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Neurolinguistics and the Non-monolingual Brain

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Introduction.

Neurolinguistics is an area of research which came into its own towards the end of the 20th century. Researchers working in this field try to understand the way language is organized in the brain, taking the performance of people with neurological impairments as the main source of evidence (Whitaker and Whitaker, 1976-1979, Goodglass 1993, Caplan 1987, Ahlsen 2006). The conceptual basis of this field was established over 100 years earlier with the clinical and theoretical work on localization of function in the cortex by Broca, Wernicke, Liepmann, etc (Eling, 1994)

A primary source for research from the 1960's onwards was the Veterans Administration Hospitals in the United States of America. This clinical setting provided a large group of typically white male English-speaking neurological patients who had suffered strokes in their 60s. In addition, they had long-stay chronic care arrangement in medical centres with interdisciplinary teams of health care and research professionals.

This particular medical context created the opportunity to make detailed observations of spared and impaired language, speech, and voice functions in people over a long period of time and correlate this with detailed neurological and psychological

assessments. For the next thirty years, groups of stroke patients were studied by clinical researchers who had the benefits of insights from Chomsky's theoretical developments in Linguistics (e.g., Goodglass and Blumstein 1973, Caplan and Hildebrandt 1988, Kean 1985, Grodzinsky 1990, Bastiaanse and Grodzinsky, 2000). Much was gained through this confluence of opportunities.

Bedside examinations, which were the rule-of-thumb approach used by clinical neurologist, have given way to formal assessment techniques developed by psychologists and speech and language pathologists. These new instruments had the virtue of being standardized with normative values based on observations of large populations samples (e.g., Boston Diagnostic Aphasia Examination, Goodglass and Kaplan, 1976, Minnesota Test for Differential Diagnosis of Aphasia (Schuell, 1965), Porch Index of Communicative Ability, (Porch, 1971), Western Aphasia Battery, (Kertesz, 1982), etc).

Correlations between clinical descriptions and neurological pathology could be made through innovations in neuroimaging techniques which were also developing in tandem with other clinical assessments. From the advent of radioactive scanning (e.g., Benson, 1967), to CAT scans (e.g., Naeser and Hayward, 1978) BEAM (e.g., Duffy, 1985), PET and MRI (e.g., Rapcsak, et al, 1990) and more recently MEG (e.g., Breier, et al. 2006), technological innovations in computing and biophysics have allowed for dynamic clinico-pathological investigations in living patients whereas previously, lesion confirmation could only be gained by autopsy.

At the turn of the 20th century, a new research landscape is beginning to take shape. In the decades of research following the breakthroughs in the 1960s, our understanding of language functioning was derived from the profile observed in a narrowly defined homogenous group, primarily consisting of right-handed English speaking 60 year old men with high school education who had suffered a single cardiovascular accident (CVA). These research observations had built up a "normal" prototype which informed our assumptions and hypotheses about how language was organized in the brain. The current picture reflects both changes in the opportunities for and access to neurolinguistic evidence, and the diffusion of North American research training throughout the world. New research is now focussing on a range of variables which have been identified as crucial to our understanding of how human language is organized in the brain.

The objective of this chapter is to provide a synthesis of neurolinguistic research, to provide a state of the art review, and to give some examples in the way in which research may be fruitfully directed in future. Consideration will be given to the development of our understanding of how language is organized in the brain by refinements in both the way research questions are framed and the manner in which answers are sought. Any domain of active research investigation undergoes refinement over the years, from observation to classification, defining categorical distinctions and generating hypotheses. With the move to experimental research, refinement is achieved through the identification of relevant sources of variation in populations and task properties which affect the nature of observations. Understanding of the sources of heterogeneity in human beings with respect to the

organization in the brain has been served by the increasing number of factors which have been demonstrated to correlate with patterns of function.

Key issues emerging from existing research

The importance of identifying subject variables.

In the 1950s, a book was published which constituted a major attempt to characterize how language impairments were produced by brain pathology. The series of 155 aphasic cases was studied with respect to diagnosis and prognosis. It was collected by Hildreth Schuell and her colleagues at the Minneapolis Veterans Hospital (1964) and can be seen as a major benchmark of modern aphasia research (see Weisenberg and McBride, 1935 for an earlier attempt). At this time, the subject variables were defined as age, education level, occupation, handedness, etiology (i.e., cause of illness), and time post onset of illness, with hearing disorders, developmental speech difficulties, and psychiatric problems excluded. The neuropathological evidence was supplied by electroencephalographic recordings (EEG).

The interpretative meaning of the first subject variable--that of age, has grown in significance recently. This arises from more sophisticated understanding of maturational issues with reference to the development of the language faculty. Advances have been made both at the neurological level, with increasing knowledge of processes of cell migration and death, myelination patterns, etc (e.g., Geschwind and Galaburda, 1984), in more complex theories about the effects of experiential stimulation from the environment (Karmiloff-Smith, 1992), and the interaction of factors under genetic control (Vargah-Khadem et al, 2005).

Throughout much of the 19th century, age was not recognized as a significant issue with regard to behaviour and the brain. Towards 1900, there was increasing awareness that patients had to be differentiated into at least two groups, that of children and adults. Work in developmental psychology and clinical neurology provided refinements which made meaningful neurolinguistic distinctions between infants, school children, post-puberty adults and the elderly (Lorch, in press). Interest in how maturation of the nervous system responded to injury at different periods of development of the language faculty grew (Lenneberg, 1967).

The acquisition of language is now seen as a dynamic process that unfolds over a long period of time. For a detailed understanding of how language capacity develops in an individual, maturational issues now appear to be central to an adequate account. New understanding of genetics on the one hand, and increasing research on the healthy aging brain with the recent extension in lifespan expectancy on the other, has also given rise to a new appreciation that with respect to how language is organized in the brain, age matters.

While, as discussed above, the foundations of the modern science of neurolinguistics was based on adults with acquired disorders, new research on Specific Language Impairment (Gopnik and Crago, 1991) and other developmental disorders which affect language such as Williams Syndrome (Bellugi et al. 1997), Down Syndrome, and Autism (Tager-Flusberg, 1994) provide another source of important evidence (Jenkins, 2000).

Although some of this research is carried out with groups of individuals defined by

their disorder, other research questions arise in the context of individual cases which display unusual patterns. For example, Atkin and Lorch (2007) studied a 4 year old boy with a highly developed reading ability (hyperlexia) in the context of a profound impairment in cognitive development (Autistic Spectrum) and the absence of spoken language. He only produced spoken language in response to written stimuli, but no evidence of language comprehension could be demonstrated through writing, speech, pictures or gestures. However, the boy produced correct heterographic homophones (here/hear) in context. In addition, he made semantic paraphrases while reading which maintained syntactic consistency across words. These two findings imply a level of linguistic development far beyond that which would be predicted by the child's mental age of one and a half years. The observations in such a case indicate the possibility of an atypical route to language acquisition and the development of literacy for which existing cognitive accounts are inadequate. In order to account for this child's behaviour, new developments in theoretical models may be called for.
Unusual developmental trajectories such as this will be an important and growing source of neurolinguistic evidence in future.

The identification and study of such individuals is serendipitous. It relies on the presence of neurolinguistically sophisticated researchers to be available to schools and clinics. Individual researchers and teams working within education and health care can provide important observations for theory development, but only if they are sufficiently grounded in neurolinguistics to identify atypically behavioural phenotypes or symptom complexes.

The variable of "time post-onset of illness".

The focus in traditional neurolinguistic research has been on adult acquired neurogenic disorders of language. The majority of aphasic subjects studied had suffered cerebrovascular accident after acquiring language normally. In the 20th century, this was a major source of illness in Western populations. (In Schuell's case series the frequency was 83%). Properties of this neurovascular insult define the quality of behavioural impairments observed clinically. That is, by their nature, strokes are singular, acute events which have a pattern of recovery determined by how the nervous system responds to the changes in blood supply on the day, over the next few days, in the first two months and chronically. The understanding of how recovery unfolds over time in response to a cardiovascular event is an active area of present clinical research (Hillis et al., 2001). The variable 'time post onset of illness' for stroke patients can now be interpreted in a more meaningful way.

Alternatively, in other etiologies causing chronic, relapsing, or progressive illness, the notion of 'time post onset of illness' takes on a completely different status. These etiological properties will determine some of the clinical picture in aphasia. If, for example, a person has a language disorder as a result of a tumour, which is slow growing and space occupying, the picture will necessarily be quite different. Our clinico-pathological correlation approach to language disorders and brain function has been based on the properties of impairment observed in stroke. This approach capitalized on the singular and acute aspects of CVAs. Patients suffering from other illnesses are now beginning to provide a more elaborated picture of the organization of language through these distinct patterns of impairment. Alzheimer's disease (Nicholas et al, 1985), Primary progressive dementia (Hodges et al, 1992), Multiple Sclerosis (Devere et al. 2000), Parkinson's disease (McNamara, & Durso 2003),

Spasmodic Dysphonia (Whurr et al., 1993), etc, all provide sources of evidence for how thought, language, speech and voice are produced in the brain.

The reduction in the frequency and severity of strokes has been achieved in Western populations through as series of public health advances. At the same time, progressive diseases in the elderly are being studied more intensively as the general population enjoys increased longevity. In future, the issue of how different disease processes affect neurological system functions will ultimately prove to be a significant issue.

Cause of illness (i.e., etiology) has typically been a variable which is reported as a subject variable but not often incorporated into the interpretation of data. More sophisticated understanding of how functions are impaired and recover from various neurological pathologies will provide better accounts of their neurolinguistic performance.

Other variables of current neurolinguistic interest are gender and handedness differences. (Note that gender was not included in Schuell's 1964 list perhaps due to the predominance of male Veterans subjects.) Studies of women suggest that mental faculties and brain organization may vary, although there is great debate as to whether this may be accounted for by learned social roles, genetic factors, or some interaction of the two (Kimura, 1999). Similarly, some left-handed individuals appear to have different patterns of cognitive organization. Studies of hemispheric specialization and lateralization of function were prevalent in neurolinguistic research in the latter part of the 20th century (Benson and Zaidel, 1985). The strong predictive relationship between left hemisphere pathology and aphasic speech has been documented for over 100 years (Schwartz, 1984). However, a more complex view has developed with the study of extralinguistic impairments in communication in people suffering right

hemisphere damage (Code, 1987). This line of research has been assisted by the growing fields of pragmatics and emotional processing in relation to the social functions of speech (Paradis, 1998). At the same time, recent imaging studies indicate bilateral participation in the language processing of healthy individuals and right hemisphere involvement in recovery of language functions in aphasic individuals (Cappa and Vallar, 1992).

The development of different patterns of brain organization for cognitive functions including language has been emerging on another front. Prescient work initiated by Norman Geschwind (d. 1985) and colleagues on handedness, the development of particular cognitive abilities, epigenetic factors in foetal brain development, and their consequences in later life such as dyslexia (Geschwind and Galaburda, 1985) have recently begun to be pursued with renewed vigour. For example, arising out of his work in Autism, Baron-Cohen (2002) has detailed a continuum of cognitive behavioural patterns linked with genetic factors for the normal population. The notion of multiple intelligences, developed over the past two decades by Howard Gardner (1999), has also fostered a view of the language faculty as one part of a mosaic of differentially developing mental capacities driven by genetic and environmental influences.

The Language Variable.

Although the research landscape reviewed above showed a positive trend in potential developments for understanding in neurolinguistics, one crucial variable has yet to be widely recognized, that is the language or languages a person speaks. In Schuell's case series (1964) no patient information was recorded on this variable. It was either

assumed that an individual was an English-speaking monolingual, or that the knowledge of other languages was irrelevant to their language disorder in this clinical setting. All assessment and treatment would take place in English. No notice was taken if a person had grown up speaking another language, or in fact predominantly spoke something other than English outside of the hospital setting. Although bilingual aphasia cases were reported in the literature (first in 1895 by Pitres), throughout much of the 20th century, there was little theoretically-driven interest in how being multilingual might affect how their languages were represented in the brain (Lorch, 2007). In addition, there was a lack of research into how damage to the brain might affect languages with grammatical properties which were distinct from those exhibited by English.

In the 1980s, a number of researchers with training in both linguistics and neuropsychology began to realize that aphasia research which focused exclusively on English-speaking monolingual individuals would not afford an adequate description of the human language faculty (Chiarello, Knight and Mandel, 1982, Paradis, Hagiwara and Hildebrandt, 1985). Cross-linguistic aphasia projects were carried out on monolingual individuals in different countries by researchers with training in the North American tradition (Bates and Wulfeck, 1989, Menn and Obler, 1990). This ensured consistency in methodology and clinical practice. Interest in questions regarding language universals, which was growing in the domain of theoretical linguistics, helped to motivate this research (Comrie, 1981). This research effort was also aided by better grammatical descriptions of languages other than English that were emerging at the same time in the Principles and Parameters framework of generative grammar (Chomsky, 1981). In addition, the increased professionalization

and academic training of speech therapists world-wide at the end of the 20th century has contributed to more published research on language disorders in people speaking languages other than English. In parallel, there has been a flowering of research into the neurolinguistic properties of visual-gestural languages with the growth in social prominence of the Deaf communities (Poizner, Klima and Bellugi, 1987). In addition, increasing multilingualism and the socio-political drivers to provide health care and education for people who speak languages other than that of the dominant population has changed the potential for neurolinguistic research.

Modern bilingual aphasia research was instigated by a number of researchers in the 1970s such as Paradis (1977) studying the bilingual culture in Montreal Canada, and Albert and Obler (1978) multilingual researchers in Boston. Throughout the next two decades, there was a great deal of research activity investigating bilingual aphasia. This topic was regarded as an important source of evidence for understanding the general relationship between brain organization and language processing.

The value of bilingual aphasia as evidence for neurolinguistic theory is due to the huge variability in the picture of clinical symptoms and patterns of recovery that have been documented. One would expect that if all a multilingual speakers' languages were processed in the same way, brain damage which led to language impairment would affect them equally. Surprisingly, there appears to be a substantial minority of individuals who do not show this pattern of language impairment. There may be different types of aphasic symptoms in the different languages; different levels of severity of aphasic symptoms in the different languages; and/or different rates of recovery of aphasic symptoms in the different languages. It appears that languages in

bilinguals may be psychophysiologically distinct, with languages being selectively impaired and preserved.

Although many aspects of aphasia appear to be fairly consistent and predictable (such as the strong association between anterior lesions with production difficulties and posterior lesions with comprehension problems), the patterns of impairment documented in non-monolinguals are difficult to interpret. This is unexpected and surprising. It suggests that people who learn to use more than one language do so in many different ways, and that the mental representation of those languages can have a variety of different forms and functions.

A number of different factors have been suggested to explain the patterns seen in impairment and recovery of bilingual aphasics: 1) a patient's native language would recover before languages learned later. Ribot, 1881; 2) "… [the language] the most familiar to the patient (usually, but not always, the mother tongue)…reappears first because it is the one that uses the most solidly fixed associations" Pitres, 1895; 3) the order of recovery seen in bilingual aphasia based on degree of automatization. (Pick 1921/1974); 4) Recovery of languages depended on affective and emotional factors Minkowski (1927). More recently, other social aspects of communication have also been considered to be of relevance to the picture of language impairment in non-monolingual speakers: 1) the language of the patient's present environment, 2) the individual's communicative needs, 3) the individual's literacy attainment and practice, 4) the domain of communication (i.e., related to work or personal topics, etc), 5) the language of the clinical environment and of therapy delivery, 6) the degree of structural difference between the grammars of the languages spoken, and so on.

Paradis (1977) devised a classification of bilingual aphasia recovery patterns:

- Parallel – similarly impaired and recover at the same rate
- Differential impairment and recovery -- of a different degree in the different languages relative to the pre-morbid mastery.
- Successive -- one language does not begin to reappear before another is maximally recovered.
- Antagonistic--one language regresses as another progresses.
- Selective --recovery occurs in one language but not in another.
- Blended or mixed -- inappropriate mixing of two or more languages (not equivalent to normal code switching).
- Alternating antagonism -- for alternating periods of time the patient has access to only one of their languages.

All logically possible patterns of impairment and recovery have been documented. Twenty four years later, Paradis (2001) carried out a review of all cases of bilingual aphasia published between 1985 and 2000. In the 132 bilingual aphasic cases that had been reported, there were 81 with parallel recovery, and 24 with differential recovery. Of those showing differential recovery of their languages, 12 individuals displayed language mixing, 9 showed selective impairment in one language with respect to the other(s), and 6 showed successive recovery of their languages.

After reviewing all possible variables which might explain this pattern of results, Paradis concluded that none of the factors identified could account for the observations: "Neither primacy, automaticity, habit strength, stimulation pre- or post-

onset, appropriateness, need, affectivity, severity of aphasia, type of bilingualism, type of aphasia nor structural distance between the languages could account for all the non-parallel recovery patterns observed." (Paradis, 2001)

Current approaches to understanding non-monolingual language functions draw on psycholinguistics processing models which employ metaphorical computational instantiations of activation and inhibition of nodes in networks (Green 1986, 1993, 1998). In addition, there have been attempts to understand the variety of ways in which a person might become multilingual within a framework drawing on current models of working memory. Paradis' model is based on ideas about short versus long term memory, and implicit versus explicit memory systems. Paradis has put forward the hypothesis that that the mother tongue and the second language may be subserved by different memory subsystems. The acquisition of the mother tongue is thought to rely more on implicit procedural memory, while second language learning after the age of seven in a classroom will rely more on explicit declarative memory. These two types of memory are known to be neuroanatomically distinct.

It has become increasingly clear that limitations in our understanding of how non-monolingual speakers process multiple languages are to some extent based on the difficulty in identifying and classifying the neurolinguistically relevant features of individuals' life history in the learning and use of multiple languages. That is, in order for this strand of neurolinguistic research to make any progress, new subject and task variables must be identified.

Bilingualism research in sociolinguistics has suggested a number of variables which appear to impact on the way speakers use different languages in different settings, e.g., at home, work, social and community (Grosjean, 1982). In addition, the manner of language learning is an area of active research in applied linguistics. Such issues which are currently being examined explore a variety of dimensions including: how an infant is exposed to languages at home, study and instruction methods in school, the role of the individual in relation to properties of the social context such as identity and attitudes, group status, group size, etc. Levels and domains of proficiency and attainment and aspects of literacy are also relevant factors. All of these factors shape individual language histories which will be reflected in different neurolinguistic instantiations. In addition, differential use of languages on a day-to-day basis may also lead to significant effects. Regular use of codeswitching in integrated bilingual communities may represent a type of neurolinguistic functioning quite distinct from a person who used of one language as an infant and another for the remainder of their adult life in as an immigrant to a new language community.

Curiously, although multilingual communities are increasing in major urban areas of Western countries, this has had little impact on clinical practice. Paradis noted that in the USA, "whereas 25 years ago, the fact that a patient spoke a language other than that of the hospital environment was rarely recorded in that patient's file, today at least one course in bilingualism is required in language pathology training programs, and patients are increasingly assessed in more than one language." (Paradis, 2000) This seems to be a minimal change in practice in response to such a large social change.

Recent appraisals of the field of bilingual aphasia research have been discouraging. In a review of the current state of neurolinguistics, Ahlsen states "Neurolinguistic aspects of bi or multilingualism have only been studied extensively by a few researchers." (2007). In another recent overview of research findings in this area, Fabbro (2002) asserted that, "It can thus be concluded that so far empirical studies have not provided tenable explanations for the presence of parallel recovery in some bilingual aphasic patients and of differential recovery in others."

Imaging the Brain

Although research into non-monolingual aphasia has yet to realize a new way forward, there is great interest in bilingualism with respect to processing research in healthy individuals. The advent of imaging techniques such as functional magnetic resonance imaging (fMRI) has afforded the opportunity to investigate the localization of languages in the healthy bilingual brain. For example Mechelli and colleagues claim that the gray matter in Broca's area increases in bilinguals relative to monolinguals, especially in those who learned a second language early in life. "It reinforces the idea that it is better to learn early rather than late because the brain is more capable of adjusting or accommodating new languages by changing structurally…"(Mechelli, 2004) .

The cerebral localization of multiple languages by using imaging techniques in healthy individuals appears to be a topic of active research. To date, over 40 imaging studies with healthy non-monolingual speakers have been published. A recent meta-analysis of this research led Hull to state that: "Unfortunately… very few of these studies have been designed in a way to allow comparisons of bilinguals with

monolinguals, or of bilinguals with other bilinguals differing in age of onset of language exposure, thereby making this source of evidence not very informative about individual differences in brain organization related to language experience." (Hull, 2003) This underscores again the importance of determining the theoretical status of such subject variables with precision.

A Research Strategy of Converging Evidence.

The need for renewing our attempts to identify sources of converging evidence should shape the future research landscape into neurolinguistics. Our accounts of clinical observations from people with language impairments must be compatible with understanding that is gained through 1) developments in anatomy and physiology to characterize the function of the nervous system, 2) social and cognitive psychology which models behaviours of healthy individuals and 3) theoretical linguistics which provides accounts of grammar. Insights from these subjects should inform the questions we ask of aphasic subjects. It is often the case that patterns of spared and impaired performance in particular task domains have gone undocumented because investigators had not thought to examine them. Stimulus materials, task design and assessment materials must reflect the current state of theory.

For example, current investigations which employ tasks comprised of single words are common in imaging studies of language processing due to technological constraints on scanning. However, it is clear that single words have particular properties which means that they may not represent the functioning of language systems per se. An argument put forward on this point by Paradis (2004) is a good example of the types of converging evidence which should be used to inform our

investigative strategies. "…single words are the least likely candidates for investigating 'language' representation, given that what makes language most specific as a cognitive function, i.e., the language system (phonology, morphology, syntax), is supported by procedural memory, whereas isolated words are supported by declarative memory and are hence less focalized in their cortical representation." (Paradis, 2004 p. 173) In order to support his argument, Paradis lists a number of different sources of evidence for backing up this claim: 1) the ease of word learning but not syntactic acquisition by non-humans, 2) the limited acquisition of syntax in contrast to lexical development as a consequences of deprivation in early childhood, 3) the difficulty of learning new words but not procedures by anterograde amnesic patients such as H.M., 4) the difficulties of word retrieval but not syntax in those suffering from Alzheimer's dementia, 5) loss of lexical but not syntactic performance in first language attrition, 6) the relative ease of vocabulary learning in late second language students relative to difficulty with phonology, morphology and syntax (Paradis, 2004). Words presented in isolation lose the linguistic properties that only exist in particular constituent contexts. This notion of the unit of the sentence as prime for any linguistic characterization has been accepted since the middle of the last century (Chomsky, 1965). Researchers who use single word stimuli must not believe that their results will have any direct bearing on explanations regarding language processes *per se*.

Consider the currently widely-used clinical task of "word fluency." This requires one to produce as many words as possible in a given amount of time with a particular 'phonological' [sic] (i.e., orthographic) or 'semantic' [sic] (i.e., world knowledge) property such as beginning with the letter 'f' or animals. This is not a task which

reveals anything about the language faculty in and of itself. It is used as a clinical diagnostic tool with patients suffering from a diverse group of disorders which involve cognitive but not language impairments (e.g., Neurofibromatosis 1, Lorch, Ferner, Golding and Whurr, 1999). Poor performance is interpreted with respect to attention and executive control functions not linguistic processes.

In addition to crucial aspects of a research strategy pertaining to task selection, issues regarding the status of individual differences must also be considered. The tendency towards group studies with an emphasis on homogeneity of subjects which prevailed in the mid 20th century has been steadily replaced by a preference for single case studies. The type of strategy based on explanations of behaviour in single cases has been the hallmark of the cognitive neuropsychology research agenda (Shallice, 1988). It asserts the value of an account which is theoretically coherent for an individual pattern of spared and impaired behaviours in acquired disorders. By generating subject variables which are theoretically derived, more convergence of findings based on individual cases may be achieved.

Looking Back to Go Forward.

Finally, current theoretical developments and research strategies may be enhanced by employing an applied historical perspective. A historical analysis may reveal the social and cultural context in which current theory and methodology was initially developed. It may also lead to the development of a more comprehensive approach for current research. How we perceive a problem and characterize variables will directly affect our ability to find solutions. For example, bilingual aphasia appears to be a crucial area of neurolinguistics in which to address questions about biobehavioral

concomitants of language experience. However, as the review presented above demonstrates, current researchers are at a loss to provide a coherent explanation of the body of research findings which have been amassed over the past three decades. Insights from an historical perspective may provide novel approaches to such areas of research which are currently at an impasse.

A recent applied historical approach to the characterization and etiology of Tourette's syndrome is a groundbreaking piece of research. The development of vocal tics and involuntary swearing does not currently have a theoretically motivated explanation. Kushner (1999) went back to the original 19th century clinical reports and found that a consistent association of rheumatic fever with the subsequent development of tics and vocalizations was noted in this earlier literature. On the strength of this observation, Kushner initiated lab research which identified post-infectious streptococcus antibodies as one source of the neuropathology leading to Tourette's syndrome. Kushner states the rationale for an applied historical approach as follows:

> "On the one hand, such investigations provide an illustration of how a historical interrogation of syndrome construction can free medical researchers to pursue alternative and novel approaches. On the other hand, they demonstrate how historians can make unique contributions as collaborators in clinical care and medical research … Historical investigations of syndrome construction can elicit useful issues for the development of research hypotheses and clinical diagnoses. In this way, applied historians of medicine can become important partners in collaborative interdisciplinary medical research." (Kushner, 2003)

I have considered the problem of characterizing the patterns observed in bilingual aphasia using an applied history approach. The aim is to reveal some new avenues for research into language disorders in non-Monolingual speakers. Paradis' (1983) extensive review of the historical literature identified a paper by Pitres (1895) as being the first documented case of bilingual aphasia. This is surprising, since there

were thousands of publications recording cases of acquired language disorders in monolingual speakers after Trousseau coined the term aphasia in 1864. The question I raised is why no cases of bilingual aphasia were recorded in that thirty year period of active research? In the archival study I recently carried out (Lorch 2006a; 2008), no records were found in the English medical literature of cases identified as bilingual aphasia before Pitres, 1895. What was revealed through my investigation were detailed descriptions of cases where one language was differentially affected subsequent to neurological illness in non-Monolingual speakers, but these patients were categorized and conceptualized completely differently by 19th century practitioners. These cases were not clinically classified as "loss of speech" (the term for aphasia pre-1864), but rather as memory disorders. It appears that in the 19th century, knowledge of second languages was considered to have a different psychological status than today. They were assumed to be a reflection of a general intellectual achievement rather than something pertaining to the language faculty. Learning a second language was categorized as an academic endeavour akin to learning geography or science. This 19th century characterization of the problem drew a clear distinction between speech disorders in monolinguals as opposed to memory impairment in bilinguals. This historical demarcation throws into relief some of our own current conceptualization of the difference between 1st language acquisition of a native language and other types of learning. In order to develop our ideas about language organization in non-monolinguals we may need to revise our assumptions about the contribution of "learning" and "memory." With our growing understanding of the neurological underpinnings of such processes, more sophisticated neurolinguistic models may emerge concerning how an individual becomes non-monolingual.

The cultural learning of more than one language by an individual is generally considered as exceptional in neurolinguistic terms from an Anglo-American perspective. As highlighted in the review above, current formulations take the monolingual individual as the neurolinguistic norm to be modelled. What is also considered to be the neurolinguistic norm in this research domain is that of literacy. The cultural learning of an orthographic representation of spoken language has gained such primacy in our society that the possibility that the typical neurolinguistic state of humans, from a more global, historical, and anthropological perspective, is more likely to be multilingual and illiterate. Nevertheless, a large portion of modern research into language processing is focused on the neurolinguistic substrates for reading and writing.

An applied history approach to the neurolinguistic substrates of literacy have also reveal interesting shifts in our theoretical conceptualization of such processes. My research into the 19th and 20th century literature on the acquired disorder of written language production reveals some interesting changes in the cultural value placed on this cognitive ability, and how cultural learning is thought to have direct effects on the specialization of the brain (Lorch and Barrière, 2002; 2003). In the class of acquired disorders of cognitive functions, pure agraphia represents something of an anomaly. It was first described in the modern literature by Pitres in 1884 as a selective loss of the ability to produce written language in the context of spared spoken language and reading ability. Over the next 125 years, papers have been published documenting other cases of this rare clinical picture while, at the same time, others have made statements in print denying its existence. Questions have been raised about the robustness of observations. At the same time, the possibility of its existence has been rejected *a priori* on theoretical grounds. This raises issues regarding the rareness of

an observation which by its compelling nature is viewed as requiring an explanatory account on the one hand, or as an exception ruled as a methodologically flawed piece of outlier data (Barrière and Lorch, 2004).

Following on from the analysis of pure agraphia, my historical investigations probed the methodological status of clinical observation and the potency of another emblematic case in the historical literature which became a source of evidence for significant theoretical argumentation. Hellal and I (2007) reviewed the case of a child with an unusual pattern of acquired language impairment, recovery, and impairment, who had was reported to have had homologous lesions in left and right Broca's area at his death. This case, published by Thomas Barlow in 1877, was cited in the literature for over three decades as definitive evidence in support of a number of theories regarding the role of the left hemispheric for language, and the right hemisphere in the recovery of function.

We compared the record as published in the *British Medical Journal* with copies of the hospital case notes archived at the Great Ormond Street Hospital, London. We found a number of fundamental discrepancies between the clinical case notes and the journal article belying claims about the recovery of his language impairment and the size and locations of the lesions. These were compounded by subsequent authors when citing this case. This dubious evidence was nevertheless used by leading theoreticians to support arguments about language function, development of dominance and recovery patterns in children. These notions were so pervasive in the late 19th and early 20th century that this one, poorly reported case was sufficient to persuade people of the validity of these theories. Our review of this case also raises questions regarding observational and recording practices which are relevant to

today's clinical researchers. Other issues which have been illuminated by this type of applied historical neurolinguistics the evolving concepts of organic versus functional disorders and methodological issues (Lorch, 2006b), the changing status of behavioural evidence for diagnosis (Lorch, 2006c), and how subject variables get identified (Hellal and Lorch, in press).

This chapter has reviewed the state of the art research which has given rise to universal biolinguistic accounts for how language is organized in the brain. However, I point out that these accounts are predicated on research observations primarily drawn from monolingual literate individuals. Recent research has begun to actively investigate the organization of language in non-monolingual speaker using both clinico-pathological lesion studies and imaging techniques in neurologically impaired and healthy adults and children. There has been only limited progress in the interpretation of these finding towards the development of an account of multilingual language processing in the brain. I suggest that one avenue of research is to explore our current formulation of theoretical issues, methodological strategies, and forms of argumentation in the neurolinguistics through exemplars from the historical literature of our field.

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