What Bilingual Aphasia Tells Us About Language Processing in the Unilingual Brain

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The study of bilingual aphasia has made us focus on a number of issues that have proven useful for the understanding of aphasia in unilinguals and of the way the brain processes language in general: (1) An attempt to account for the various recovery patterns has led to the notion of inhibition/disinhibition in the use of languages, and of activation threshold of the various language subsystems in unilinguals as well; (2) sociolinguistic registers in unilinguals have come to be viewed as neurofunctionally fractionable in the same way as two languages in the brain of bilinguals; (3) the dissociation between linguistic competence and metalinguistic knowledge in second language learners has led to a better grasp of the roles of procedural and declarative memory in language acquisition and use; and (4) the study of the use of pragmatic features in order to compensate for the lack of linguistic competence in second language speakers has shed light on the role of pragmatics in normal language processing as well as in 2-year-olds' incipient first language acquisition and in unilingual aphasic patients.

Each of the above considerations has implications not only for our understanding of the way languages are represented and processed in the brain, but also for a better diagnosis and rehabilitation of neurogenic communication disorders. We shall briefly consider each of these four issues in turn.

Patterns of Recovery and Explanations: Activation Threshold

Because bilingual aphasic patients do not always recover both languages to the same extent or at the same time, and in fact one of the languages may never be recovered, some authors had speculated that perhaps each language was located in a different part of the cortex. Pitres (1895) proposed instead that each language independently could be temporarily or permanently inhibited. This suggestion prefigures two present-day notions: that of modularity of language systems and that of differential inhibition which in turn led to the activation threshold hypothesis (Paradis, 1993).

Certain recovery patterns, reported long after Pitres's monograph, confirmed his insight. Antagonistic recovery, and in particular alternating antagonism could definitely not be accounted for by differential localization. For, if the reason why a patient could not speak Arabic on Monday was that its neural substrate had been destroyed, in contrast with French, located in an area that had been spared by the lesion, and hence that she could speak, how could we explain that, on Tuesday, she was able to speak Arabic again, but not French? Or in the case of successive recovery, that a language spontaneously recovered several months later? Thus, the temporary or permanent inaccessibility of languages must be accounted for by something other than location at different cortical sites.

Pitres proposed that the neural substratum of languages that are not accessible is not physically destroyed but functionally impaired. This inhibition, however, is not an all-or-nothing phenomenon: it admits of degree of severity, as evidenced by languages that are more impaired than others in cases of differential recovery. It was quickly assumed that, in the normal use of language, in order to avoid interference, one language was being inhibited while the other was activated (on the model of any function and its antagonist).

However, experimental evidence showed that the language not currently in use was nevertheless never totally deactivated (Green, 1986; Grosjean & Soares, 1986). It had also been observed that in non-brain-damaged individuals, language items were sensitive to frequency and recency of use, in that they were more easily available when they had been frequently or recently used. Elements that have been activated show a priming effect: they are easier to activate again. From these various observations emerged the Activation Threshold Hypothesis.

The Activation Threshold Hypothesis proposes that an item is activated when a sufficient amount of positive impulses have reached it. The amount necessary for the item to be activated is its activation threshold. Every time the item is activated, its threshold is lowered, and fewer impulses are then required to reactivate it. After each activation, the threshold is lowered but it gradually rises again and if it is not stimulated, becomes more and more difficult to activate. Attrition is the result of long term non-stimulation. Comprehension of a given item does not require a threshold as low as for production of that item. In other words, comprehension requires fewer impulses than production, and is thus easier. This is probably due in part to the fact that the item is activated by the impulses generated by the stimulus as it impinges on the senses. No such external support exists for self-activation of an item, hence the total sum of the impulses required to reach the activation threshold have to be internally generated. Entire systems or subsystems may be inhibited in this way (their threshold raised beyond possible activation). Thus, after a long period of disuse, one of the languages might still be understood but no longer spoken spontaneously. This is of course true of any item within each language.

Pathology (or normal aging) may disrupt the normal activation levels, causing word finding difficulty, for example. Aphasia would correspond to the blanket raising of the threshold of a system, or subsystem, or module, thus selectively or differentially affecting the entire language system, or one of the languages, or phonology, syntax, or lexical access in only one of the languages. The hypothesis can be extended without modification to unilingual systems.

Neurofunctional Modularity: Sociolinguistic Registers

After considering a number of possible ways in which the two languages of a bilingual speaker might be represented in the brain, and having rejected the extended system, the dual system, and the tripartite system (Paradis, 1987a) as not being compatible with all of the reported data, the Subsystems Hypothesis was adopted as the most adequate working hypothesis. It proposes that each of the languages forms a subsystem within the larger system of language. The various dissociations between languages in bilingual aphasia have shown that each language is capable of selective impairment, and hence must at some level constitute a coherent neurofunctional system. But the ability to mix languages without apparent loss of fluency and cross-linguistic priming point to both languages being part of a larger system, the language faculty, which can selectively be inhibited as a whole, with other cognitive functions remaining relatively intact.

A comparison between unilinguals and bilinguals revealed that there are no functional differences between them: Borrowing, mixing, switching, and translating have their unilingual counterpart in using words from different registers, switching registers in response to changes in the social contexts, and paraphrasing (that is, relating the same message in different words, sometimes with a different pronunciation, syntax and morphology, as well as different lexical items). This led to the assumption that there were probably no neurofunctional differences either, and that therefore, the brain of a unilingual should be organized in the same way as that of a bilingual, with its registers organized in the same way as the languages of multilinguals. The study of Japanese dyslexia, with its double dissociations between the various writing systems (kana and kanji, Roman and kanji numerals), as well as dissociations between musical notation, morse code, or shorthand and cursive writing, and between languages in bilingual aphasic patients led to the hypothesis of neurofunctional modularity (Paradis, 1987b). The Subsystems Hypothesis was then extended to cover the different registers of unilingual speakers as well. One could thus expect the same kind of dissociation between registers in unilingual aphasia as have been observed in bilingual aphasia. Indeed some cases of such dissociations have been described, between formal and familiar registers (Riese, 1949) and between Cockney and Oxford dialects but such reports remain few because the phenomenon has not been systematically investigated so far. Once one starts looking for them, more cases are likely to be found.

The Role of the Right Hemisphere in Language Processing

A major question about the bilingual brain has been the extent to which it might differ from the unilingual brain. On the basis of results from a few dichotic listening and visual half-field tachistoscopic studies, it was first speculated that language organization in the brain of the average bilingual may be more bilateral than in that of a unilingual and that patterns of cerebral dominance may be different for each language in the brain of a bilingual (Albert & Obler, 1978). Even at that time it was apparent that the few studies on which the differential lateralization hypothesis was based presented several contradictions. As additional studies failed to support predictions, the hypothesis was gradually narrowed to apply to more and more restricted subgroups of bilinguals: Late acquirers (the age hypothesis), late acquirers at the beginning stages of acquisition (the stage hypothesis), late acquirers at the beginning stages of acquisition in an informal environment (the stage + manner of acquisition hypothesis). While many studies continued to find no difference, those studies that did report a difference were making contradictory predictions. For example, in direct contradiction with the stage and manner hypothesis, students in a *formal* learning environment were reported to become less lateralized as they became more proficient (Bergh, 1986). Finally, a meta-analysis of all the available experimental data could not find evidence of lesser asymmetry of language representation in the brains of bilinguals of any type (Vaid & Hall, 1991). Clinical studies have consistently reported the same incidence of crossed aphasia in bilingual as in unilingual subjects (Chary, 1986; Karanth and Rangamani, 1988; Rangamani, 1989), suggesting that the contradictory results of experimental studies might be due to the lack of validity of the laterality paradigms used in these experiments, given a 90% chance of misclassification of subjects into a right-brain language group, as was argued 20 years ago by Satz (1977). Colbourn (1978) also pointed out that there was no foundation for the assumption that the degree of a performance asymmetry reflects the degree of lateralization for the task or stimulus material used.

An inquiry into what the alleged increased participation of the right hemisphere might consist of (Paradis, 1987a) has led to the realization, on the basis of language-related deficits reported in right-brain damaged patients, that non-balanced bilinguals might well rely to a greater extent on pragmatic aspects of language in order to compensate for the gaps in linguistic competence in their weaker language. It became clear that in order to derive the meaning of any utterance in context that is, in the normal use of language both linguistic competence and pragmatic competence are needed. Both are necessary, but neither is sufficient, and each is subserved by a different hemisphere (Paradis, 1994a). A left hemisphere lesion will result in dysphasia (the disruption of phonology, morphology, syntax and/or the lexicon); a right hemisphere lesion will result in dyshyponoia[1] (an impairment in making appropriate inferences from the context or from general knowledge).

The use of pragmatic features to compensate for lack of linguistic competence is also a fact of incipient first language acquisition (Bloom, 1974). It then becomes apparent that there is no

1. Dyshyponoia: From the Greek ὑπονοῶ what is «undestood» in an utterance, albeit unsaid, in the sense of the French *«sous-entendu»*, Spanish *«sobrentendido»*, Catalán *«sobreentès»)*. Impairment of the use of linguistic pragmatics (e.g., the inability to draw correct inferences from the context or from general knowledge, leading to problems in the interpretation of indirect speech acts, metaphors, and in general of the unsaid component of an utterance).

clinical evidence of right hemisphere involvement in the processing of linguistic competence in unilingual two- to five-year-old children. The original rationale for suspecting the involvement of the right hemisphere in the beginning stages of second language acquisition was that it recapitulated first language acquisition. But there is no evidence that children process grammar (i.e., phonology, morphology, syntax, and the lexicon) in the right hemisphere even at the earliest stages of language development. There is therefore no foundation to the assumption that the acquisition of linguistic competence in a second language, like that in the first, would involve the right hemisphere in the beginning stages. Second language acquisition may indeed recapitulate the sequence of processes engaged in first language acquisition, including right hemisphere participation but by implicating pragmatic, not linguistic competence.

(I assume researchers that claimed right hemisphere participation for language referred to grammar since they used methodologies that purport to measure language *as it is represented in the left hemisphere of unilinguals*, and could not be influenced by right hemisphere-based pragmatic features without admitting that their procedures were invalid (i.e., not measuring what it is purported to measure). In fact it is difficult to see how results could be contaminated by pragmatics when the stimuli consisted in digits, syllables or, at best, isolated words).

The Use of Metalinguistic Knowledge and Implicit Linguistic Competence

Another means by which second language speakers are able to compensate for their lack of linguistic competence is metalinguistic knowledge. While competence in a native language is acquired incidentally, i.e., by focusing attention on some aspect of utterances other than that which is internalized (e.g., on meaning while acquiring a grammar; on acoustic properties of sounds while acquiring motor programmes for the production of those sounds); is stored implicitly (i.e., outside the scope of awareness) and remains for ever opaque to introspection, and is used automatically (i.e., without conscious control); metalinguistic knowledge, on the other hand, typically encountered in school, is learned consciously, that is, by paying attention to what is memorized, can be recalled and recounted, and is produced in a controlled manner. The observation that some language students who obtain good marks in school do poorly in conversational settings, while some students who obtain poor maks communicate quite fluently (albeit not necessarily very accurately) drew attention to the implicit linguistic competence/explicit metalinguistic knowledge distinction.

Clinically a double dissociation is observed between amnesiac and aphasic patients. Anterograde amnesiac patients are unable to acquire new knowledge, in fact to remember anything of which they have been conscious since the onset of their condition. They cannot remember where they parked their car or what their new address is if they have moved. They cannot learn new words or remember the names of new acquaintances (or remember having seen them before) or new place names (like the name of their new hospital or town). Yet, they are able to acquire new motor or cognitive skills and show the same improvement with practice as normals, without ever being aware of having encountered the task before. In other words, their declarative memory (knowing that) is impaired but their procedural memory (knowing how) is intact. Aphasic patients, on the other hand, have deficits in the procedural memory system that subserves their language competence (a cognitive skill) but have no problem with declarative memory. Implicit competence is represented in those cortical areas that were active in their acquisition. Thus implicit linguistic competence is represented in the perisylvian area long identified as the «language area» including Broca's area in the frontal lobe, and Wernicke's area in the temporal and parietal lobes of the left hemisphere. Declarative knowledge, of which explicit metalinguistic knowledge is a part, is bilaterally represented in large areas of associative cortex. The metalinguistic rules of pedagogical grammar, like most overlearned material, may in fact be represented preponderantly in the right hemisphere.

The amnesiac patient's difficulty with learning new words has highlighted a distinction between morphosyntax and vocabulary. While morphosyntax (as well as phonohology) is implicit, vocabulary is to a large extent explicit: speakers consciously know the sound and the meaning of words and can produce either on demand —something they cannot do about the algorithms that underlie morphosyntax or phonology (professional linguists themselves continue to disagree on the form of linguistic representations, a testimony to the opacity of implicit linguistic competence). Lexical access and the automatic insertion of lexical items in the course of the microgenesis of an utterance produced under normal circumstances is equally unavailable to awareness. In addition, there is a clear dissociation between phonology and morphosyntax on the one hand and vocabulary on the other in individuals with genetic dysphasia (Paradis & Gopnik, 1997), in children who are not exposed to language until seven (Lebrun, 1978) or thirteen (Curtis, 1977) years of age, for whom the acquisition of implicit grammar is arduous, whereas vocabulary expansion is relatively easy.

The declarative and procedural memory systems are not only neurofunctionally distinct, but involve different subcortical neural structures. The acquisition of declarative memory relies crucially on the integrity of the hippocampal system whereas procedural memory engages other subcortical structures, such as the basal ganglia (Butters, Salmon & Heindel, 1994; Dubois, Malapani, Verin, Rogelet, Deweer & Pillon, 1994), the striatum, as well as the cerebellum (Leiner, Leiner & Dow, 1991; Ito, 1993). Both memory systems depend upon cortical and subcortical structures, but different ones.

These observations led to a reconsideration of the selective or differential paradoxical recovery of some bilingual aphasic patients who had recovered their least known language over their previously fluent native language. It may well be the case that patients who have no longer access to the procedural memory system underlying linguistic competence for both their languages have nevertheless retained access to their declarative metalinguistic knowledge which may be more extensive in their formally learned second language. This may also explain the observed better prognosis that is generally correlated with a higher level of education in unilingual speakers. One may speculate that metalinguistic knowledge should still be available (or taught) to aphasic patients and thus compensate for their lack of access to their implicit linguistic competence, in the way that individuals with genetic dysphasia and some second language learners do.

Conclusions

What applies to the bilingual brain also applies to the unilingual brain: there are no qualitative differences. Individuals find themselves on a continuum from several registers in a unidialectal speaker to bidialectal speakers, to speakers of closely related languages, to speakers of unrelated languages. All use the same cerebral mechanisms, albeit to differing extents.

When the procedural memory system for language is genetically impaired or when the system has not been engaged during the time of its normal development (i.e., between the ages of 2 and 5), speakers compensate (for their lack of competence in their first or second language) from two sources: right-hemisphere-based pragmatic competence and metalinguistic knowledge. Unilingual individuals with acquired aphasia should have the same options.

The evidence points to a neurofunctional modular system for language representation, with specific neuroanatomical substrates, irrespective of the number of languages stored in the brain. Differences between cerebral processes involved in language representation and use in unilinguals and different types of bilinguals appear to be only quantitative, as speakers of a second, weaker language may rely to a greater extent on explicit metalinguistic knowledge and pragmatic features to compensate for lacunae in their implicit linguistic competence. *What* is represented may differ, *how* it is processed does not. However, if the results reported by Weber-Fox and Neville (1996) are confirmed, namely, that bilingual individuals after the age of six or seven process functional items as lexical items, then it may be that later acquirers of a second language, like individuals with genetic dysphasia (Paradis & Gopnik, 1997), do in part process language in a qualitatively different manner. A distinction will then be necessary between bilinguals that is, *early* bilinguals and fluent speakers of a second language.

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