exaggerated claims about "right-brain learning," which have, incidentally, become quite profitable for a coterie of "academic hucksters." Actually, as Rose (1988) has suggested, this fascination with "right-brained education" derives from Romantic thought about language and logic. In this century, the work on commissurotomy has, unfortunately, led to the creation of a popular mythology of hemisphericity which, as Walker (1990: 302) phrases it, constitutes a "simple reification of a tacit *idée fixe* already more than two centuries old."

Such popular mythological notions aside, there are several things that are now known about how the two hemispheres work that are germane to the present discussion. It is now a fact, for instance, that they work cooperatively. In individuals with intact brains both hemispheres are complementary processors of information, reconciling two clearly-differentiated modes of perception. Using Edwards' (1979) useful notation, whereby the LH mode of processing stimuli is abbreviated to "L-Mode," and the RH one to "R-Mode," I have elsewhere suggested (Danesi 1986, 1988a, 1988b, 1988c) that the complementary interaction of the two hemispheres during SLA can be referred to as *bimodal*, i.e., as involving both the analytical features of the L-Mode and the synthetic ones of the R-Mode.

The study of *bimodality*—i.e., of the roles played by the two hemispheres in SLA—that has become a point-of-reference is the one by Albert and Obler (1978). After reviewing case studies of aphasic bilinguals these two

scholars concluded: (1) that during childhood the organization of language is more bilateral in bilingual subjects than in monolingual ones; and (2) that the RH has an important role to play in SLA no matter what the age of the learner. Hamers and Lambert (1977), Vaid and Genesee (1980), and Vaid (1983), among others, however, have presented evidence and arguments against Albert and Obler's first hypothesis, suggesting, moreover, that the role of the RH is probably more active in the case of adults than in that of children.

The debate on the role of the RH in language, supported by case studies in neuroscience (Chiarello 1988, Joannette, Goulet, and Hannequin 1990), has led both to the development of several theories of SLA and to the design of teaching methods and approaches based upon them. Obler (1980), Galloway, and Krashen (1980), and others have advanced an interesting "stage hypothesis" which posits that the RH dominates the SLA process during its initial stages, with the LH increasingly taking on more of the burden at later stages. My own view (Danesi 1988a, 1991) is that SLA is a process which enlists the RH and LH according to both stage of acquisition and language task. The RH has a crucial role to play in SLA, but only for tasks which primary-language schemata cannot accommodate. The LH remains the dominant one for tasks requiring the processing of language as "text" (phonology, grammar, semantics), while the RH is the primary processor of language as "context" (prosody, metaphorical meaning, etc.). The views of Walsh and Diller (1978, 1981) are relevant here. They suggest that Broca's and Wernicke's areas control motor and grammatical processes during tutored SLA, while semantics and verbal cognition are distributed throughout various areas of the cortex.

Stage models have produced very little in the way of empirical research to lend them support. They are based primarily on extrapolations from the clinical data and on the observations of teachers of second languages. So, I cannot help but agree with Obler (1983) when she observes that many problems crystallize when extracting too many implications from the work on hemisphericity. As Hatch (1983: 198) has also aptly remarked, where verbal messages "go in the brain and what happens to them" still remains largely a mystery. This notwithstanding, neurological stage models of SLA have an intuitive appeal. Moreover, they have spawned three major teaching methods in the last few decades -Lozanov's (1979) "Suggestopedia," Asher's (1977, 1981, 1988) "Total Physical Response," and Krashen and Terrell's (1983) "Natural Approach."

Lozanov's Suggestopedia stresses the importance of creating an environment for learning that is capable of stimulating subliminal (unconscious) learning processes, i.e. the R-Mode of learning. This is why it employs the technique known as the *séance*—a period during which students relax and sit comfortably in reclining chairs listening to background music (usually the slow movements of Baroque composers such as Bach, Handel, Vivaldi, Corelli and Telemann) while new language material is being read in the SL and in translation. The claim is that the *séance* will activate crucial

R-Mode processes during initial orientation tasks. Similarly, in both Total Physical Response and the Natural Approach, the R-Mode is viewed as being the crucial one for acquisition. So, comprehension is put before production and the direct involvement of the student in physical or experiential tasks (pointing out, identifying, etc.) is considered to be of crucial importance.

Total Physical Response attempts to teach the SL primarily through physical (motor) activity. Although it draws upon several traditions, including humanistic psychology, the trace theory of memory (Katona 1940), and the pedagogical ideas of Harold and Dorothy Palmer (1925), Total Physical Response aims to reconstruct the contextual parameters in which PLA is purported to unfold. Asher notes that there always is a preverbal sensory-motor stage during which the speech directed at children in their natural environment consists mainly of commands to which they respond physically. He suggests that SLA in formal environments follows this same developmental route. There is also an interesting Vygotskian (1962) feature to Asher's theory. Like Vygotsky's "zones of proximal development" theory—which posits that children will learn something only when they are ready to do so (i.e., when it is just within their next, or proximal, "zone" of development)—Total Physical Response claims that the criterion for including an item of vocabulary, grammar, or communication at a particular point in an instructional program for tutored SLA should be the ease of assimilation shown by the students. If the item is not learned rapidly, then they are obviously not ready for that item. Hence, it should be withdrawn and presented again at some future time. The "flow" of learning which Asher intends to activate with Total Physical Response goes from concrete actions to linguistic abstractions; i.e., from the R-Mode to the L-Mode. It thus ascribes more importance to the R-Mode. The use of sensory-motor comprehension techniques, the lowering of stress (an affective filter), and a concrete-to-abstract flow of information define its neuroscientifically-conceived path for SLA. Asher posits that when a sufficient amount of R-Mode learning has taken place, the L-Mode will be triggered naturally to produce the more abstract linguistic notions.

Krashen and Terrell's Natural Approach has become one of the most discussed teaching proposals in recent years, probably because of its intuitive appeal to teachers and learners alike. It too ascribes great salience to the R-Mode during all stages of SLA, but especially during the initial ones. The R-Mode functions are seen to constitute the natural "acquisitional" mode of the student. Grammar training has been virtually abandoned, since knowledge of structure is believed to emerge on its own through the L-Mode's inbuilt "monitoring" system, although Terrell, before his untimely death, recently modified this view (1991). In so doing, however, the Natural Approach has downplayed the role of the L-Mode perhaps too drastically. Krashen and Terrell assume that adolescent and adult SL learners follow the same route of PLA. They assume, in other words, that SLA is bound to occur in the same neural pathways of the brain

as PLA. But most of the evidence used in support of this hypothesis has been anecdotal or based solely on pedagogically-persuasive argumentation. If it is true that the L-Mode processes incoming verbal stimuli in terms of its discrete units, while the R-Mode is involved in molding these units into meaningful discourse structures (Zaidel 1978, 1983), then it should be possible to test both these hypotheses in an empirical way.

Danesi and Mollica (1988) have, in fact, attempted recently to test the viability of translating a stage view of tutored SLA into instructional practice. An experimental group of university SL learners trained in a "bimodal" fashion –i.e. by means of techniques that purportedly activated both the R-Mode and the L-Mode in an integrated fashion– fared significantly better on all tests of proficiency than did control groups taught in rigid analytical (L-Mode) and experiential (R-Mode) ways. An unexpected finding of the study was that teachers could be easily trained to view the learning process in terms of "brain-compatibility." Soon after the study was published, the researchers realized that the findings they had collected could be explained in non-neurofunctional ways. One could say, for instance, that the bimodally-trained subjects turned out to be more effective learners simply because they were trained by techniques that were varied and sufficiently well-designed *in themselves*. This would preclude the need to explain the results in neurofunctional terms. The study thus raised a rather fundamental question for this whole line of research on tutored SLA: To what extent is it correct to label a technique, *X*, as right-hemispheric, and another one, *Y*, as left-hemispheric? I decided to examine this precise question in a follow-up study (Danesi 1991). Using the Lateral Eye Movement (LEM) technique, which is based on the fact that in most people the activation of left-hemispheric functions causes the eyes, in general, to orient slightly to the right, while leftward orientation ensues from the activation of right-hemispheric functions, I repeated the previous experiment, this time seating the students selected to be in the three groups at a table in front of a video camera that recorded their eye movements. The students were not made aware of the exact nature of the experiment. At the end of each training session they were asked to think about the lesson for one minute before engaging in a written task related to the lesson. They were told to look into the video camera for the entire minute as they thought. The LEM findings turned out to be comparable with the general findings in the LEM literature, indicating that the Danesi and Mollica study had indeed labeled the techniques in a neuroscientifically appropriate way: those designated as R-Mode did indeed produce a leftward eye movement, and those labeled as L-Mode a rightward movement, well within the statistical categories established by the LEM procedure.

But, despite the fact that I have myself been a participant in investigating stage and bimodal models of teaching empirically, it is obvious that they are fraught with problems. The LEM method, for instance, is subject to too many constraints and weaknesses to be of any

true value to the experimental study of tutored SLA (see, for instance, Stieblich 1983, Dunn, Bartscher, Turaniczo, and Gram 1989); the use of small classroom groups of subjects is statistically insignificant; constructs such as R-Mode and L-Mode, although highly plausible, are nonetheless artificial ones; and, as Genesee (1988: 107) has pointed out, such constructs do not lend themselves easily to "developing new educational programs or approaches." Still, when research of this kind is coupled with the anecdotal experiences of teachers using methods such as the Natural Approach, it suggests that stage models of tutored SLA are, at the very least, worthy of further experimental consideration.

The recent research in neuroscience vis-à-vis the role of the RH in language is, needless to say, instructive, even if at times it appears to be ambiguous (see Joannette, Goulet, and Hannequin 1990, and Satz, Strauss, and Whitaker 1990 for recent in-depth assessments of the relevant literature). It has now become apparent that the two hemispheres do share some features. The LH has been shown to have the capacity to engage in some holistic and parallel processing, and the RH in some analytic and serial processing. But, for the most part, RH language performance is inferior to that of the LH. A rapid synthesis of some research findings follows. McKeener and Hunt (1989) found no evidence of any significant RH involvement in Navajo, purported to be more R-Mode in its semantic structure. Segalowitz and Cohen (1989) found that consonant voicing was a bilateral phenomenon; and they subsequently found (Cohen and Segalowitz 1990) that the neurological programming of phonetic structure at the feature level also involved both hemispheres. Richards and Chiarello (1989) discovered that there was no hemispheric differentiation in the comprehension of artificial categories, while Chiarello, Richards, and Pollack (1992) found a RH involvement in some areas of semantic programming. Hunter and Liederman (1991), Beeman (1993), and Faust, Kravitz, and Babkoff (1993a, 1993b) found a greater RH participation in semantics vis-à-vis the LH. Generally, the ongoing research program on the neurofunctional organization of language suggests that the RH probably plays an important role in the processing of word meaning (Chiarello 1988), especially of metaphorical and connotative meaning (Winner and Gardner 1977, Brownell 1988, Danesi 1989). Rapcsak, Beeson, and Rubens (1991) also found the RH to play a significant role in writing. And a number of studies continue to point to the RH's participation in language as a discourse phenomenon (e.g., Behrens 1989, Hough 1990, Kaplan, Brownell, Jacobs, and Gardner 1990, Rayman and Zaidel 1991).

At the present time, however, I am inclined to agree with Paradis (1989) when he warns that there exists no hard evidence to suggest that the RH participates in any different way in the organization of language in SLA. All attempts to construct models of SLA based on the participation of the RH at various stages and to translate such models into instructional practices for tutored SLA, must tread very cautiously and judiciously.

CONCLUDING REMARKS

Despite the above caveat, it is clear from the overall tone of the discussion in this essay that I intend to put forward an affirmative answer to the first question I posed in my introductory remarks –namely, whether the foray into the neuroscientific domain has produced some valuable insights for applied linguistics. Indeed, the findings in neuroscience can now be enlisted to help understand various issues of SLA, such as the difference between PLA and SLA, the probable existence of a critical period, and the role of experiential (R-Mode) vs. analytical (L-Mode) processes in the flow of acquisition. The work in neuroscience has also made it obvious, paradoxically, that nonbiological factors also have crucial roles to play in SLA, thus confirming the highly complex and multidimensional nature of this process. Above all else, it would seem that the cognitive processes associated with brain structures are susceptible to environmental features. In the case of tutored SLA these processes may be altered significantly when the situation arouses stress or anxiety (e.g., Schwartz, Davidson, and Maer 1975).

The work in neuroscience has also allowed the SLA researcher to assess SLA theories in terms of their consistency or compatibility with the findings on cerebral processes. In this paper, for instance, I have looked briefly at how neuroscientific theorizing has produced a stage model of SLA (which is, in turn, an offshoot of Krashen's Monitor Model) and several associated instructional models (Suggestopedia, Total Physical Response, Natural Approach). I have also looked at how the critical period hypothesis is intrinsic to a UG conception of language acquisition (see the assessment which Jacobs 1988 has also made of UG in a previous and much more extensive critical study).

The answer to my second question –whether or not future forays into the brain sciences will be worthwhile– is also self-evident. Throughout the first half of this century, theories of SLA were shaped in large part by theories and findings coming out of two scientific domains, psychology and linguistics, not the brain sciences. Since the late 1960s, however, SLA research has been developing its own identity and its own independent research agenda. A growing number of SLA researchers have been turning to neuroscience since the 1970s. In other words, the realization has been slowly dawning that the research in neuroscience has opened up a window for the applied linguist to see what is going on inside the brain of the learner, so to speak.

The neuroscience/SLA interface has produced some rather interesting hypotheses, constructs, and suggestions for conducting research on SLA and for modeling instructional practices. The issues that such an interface maps out for investigation are intriguing and important ones. Ultimately, it attempts to answer the question with which I started off this essay, namely, does SLA entail neurological consequences, and, if so, what are they and what do they signify? If applied linguists are truly interested in

understanding SLA in all its dimensions, then, as Spolsky (1985: 279) put it a few years ago, it is "certainly not unreasonable to seek insights from the brain sciences."

REFERENCES

- ALBERT, M. and L.K. OBLER. (1978). *The bilingual brain*. New York: Academic Press.
- ARBIB, M.A. (1982). From artificial intelligence to neurolinguistics. In M.A. Arbib, D. Caplan, and E. Marshall (Eds.), *Neural models of language processes*. Pp. 77-94. New York: Academic.
- ASHER, J.J. (1977). *Learning another language through actions: The complete teacher's guidebook*. Los Gatos: Sky Oaks.
- ASHER, J.J. (1981). The total physical response: Theory and practice. In H. Wintz (Ed.), *Native language and foreign language acquisition*. Pp. 324-331. New York: New York Academy of Sciences.
- ASHER, J.J. (1988). *Brainswitching: A skill for the 21st century*. Los Gatos: Sky Oaks.
- BAKAN, P. (1969). Hypnotizability, laterality of eye movement and functional brain asymmetry. *Perceptual and Motor Skills* 28: 927-932.
- BEEMAN, M. (1993). Semantic processing in the right hemisphere may contribute to drawing inferences from discourse. *Brain and Language* 44: 80-120.
- BEHRENS, S.J. (1989). Characterizing sentence intonation in a right hemisphere damaged population. *Brain and Language* 37: 181-200.
- BIALYSTOCK, E. (1981). Some evidence for the integrity and interaction of two knowledge sources. In R.W. Anderson (Ed.), *New dimensions in second language acquisition research*. Pp. 62-74. Rowley, Mass.: Newbury House.
- BOGEN, J.E. (1975). Some educational aspects of hemispheric specialization. *UCLA Educator* 12: 24-32.
- BOUTON, C.P. (1984). *La neurolinguistique*. Paris: Presses Universitaires de France.
- BROCA, P. (1861). Remarques sur le siège de la faculté du langage articulé suivies d'une observation d'aphémie. *Bulletin de la Société d'Anatomie* 36: 320-357.
- BROSELOW, E. (1988). Second language acquisition. In F. J. Newmeyer (Ed.), *Language: Psychological and biological aspects*. Pp. 194-209. Cambridge: Cambridge University Press.
- BROWNELL, H.H. (1988). Appreciation of metaphoric and connotative word meaning by brain-damaged patients. In C. Chiarello (Ed.), *Right hemisphere contributions to lexical semantics*. Pp. 19-32. New York: Springer.
- CAPLAN, D. (1987). *Neurolinguistics and linguistic aphasiology*. Cambridge: Cambridge University Press.
- CARROLL, S. and J.M. MEISEL. (1990). Universals and second language acquisition. *Studies in Second Language Acquisition* 12: 201-208.
- CHIARELLO, C. (Ed.). (1988). *Right hemisphere contributions to lexical semantics*. Berlin: Springer.
- CHIARELLO, C., L. RICHARDS, and A. POLLACK. (1992). Semantic additivity and semantic inhibition: Dissociative processes in the cerebral hemispheres? *Brain and Language* 42: 52-76.
- CLAHSEN, H. (1990). The comparative study of first and second language development. *Studies in Second Language Acquisition* 12: 135-153.
- COHEN, H. and S. SEGALOWITZ. (1990). Cerebral hemispheric involvement in the acquisition of new phonetic categories. *Brain and Language* 39: 398-409.
- COHEN, N. (1984). Preserved learning capacity in amnesia: Evidence for multiple memory systems. In L. R. Squire and N. Butters (Eds.), *The neuropsychology of human memory*. Pp. 83-103. New York: Guilford.
- COMRIE, B. (1990). Second language acquisition and language universals research. *Studies in Second Language Acquisition* 12: 209-218.
- DANESI, M. (1986). Research on the brain's hemispheric functions: Implications for second language pedagogy. *Linguas Modernas* 13: 99-113.
- DANESI, M. (1988a). *Cervello, linguaggio ed educazione*. Roma: Bulzoni.

- DANESI, M. (1988b). *Neurolinguistica e glottodidattica*. Padova: Liviana.
- DANESI, M. (1988c). Neurological bimodality and theories of language teaching. *Studies in Second Language Acquisition* 10: 13-35.
- DANESI, M. (1989). The neurological coordinates of metaphor. *Communication and Cognition* 22: 73-86.
- DANESI, M. (1991). Neurological learning flow and second language teaching: Some evidence on the bimodality construct. *Rassegna Italiana di Linguistica Applicata* 23: 19-29.
- DANESI, M. and A. MOLLIKA. (1988). From right to left: A "bimodal" perspective of language teaching. *Canadian Modern Language Review* 45: 76-90.
- DÉJERINE, J. (1892). Contribution à l'étude anatomo-pathologique et clinique des différents variétés de cécité verbale. *Comptes Rendus des Sciences de la Société de Biologie* 9: 61-90.
- DIMITRIJEVIC, N. and R. DJORDJEVIC. (1980). A bibliography for neurolinguistics. *Studi Italiani di Linguistica Teorica ed Applicata* 6: 511-524.
- DUNN, B.R., J. BARTSCHER, M. TURANICZO, and P. GRAM. (1989). Relationship between conjugate lateral eye movements, brain organization, and cognitive style. *Brain and Cognition* 10: 171-188.
- EDWARDS, B. 1979. *Drawing on the right side of the brain*. Los Angeles: J.P. Tarcher.
- ELLIS, R. (1986). *Understanding second language acquisition*. Oxford: Oxford University Press.
- FABBRO, F. (1990). Cerebral lateralization in simultaneous interpretation. *Brain and Language* 39: 69-89.
- FABBRO, F., B. GRAN, and L. GRAN. (1991). Hemispheric specialization for semantic and syntactic comprehension of language in simultaneous interpretation. *Brain and Language* 41: 1-42.
- FAUST, M., S. KRAVITZ, and H. BABKOFF. (1993a). Hemisphericity and top-down processing of language. *Brain and Language* 44: 1-18.
- FAUST, M., S. KRAVITZ, and H. BABKOFF. (1993b). Hemispheric specialization or reading habits: Evidence from lexical decision research with Hebrew words and sentences. *Brain and Language* 44: 254-263.
- GALIN, D. and R. ORNSTEIN. (1972). Lateral specialization of cognitive mode: An EEG study. *Psychophysiology* 9: 412-418.
- GALL, F.J. (1791). *Philosophisch-medicinische Untersuchungen*. Vienna: Gräffer.
- GALLOWAY, L. and S.D. KRASHEN. (1980). Cerebral organization in bilingualism and second language. In R. Scarcella and S.D. Krashen (Eds.), *Research in second language acquisition*. Pp. 74-80. Rowley, Mass.: Newbury House.
- GARDNER, H. (1982). *Art, mind, and brain: A cognitive approach to creativity*. New York: Basic.
- GASS, S. and C. MADDEN. (Eds.). (1985). *Input in second language acquisition*. Rowley, Mass.: Newbury House.
- GAZZANIGA, M.S. and R.W. SPERRY. (1967). Language after section of the cerebral commissures. *Brain* 90: 131-148.
- GAZZANIGA, M.S., J.E. BOGEN, and R.W. SPERRY. (1963). Laterality effects in somesthesia following cerebral commissurotomy in man. *Neuropsychologia* 1: 209-215.
- GENESE, F. (1982). Experimental neuropsychological research on second language processing. *TESOL Quarterly* 16: 315-324.
- GENESE, F. (1988). Neuropsychology and second language acquisition. In L. M. Beebe (Ed.), *Issues in second language acquisition: Multiple perspectives*. Pp. 81-112. Rowley, Mass.: Newbury House.
- GESCHWIND, N. (1979). Specializations of the human brain. *Scientific American* 241: 180-201.
- GOLDBERG, E. and L.D. COSTA. (1981). Hemispheric differences in the acquisition of descriptive systems. *Brain and Language* 14: 144-173.
- GREEN, A., N.S. NICHOLSON, J. VAID, and A. WHITE. (1990). Hemispheric involvement in shadowing vs. interpretation: A time-sharing study of simultaneous interpretation with matched bilingual and monolingual controls. *Brain and Language* 39: 107-133.
- GROSJEAN, F. (1989). Neurolinguists beware! The bilingual is not two monolinguals in one person. *Brain and Language* 36: 3-15.

- GUR, R.E. (1975). Conjugate lateral eye movements as an index of hemispheric activation. *Journal of Personality and Social Psychology* 31: 751-757.
- HAMERS, J. T. and W. E. LAMBERT. (1977). Visual field and cerebral hemispheric preferences in bilinguals. In S.J. Segalowitz and F.A. Gruber (Eds.), *Language development and neurological theories of language*. Pp. 57-62. New York: Academic.
- HATCH, E.M. (1983). *Psycholinguistics: A second language perspective*. Rowley, Mass.: Newbury House.
- HOUGH, M.S. (1990). Narrative comprehension in adults with right and left hemisphere brain damage: Theme organization. *Brain and Language* 38: 253-277.
- HUNTER, N. and J. LIEDERMAN. (1991). Right hemisphere participation in reading. *Brain and Language* 41: 475-495.
- JACKSON, J.H. (1874). On the nature and duality of the brain. *Medical Press and Circular* 1: 19-41.
- JACKSON, J.H. (1878). On affectives of speech from disease of the brain. *Brain* 1: 304-330.
- JACOBS, B. (1988). Neurobiological differentiation of primary and secondary language acquisition. *Studies in Second Language Acquisition* 10: 303-337.
- JAKOBSON, R. (1942). *Kindersprache, Aphasie und allgemeine Lautgesetze*. Uppsala: Almqvist and Wiksell.
- JOANETTE, Y., P. GOULET, and D. HANNEQUIN. (1990). *Right hemisphere and verbal communication*. Berlin: Springer.
- KANDEL, E. R., J.H. SCHWARTZ, and T.M. JESSELL. (1991). *Principles of neuroscience*. New York: Elsevier.
- KAPLAN, J.A., H.H. BROWNELL, J.R. JACOBS, and H. GARDNER. (1990). The effects of right hemisphere damage on the pragmatic interpretation of conversational remarks. *Brain and Language* 38: 315-333.
- KATONA, G. (1940). *Organizing and memorizing: Studies in the psychology of learning and teaching*. New York: Columbia University Press.
- KIMURA, D. (1961). Cerebral dominance and the perception of verbal stimuli. *Canadian Journal of Psychology* 15: 156-165.
- KIMURA, D. (1967). Functional asymmetry of the brain in dichotic listening. *Cortex* 3: 163-178.
- KRASHEN, S.D. (1973). Lateralization, language learning, and the critical period: Some new evidence. *Language Learning* 23: 63-74.
- KRASHEN, S.D. (1975). The development of cerebral dominance and language learning: More new evidence. In D. Dato (Ed.), *Developmental Psycholinguistics*. Pp. 179-192. Washington, D.C.: Georgetown University Press.
- KRASHEN, S.D. (1985). *The input hypothesis*. London: Longman.
- KRASHEN, S.D. and R. Harshman. (1972). Lateralization and the critical period. *UCLA Working Papers in Phonetics* 23: 13-21.
- KRASHEN, S.D. and T. Terrell. (1983). *The natural approach: Language acquisition in the classroom*. Oxford: Pergamon.
- LAMENDELLA, J.T. (1977). General principles of neurofunctional organization and their manifestation in primary and non-primary acquisition. *Language Learning* 27: 155-196.
- LAMENDELLA, J.T. (1979). The neurofunctional basis of pattern practice. *TESOL Quarterly* 13: 5-19.
- LASHLEY, K.S. (1929). *Brain mechanisms and intelligence*. Chicago: University of Chicago Press.
- LENNEBERG, E. (1967). *The biological foundations of language*. New York: John Wiley.
- LEVY, J., C. TREVARTHEN, and R.W. SPERRY. (1972). Perception of bilateral chimeric figures following hemispheric disconnection. *Brain* 95: 61-78.
- LEWANDOWSKY, S., J.C. DUNN, and K. KIRSNER, (Eds.). (1989). *Implicit memory: Theoretical issues*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- LOZANOV, G. (1979). *Suggestology and outline of suggestopedy*. New York: Gordon and Breach.
- LURIA, A. (1947). *Traumatic aphasia*. The Hague: Mouton.
- MARCEL, T., L. KATZ, and M. SMITH. (1974). Laterality and reading proficiency. *Neuropsychologia* 12: 131-139.
- MARCOTTE, A. (1990). Speech lateralization in deaf populations: Evidence for a developmental critical period. *Brain and Language* 39: 134-152.

- McKEENER, W.W. and L.J. HUNT. (1989). Language laterality in Navajo reservation children: Dichotic tests results depend on the language context of the testing. *Brain and Language* 36: 148-158.
- MENDELSON, S. (1988). Language lateralization in bilinguals: Facts and fantasy. *Journal of Neuroscience* 3: 261-292.
- MYERS, R.E. and R.W. SPERRY. (1958). Interhemispheric communication through the corpus callosum: Mnemonic carry-over between the hemispheres. *Archives of Neurology and Psychiatry* 80: 298-303.
- OBLER, L. (1980). Right hemisphere participation in second language acquisition. In K. Diller (Ed.), *Individual differences and universals in language learning aptitude*. Pp. 87-98. Rowley, Mass.: Newbury House.
- OBLER, L. (1983). Knowledge in neuroscience: The case of bilingualism. *Language Learning* 33: 159-191.
- OBLER, L. (1988). Neuroscience and parameter-setting. In S. Flynn and W. O'Neil (Eds.), *Linguistics in second language acquisition*. Pp. 117-126. Dordrecht: Kluwer.
- OJEMANN, G.A. (1983). Brain organization for language from the perspective of electrical stimulation mapping. *The Behavioral and Brain Sciences* 6: 189-230.
- OJEMANN, G.A. and H.A. WHITAKER. (1978). The bilingual brain. *Archives of Neurology* 35: 409-412.
- OMAGGIO, A. (1986). *Teaching language in context*. Boston: Heinle and Heinle.
- OMBREDANE, A., T. ALAJOUANINE, and M. DURAND. (1939). *Le syndrome de désintégration phonétique dans l'aphasie*. Paris: Masson.
- PALMER, H. and D. PALMER. (1925). *English through actions*. London: Longman.
- PARADIS, M. (1977). Bilingualism and aphasia. In H. Whitaker and H.A. Whitaker (Eds.), *Studies in neurolinguistics*, vol. 3. Pp. 65-121. New York: Academic.
- PARADIS, M. (1985). On the representation of two languages in one brain. *Language Sciences* 7: 1-39.
- PARADIS, M. (1987). *The assessment of bilingual aphasia*. Hillsdale, NJ: Lawrence Erlbaum.
- PARADIS, M. (1989). Bilingual and polyglot aphasia. In H. Goodglass and A.R. Damasio (Eds.), *Handbook of neuropsychology*, vol. 2. Pp. 117-140. New York: Elsevier.
- PARADIS, M. (1991). Language lateralization in bilinguals: Enough already. *Brain and Language* 39: 576-586.
- PARADIS, M., H. HAGIWARA, and N. HILDEBRANDT. (1985). *Neurolinguistic aspects of the Japanese writing system*. New York: Academic.
- PENFIELD, W. and R. RASMUSSEN. (1950). *The cerebral cortex of man*. New York: Macmillan.
- PENFIELD, W. and L. ROBERTS. (1959). *Speech and brain mechanisms*. Princeton: Princeton University Press.
- PERECMAN, E. (1989). Language processing in the bilingual: Evidence from language mixing. In K. Hiltentam and L. K. Obler (Eds.), *Bilingualism across the lifespan*. Pp. 227-244. Cambridge: Cambridge University Press.
- PINKER, S. (1990). Language acquisition. In D.N. Osherson and H. Lasnik (Eds.), *Language: An invitation to cognitive science*. Pp. 191-241. Cambridge, Mass.: MIT Press.
- RAPCSAK, S.Z., P.M. BEESON, and A.B. RUBENS. (1991). Writing with the right hemisphere. *Brain and Language* 41: 510-530.
- RAYMAN, J. and E. ZAIDEL. (1991). Rhyming and the right hemisphere. *Brain and Language* 40: 89-103.
- RICHARDS, L.G. and C. CHIARELLO. (1989). Typicality effects in artificial categories: Is there a hemispheric difference? *Brain and Language* 37: 90-106.
- ROSE, M. (1988). Narrowing the mind and page: Remedial writers and cognitive reductionism. *College Composition and Composition* 39: 267-302.
- RUMELHART, D.E. and J.L. MCCLELLAND. (Eds.). (1986). *Parallel distributed processing*. Cambridge, Mass.: MIT Press.
- SATZ, P., E. STRAUSS, and H. WHITAKER. (1990). The ontogeny of hemispheric specialization: Some old hypotheses revisited. *Brain and Language* 38: 596-614.
- SCHACTER, D.L. (1987). Implicit memory: History and current status. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 13: 501-508.

- SCHEIBEL, A.B., L.A. PAUL, I. FRIED, A.B. FORSYTHE, U. TOMIYASU, A. WECHSLER, A. KAO, and J. SLOTNICK. (1985). Dendritic organization of the anterior speech area. *Experimental Neurology* 87: 109-117.
- SCHWARTZ, G.E., R.J. DAVIDSON, and F. MAER. (1975). Right hemisphere lateralization for emotion in the human brain: Interactions with cognition. *Science* 120: 286-288.
- SCOVEL, T. (1969). Foreign accents, language acquisition, and cerebral dominance. *Language Learning* 28: 129-142.
- SCOVEL, T. (1982). Questions concerning the applicability of neurolinguistic research to second language learning and teaching. *TESOL Quarterly* 16: 323-332.
- SCOVEL, T. (1988). *A time to speak: A psycholinguistic inquiry into the critical period for human speech*. Rowley, Mas.: Newbury House.
- SEGALOWITZ, S.S. and H. COHEN. (1989). Right hemisphere sensitivity to speech. *Brain and Language* 37: 220-231.
- SELIGER, H. (1978). Implications of a multiple critical periods hypothesis for second language learning. In W. Ritchie (Ed.), *Second language acquisition research*. Pp. 21-35. New York: Academic.
- SELINKER, L. and J.T. LAMENDELLA. (1978). Two perspectives on fossilization in interlanguage learning. *Interlanguage Studies Bulletin* 3: 143-191.
- SOLIN, D. (1989). The systematic misrepresentation of bilingual-crossed aphasia data and its consequences. *Brain and Language* 36: 92-116.
- SPERRY, R.W. (1968). Hemisphere disconnection and unity in conscious awareness. *American Psychologist* 23: 723-733.
- SPERRY, R.W. (1973). Lateral specialization of cerebral function in the surgically separated hemispheres. In F.J. McGuigan and R.A. Schooner (Eds.), *The psychophysiology of thinking*. Pp. 209-229. New York: Academic.
- SPERRY, R.W., M.S. GAZZANIGA, and J.E. BOGEN. (1969). Interhemispheric relationships: The neocortical commissures; syndromes of hemispheric disconnections. In P.J. Vinken and G.W. Bryn (Eds.), *Handbook of Clinical Neurology*. Pp. 273-289. Amsterdam: North Holland.
- SPOLSKY, B. (1985). Formulating a theory of second language learning. *Studies in Second Language Acquisition* 7: 269-288.
- SPOLSKY, B. (1989). *Conditions for second language learning*. Oxford: Oxford University Press.
- SPRINGER, S.V. and G. DEUTSCH. (1985). *Left brain, right brain*. New York: Freeman.
- STIEBLICH, C. (1983). *Language learning: A study on cognitive style, lateral eye-movement and deductive vs. inductive learning of foreign language structures*. Unpublished doctoral dissertation, McGill University, Montreal.
- TERRELL, T.D. (1991). The role of grammar instruction in a communicative approach. *Modern Language Journal* 75: 52-63.
- TOLLEFSON, J.W., B. JACOBS, and E. SELIPSKY. (1977). The monitor model and neurofunctional theory: An integrated view. *Studies in Second Language Acquisition* 6: 1-16.
- TRAVIS, L. (1988). Linguistic theory: Neuroscience and second language acquisition. In S. Flynn and W. O'Neil (Eds.), *Linguistics in second language acquisition*. Pp. 90-108. Dordrecht: Kluwer.
- TREVARTHEN, C. (Ed.) (1990). *Brain circuits and functions of the mind: Essays in honor of Roger W. Sperry*. Cambridge: Cambridge University Press.
- VAID, J. (1983). Bilingualism and brain lateralization. In S. J. Segalowitz (Ed.), *Language functions and brain lateralization*. Pp. 315-340. New York: Academic Press.
- VAID, J. and F. GENESEE. (1980). Neuropsychological approaches to bilingualism: A critical review. *Canadian Journal of Psychology* 34: 419-447.
- VAID, J. and D.G. HALL. (1991). Neuropsychological perspectives on bilingualism: Right, left, and center. In A.G. Reynolds (Ed.), *Bilingualism, multiculturalism, and second language learning*. Pp. 81-112. Hillsdale, NJ: Lawrence Erlbaum.
- VGOTSKY, L.S. (1931). *Storia dello sviluppo delle funzioni psichiche superiori*. Firenze: Giunti-Barbèra.
- VGOTSKY, L.S. (1962). *Thought and language*. Cambridge, Mass.: MIT Press.

- WALKER, J. (1990). Of brains and rhetorics. *College English* 52: 301-322.
- WALSH, T. and K. DILLER. (1978). Neuroscientific foundation methods of teaching a second language. *International Review of Applied Linguistics* 16: 1-14.
- WALSH, T. and K. DILLER. (1981). Neurolinguistic considerations on the optimum age for second language learning. In K. Diller (Ed.), *Universals in language learning aptitude*. Pp. 34-45. Rowley, Mass.: Newbury House.
- WERNICKE, C. (1874). *Der aphasische Symptomenkomplex*. Breslau: Cohn and Weigart.
- WHITE, L. (1990). Second language acquisition and universal grammar. *Studies in Second Language Acquisition* 12: 121-133.
- WINNER, E. and H. GARDNER. (1977). The comprehension of metaphor in brain-damaged patients. *Brain* 100: 717-729.
- ZAIDEL, E. (1978). Unilateral auditory language comprehension on the token test following cerebral commissurotomy and hemispherectomy. *Neuropsychologia* 15: 1-17.
- ZAIDEL, E. (1983). On multiple representations of the lexicon in the brain: The case of two hemispheres. In M. Studdert-Kennedy (Ed.), *Psychobiology of language*. Pp. 105-125. Cambridge, Mass.: MIT Press.