Performance in L1 and L2 observed in Arabic-Hebrew bilingual aphasic following brain tumor: A case constitutes double dissociation

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Abstract: This study aimed to verify the existence of a double first language (L1)/second language (L2) dissociation. In recent work, I described a case study of a Arabic-Hebrew aphasic patient (MH) with disturbances in the two languages, with Hebrew (L2) being more impaired. In this case, an Arabic-Hebrew bilingual patient (MM) with a similar cultural background who suffered brain damage following a left hemisphere tumor (oligodendroglioma) and craniotomy is reported. The same materials were used, which overcame methodological constraints in our previous work. The results revealed a complementary pattern of severe impairment of L1 (Arabic), while MM had mild language disorder in L2 (Hebrew) with intact semantic knowledge in both languages. These two cases demonstrate a double L1/L2 dissociation in unique languages, and support the notion that bilingual persons could have distinct cortical language areas.

Keywords: aphasia, arabic, hebrew, brain damage, dissociation, double-dissociation, bilingual, localization

Introduction

Ensuing experimental studies have not corroborated the idea that language is organized differently in monolinguals and bilinguals. Although, there is much experimental and clinical data in psycholinguistics which is relevant to this issue, little work has been done on first or second language acquisition from the neurolinguistic perspective.

In the light of above, I will discuss the question of whether two different languages in general and whether Arabic as first language (L1) and Hebrew as second language (L2), in particular, are localized in the same area or in distinct areas of the brain. Recently, I discussed this topic in relation to selective language disorders in aphasic patient, specifically in his L1 (Arabic) and L2 (Hebrew). I describe a case study of a proficient Arab-Hebrew bilingual man (MH) who suffers from brain damage following intracranial hemorrhage related to herpes encephalitis disease (Ibrahim, submitted). Using linguistic tasks in L1 and L2, the results revealed a dissociation between the two languages in terms of the magnitude of the errors and of error types, which suggests that aphasic symptoms exist in the 2 languages with Hebrew (L2) being more impaired. Further analyses revealed that this dissociation does not seem to be caused by damage to his semantic system, but rather by damage at the lexical level. It was suggested that the principles governing the organization of lexical representations in the brain are not similar for the two languages. However, not all linguistic components (like naming) were similar in the two languages.

Consequent to this case report, the purpose of this essay is to find complementary double dissociation, to allow for the discrimination of two different representations to L1 and L2. Dissociations, and double-dissociations are needed to allow for the discrimination of different cognitive processes especially those in relation to the hypothesis of the

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localization of function. Although this kind of study was demonstrated in numerous previous reports using lesion functional imaging, cortical stimulation, and it was shown that bilingual patients could have distinct cortical language areas (Bello et al 2006; Khateb et al 2007; Abutalebi et al 2008), this study is very original in the sense that it provides additional evidence from languages that were not investigated previously.

The neural basis of bilingualism

In the literature, there are number of views mentioned, often contradictory concerning how two languages are represented in the human brain. The evidences that support those different views came from studying bilingual aphasics who suffered from brain damage (Ojemann 1983; Agliotti et al 2001). Aphasia is defined as a loss or impairment of language function caused by damage to language and association areas of the brain. There are a number of possible causes including a stroke, tumor, head trauma, toxic conditions, and degenerative diseases such as Parkinson's and Alzheimer's. The issue that is relevant to this essay is the cerebral organization of languages in bilinguals. Various influential studies along with more up-to-date information obtained with technology such as neuroimaging techniques also appear to support this concept of double-dissociation.

Using neuroimaging techniques, Klein and colleagues (1999) compared cerebral organization of two typologically distant languages: English and Mandarin Chinese. The subjects, proficient in both languages, had learned their L2s during adolescence. Mandarin was chosen as it differs from English in its specified use of pitch and tone. The study examined the influence of linguistic structure on cerebral blood flow (CBF) patterns in subjects when they performed a noun–verb generation task. The task conditions consisted of repeating nouns in Mandarin, repeating nouns in English, generating a verb for a noun in Mandarin, and generating a verb for a noun in English. Overall, the pattern of CBF increase seen in response to the L1 was strikingly similar to that seen for the L2. This finding led to the conclusion that, in fluent bilinguals who use both languages in daily life, lexical search utilizes common cortical areas. More recently, based on the results from an event-related functional magnetic resonance imaging (ER-fMRI) showed a shared neural mechanism for the processing of native and second languages (Pu et al 2001).

Using clinical methods, other neurolinguistics groups found parallel recovery of both languages in bilingual aphasics (Fabbro 2001). According to this view, "linguistic domain" would affect the way L2 information is represented in the brain. Researches supporting this view have shown that there is one neural representation of multiple languages (Paradis 1990; Moretti et al 2001). Moreover, Illes and colleagues (1999) examined brain activation in bilingual participants who sequentially learned English and Spanish (or vice versa) and showed dissociation of the sites related to the same tasks in these two different languages. The participants became fluent in their L2s a decade after L1 acquisition, but were proficient in both languages. Subjects were presented with 480 concrete and abstract English nouns and their Spanish translations. Participants performed tasks that required semantic and nonsemantic decisions about those words. The semantic activation for both languages occurred in the same cortical locations. Further, no activation difference was observed in a direct comparison of semantic judgments in English and Spanish. The researchers suggested that, according to the resolution provided by functional MRI, a common neural system mediates semantic processes for the two languages in the bilingual brain. They concluded that learning a new language after puberty does not require the addition of a new semantic processing system or the recruitment of new cortical regions.

The other hypothesis was put forward by a different group of investigators at the end of the 1970s. These researchers brought demonstrated instances of pathological patterns of bilingual aphasia, with antagonistic recovery, when a patient's performance in one language improves while performance in another language deteriorates (Ojemann et al 1989; Dehaene et al 1997) and called the "language-membership principle" approach. According to this approach, L1 and L2 representations would be, to some extent, sustained by different brain areas, since they take different language membership values. In their study, in French-English bilinguals using fMRI technique, Dehaene and colleagues (1997) found dissociation between cortical areas involved in French (L1) and English (L2) languages. The regions of the left superior temporal sulcus, superior and middle temporal gyri showed consistent activation across subjects during presentation of L1. Also, other researchers that investigated single case studies, found a bilingual aphasic to be recovered selectively in one language while the other is lost (Green and Price 2001; Green 2005). The classical model assigns language functions to two regions in the left hemisphere, the inferior frontal region and the temporo-parietal region of the brain. Injuries in the general boundaries of these cortical areas have resulted in clinically and linguistically different aphasic syndromes, referred to as Broca's aphasia (agrammatic) and Wernicke's aphasia (paragrammatic).

Overview of the study

In this paper, I present the case of a native Arab patient called MM who has major disturbances in his native Arabic language

(L1) while his Hebrew language (L2) is less impaired. This case, along with the Arabic-Hebrew (MH) case we described recently (Ibrahim, submitted), demonstrated a double L1/L2 dissociation in new and unique languages.

Double-dissociation

An important concept in neuropsychology is the notion of double-dissociation. A double-dissociation within language is when a patient can perform task X, but has difficulty with task Y, and vice versa. To show that these two functions are found in separate areas of the brain, we needed two cases: one where X is fine, Y is impaired, and another where Y is fine and X is impaired. This shows that the two functions are independent and represented different modules.

The contrast between Broca's and Wernicke's aphasia supports the concept of a double-dissociation. Caramazza and Zurif (1976) used this idea of a double-dissociation to propose the single case studies as a method to support this existing hypothesis. Therefore, double-dissociations became important neuropsychological evidence as they allowed researchers to make an estimate of localization of function separation with reasonable confidence. They also allowed to separate lexical, syntactic, and semantic processing in different languages. For example, studies have revealed a dissociation between the lexical and syntactic processes in the understanding and production of Arabic numerals (Cipolotti et al 1991; Nöel and Seron 1993). In Nöel and Seron's (1993) study, a patient read words without difficulty although he could not read nonwords and had trouble with Arabic numerals. Cipolotti and colleagues (1991) published a case study in which the patient was diagnosed with severe acalculia for numbers above 4 but who did not have similar difficulties with reading. More recently, Cipolotti (1995) published the case of a patient with Alzheimer's disease who had problems reading Arabic numerals but who could read words and nonwords well. As a result of these investigations, several models have been proposed which attempt to account for the number processing system. The hypothesis of double-dissociation within bilingualism suggests that the first and second language could be impaired independently of each other. This hypothesis forms the focus of this case report.

Challenges in processing Arabic and Hebrew

Hebrew and Arabic, both Semitic languages, share similar origins but differ in some aspects like phonology, phonetics (articulation), and other linguistic structures.

As Semitic languages, they are characterized by a nonconcatenative, highly productive derivational morphology (Berman 1978). In Semitic languages, words are constructed by combining a consonantal root (that carries most of the semantic information) and a word pattern that includes vowels as well as consonants, and provides information about the word class and its morphological status, as well as the complete unequivocal structure of the word. Hence, each word in Hebrew or Arabic is, at the very least bi-morphemic, but none of the composing morphemes are words by themselves. In most words, the core meaning is conveyed by the root, while the phonological pattern conveys word class information. For example in Hebrew, the word (TARSHEEM) consists of the root (R,SH,M) and the phonological pattern TA – I- and the word (SIFRA) consists of the root (SFR) and the phonological pattern – I- A in which every line represents a consonant. In Arabic the word (TAKREEM) consists of the root (KRM, whose semantic space includes things having to do with respect) and the phonological pattern TA – I-. The combination results in the English word, 'honor'. Unlike the Latin orthography in which vowels are represented by letters, in Arabic and Hebrew, vowels are not part of the alphabet letters. The letters that make up the root may be dispersed across the word, interdigitated with letters that can double as vowels and other consonants that belong to the morphological pattern. Also, in Hebrew and Arabic, there are four letters which also specify long vowels, in addition to their role in signifying specific consonants (in Hebrew: *'alif*, *vav*, *yud'*; in Arabic: *'alif* or *'imaala*, *waaw*, *yaa'*). However, in some cases it is difficult for the reader to determine whether these dual-function letters represent a vowel or a consonant. When vowels do appear (in poetry, children's books, and liturgical texts), they are signified by diacritical marks above, below or within the body of the word. The three Arabic diacritics are: a, i, u. Additional diacritical marking, the *shadda*, is used for lexical differentiation. Most of the grammatical functions at both the morphological and syntactic levels are represented by the short vowels, which also represent mood and case endings in the verb–subject–object literary (*fusha*) syntax. From psycholinguistic view, inclusion of these marks specifies the phonological form of the orthographic string, making it completely transparent in terms of orthography/phonology relations. As the majority of written materials do not include the diacritical marks, a single printed word is often not only ambiguous between different lexical items (this ambiguity is normally solved by semantic and syntactic processes in text comprehension), but also does not specify the phonological form of the letter

string. Thus in their unpointed form, Hebrew and Arabic orthographies contain a limited amount of vowel information and include a large number of homographs. For example, the bare unvocalized *fusha* form SH-R-B-T has five readings and five corresponding semantic interpretations: (a) *sharebtu* "I drank; " (b) *sharebta* "You (singular/masculine) drank;" (c) *sharebti* "You (singular/feminine) drank;" (d) *sharebat* "She drank;" and (e*) shuribat* "It (singular/feminine) was drunk."

Despite the same origin and similarities between Arabic and Hebrew, they differ in their phonology, their phonetics (articulation), and other linguistic structures. First, Arabic has a special case of diglossia that does not exist in Hebrew. The state of affairs in Arabic is rare, since speakers of the language actually use two languages concurrently and intensively as a matter of course and not as an exception. In Arabic, the spoken form, which is *ammia* (local dialect) used by speakers of the language in a specified geographic area for daily verbal communication, is differentiated from the *fusha* (literary form), which is the language all speakers of Arabic from all over the world read and write in. Also, literary Arabic is universally used in the Arab world for formal communication and is known as "written Arabic" or "Modern Standard Arabic" (MSA) and spoken Arabic (SA) appears partly or entirely in colloquial dialect and it is the language of day-to-day communication and has no written form. Hence, from the ecological point of view, SA and MSA could be considered as an instance of 'diglossia', that is, a social environment in which a community uses two forms of the same language concomitantly (Ferguson 1964).

Concerning the written form, in Hebrew there are five letters that change shape when they are word final: (‫מ-ם‬ ,‫ן‬-‫ז,נ‬-‫צ,ך‬-‫פ‬ ,‫ך‬-‫כ‬). In Arabic, 22 of the 28 letters in the alphabet have four shapes each (for example, the phoneme /h/ is represented as: ‫ه‬ ‫ـه‬ ‫ـهـ‬ ‫هـ‬). Thus, the grapheme-phoneme relations are more complex in Arabic, with similar graphemes representing quite different phonemes, and different graphemes representing the same phoneme.

Case report

The patient MM described below is a 54-year-old, right-handed native Arabic speaker who acquired Hebrew at age eight and is considered to be a balanced bilingual Arabic-Hebrew speaker. MM is a retired Israeli army soldier. He used Hebrew in his daily life in his job and in private settings. He (as reported also by his son) declared that his Hebrew competence was high and he consider himself as

balanced bilingual. He served in army until he suffered a brain tumor in 1978 at the age of 26. According to histo-pathological test, he suffered from oligodendroglioma in the fronto-parietal region and lesions were located in the left hemisphere. Oligodendroglioma is a type of glioma and develops from cells called oligodendrocytes. These cells produce the fatty covering of nerve cells. This type of tumor is particularly in the frontal or temporal lobes. A tumor of the frontal lobe of the brain may cause gradual changes in mood and personality. There may also be paralysis on one side of the body (hemiparesis). A tumor in the temporal lobe of the brain may cause problems with coordination and speech, and may affect your memory. In the case of MM, he suffered from full right hemiparesis with language disturbance and he was diagnosed as motor aphasic. MM underwent a left frontal craniotomy at Tel-Hashomer hospital. After surgery, the patient was sent to a rehabilitation period at Bet-Levinstien hospital. He was hospitalized for two months. During this period he developed epileptic symptoms and was treated with anticonvulsion drugs. In addition, because of the motor aphasia, he underwent speech therapy for a long period. Upon admission MM was right-side disabled, but cooperative and oriented to place, situation, and time. Visual fields and auditory abilities were intact. In communicating, his fluency in Hebrew (L2) in speaking, writing, and reading was better than that in his native Arabic (L1). In MM's first general evaluation at a neuropsychological clinic, his performance was under normal limits, he took more time than normal to complete many tasks. It was hard for him to maintain his attention and to resolve verbal (arithmetic) and visual problems (mazes). However, he had no difficulty in visual-spatial tasks or copying shapes. He readily understood and correctly performed both simple and complex commands such as pointing to the parts of his own body, but it was necessary to speak in Hebrew and repeat the more complex commands. MM could read with little difficulty and understood written instructions in Hebrew, but had great difficulty reading written instructions in Arabic. When he was asked to write his name without being told which language to use, he wrote in Hebrew with no mistakes. However, he had serious problems with learning tasks in all types (verbal and nonverbal material). A series of linguistic tasks taken from Western Aphasia Battery (WAB; Kertesz 1982) and the Boston Naming Test (BNT; Kaplan et al 1983) was administered in Arabic and Hebrew by the author to evaluate MM's efficiency of different components of his linguistic processing system including (a) fluency, (b) comprehension, (c) repetition, (d) naming, (e) counting letters and syllables, (f) spelling, (g) category generation, (h)

letter generation, (i) tactile naming, and (j) matching letters, words, shapes, and pictures.

The language status that emerged from these tests was consistent with moderate motor aphasia (Albert et al 1981). Conversation with MM, although it was initially thought to be in his native Arabic, was conducted in a mixed Arabic-Hebrew with the Hebrew as dominant because of major disturbances in his Arabic. The conversation included concrete and abstract topics, but it was nonfluent, anomic in Arabic, and with literal paraphasias.

Results
Repetition naming and comprehension

A dissociation between the performance in the two languages was obtained. In Hebrew, MM exhibited mild disturbances. The speech was grammatically correct but with occasional literal and semantic paraphasias and MM had slight word-finding difficulties without disturbances in auditory comprehension and without difficulties in repetition. In contrast, more disturbances appeared in his native Arabic. As mentioned earlier, MM exhibited nonfluent speech in Arabic with prominent word-finding difficulties, disturbances in auditory comprehension, and with mild difficulties in repetition. In the written language, MM countered more problems in reading and writing in Arabic. In naming, literal and semantic paragraphias were exhibited in Arabic (for example in the literal paraphasia, the word *noor*, "flower" was replaced by *nowara*, which is not a word and in semantic paraphasia in Hebrew for example, the word *mihoga*, "*lead compasses*" was replaced by "*igol*", which means "circle". These patterns are presented in Table 1.

Different patterns emerged in both languages, though they were more severe in Arabic (L1). However, in Arabic, some preserved abilities were observed in single-word reading and some writing to dictation. MM received intensive language therapy in Arabic and in Hebrew for many years following the surgery and showed significant improvement in both languages, more in Hebrew. The improvement in Hebrew was in all linguistic abilities, but a mild improvement was noticed

in his spontaneous speech and auditory comprehension of Arabic, whereas naming ability remained without changes. His reading and writing abilities improved significantly only in Arabic.

MM's most evident initial as well as residual aphasic symptom was a marked difficulty in confrontation naming in both languages. Initially (at least two years after surgery), MM demonstrated an almost typical pattern of severe motor aphasia in both languages (Benson 1979). During continuous treatment, the clinical picture of MM's language disorders changed. With treatment, a significant improvement of auditory comprehension (including single-word comprehension) gradually appeared. Whereas speech fluency, articulation and naming in Hebrew improved, the difficulties in speech fluency and naming impairment in Arabic remained constant. Phonemic priming in both languages was effective and MM's performance improved if he received more than one syllable. These patterns are presented in Table 2.

As mentioned, MM's naming abilities were impaired in all modalities and in all types of naming tasks. However, these deficits were not equivalent in the two languages, where Hebrew was more productive than Arabic.

Visual abilities

To rule out symptoms due to right frontal hemorrhage, tasks assessing visual-spatial and frontal difficulties were conducted. The patient demonstrated good visual ability. These data are presented in Table 3. However, MM demonstrated moderate copying difficulties and construction abilities (clock drawing) and his score was 8/10 (CERAD; Consortium to Establish a Registry for Alzheimer's Disease) consistent with his intact visual perception. The nonverbal abstraction on the Wisconsin Sorting Cards (WCST) was below his age norms (reached on category), he exhibited preservative reactions leading to disorders in reasoning skills.

Table 1 Degree of language impairments on the Western Aphasia Battery

Subtests	Arabic	Hebrew
Fluency	4/10	8/10
Comprehension	8.8/10	9/10
Repetition	8/10	10/10
Naming	5/10	8/10

Table 2 MM's performance on naming tasks in Arabic and Hebrew

Tasks	Arabic	Hebrew
Category generation task*	9	12
Letter generation task (B)**	1	7
Tactile naming***	3/10	6/10

Notes: *MM was asked to name as many members of a specified semantic category as possible in 1 minute. The list of categories included animals and fruits; **MM was asked to name all the words she could that began with letter (sound) B; ***Ability to name through the tactile modality was compared with visual naming, using the same 10-item set of household objects the use of which MM had been able to gesture.

Table 3 The results of the investigation of visual ability

	Results
	10\10
Matching shapes	10\10
Matching letters*	10\10
Matching words*	10\10

Note: *For both languages.

Phonological/phonetic abilities

MM was presented with three auditory tasks following Luria (1970): (a) counting the number of letters in individual words (ie, saying how many letters there are in a spoken word), (b) counting the numbers of syllables in an individual word, and (c) synthesizing words from individually pronounced letters (ie, recognizing a word spelled out aloud). The mouth movements of the examiner were hidden in all of these tests. The results of these tasks appear in Table 4.

Performance here was dependent on word length, with better performance on short words (three to five letters). Both Arabic and Hebrew are languages with deep orthography where there is no one-to-one correspondence between letters and sounds because most Arabic and Hebrew vowels are not instantiated as letters. This is probably reflected in his relatively similar performance in counting syllables in both languages. Also, In many cases, MM counted syllables instead of sounds or letters. Note that his ability to calculate syllables was intact. It was noticed also that MM had no errors in Hebrew phonemes.

Reading and writing

MM's reading aloud in Arabic revealed reading short and simple words using the direct visual strategy. However, in some cases, specially those include complex words, this strategy was not successful and he tried the letter-by-letter strategy. Although, his strategy for reading in Arabic was similar, he exhibited poor performance in this language compared to Hebrew. This is probably due to the fact that, while he learned to read Arabic that appear in the voweled form, in letter-by-letter strategy, he learned Hebrew in both strategies because the unvoweled form is more prevalent

Table 4 The results of auditory tasks of phonological ability

Tasks	Arabic	Hebrew
Counting letters	11/20	18/20
Counting syllables	20/20	20/20
Spelled word recognition	3/10	9/10

in Hebrew (Birnboim 1995). The spontaneous writing in Hebrew was at a better level than Arabic in all types of words (single words and word combinations). In Arabic, writing to dictation was possible only at the level of single words.

Discussion

Cases of bilingual aphasia afford an excellent opportunity to study language processes. The pattern of aphasia following brain injury to a bilingual is very diverse and therefore results obtained should be wearily approached. Previous studies showed that, a brain lesion could selectively disrupt one language but not the other (Ojemann 1983) and bilingual persons could have distinct cortical language areas (Dehaene et al 1997). On the other hand, there are numerous reports of aphasia simultaneously affecting both of a bilingual patients languages following lesions of the left hemisphere suggesting that, both overlapping and distinct brain regions are involved in the representations of multiple languages (Gomez-Tortosa 1995; Fabbro 2001). A further complication to the resolution of this issue comes from the fact that the cortical organization of L2 in relation to L1 seems to depend on various factors such as level of proficiency, age of acquisition and exposure (eg, Kim et al 1997).

This conflicting data can be resolved with case studies selected bilingual aphasic patients indicating dissociation and a double dissociation between L2 and L1. However, researchers must keep in mind that lesions in the brain are often widespread.

In the present paper, I report the performance of MM, an Arabic-Hebrew bilingual man who had suffered a brain tumor and underwent surgery in the left hemisphere, in his L2 (Hebrew) and compared that with his L1 (Arabic). As a result of his brain lesion, MM's cognitive and linguistic abilities were impaired. He exhibited motor aphasia in the both languages, with a significantly more prominent disorder in L1. The primary purpose of this research then was to analyze this dissociation between the two languages in terms of the magnitude and type of the impairment within the framework of existing models. Perhaps the most relevant observation of this study is the fact that MM's performance constitutes a double-dissociation following a recent case report on MH, a native Arabic speaker who suffered a brain damage following hemorrhage that showed more prominent disorder in second language (L2) than in first language (L1) (Ibrahim, submitted). To examine MM's main problems of language processing, the same materials were used in examining the previous case, MH, to overcome methodological problems. Both dissociation (found in MH) and the double-dissociation that MM showed are discussed.

The results of the standard examination showed that MM suffered from a different language impairment in Arabic and Hebrew, with a significantly more prominent disorder in Hebrew. The initial diagnosis was that MM suffering from amnestic aphasia. During the period of the language treatment, MM was administered various tests to investigate further the nature of his impairments in the two languages. At the beginning, his speech was quite unclear with poor diction and grammar in both languages. Moreover, he displayed parallel progress in both languages in consequence of language therapy, though progress in Arabic was greater. The language of speech treatments for MM was both in Arabic (L1) and Hebrew (L2) which in both the clinicians were fully proficient. Note that the Hebrew is the formal language of the institute and the mother tongue for some of the crew members. This clinical picture is of interest because Arabic is structurally not very distant from Hebrew (especially in terms of morphology and syntax). It is important to remind that, although Arabic is the native language, the prior level of language competence in the two languages was almost equivalent. The pattern of the results is complementary to the recent case study of MH (Ibrahim, submitted) that exhibited dissociation between languages.

This finding is compatible also with two neuropsycholgical and psycholinguistic data gained in our lab in previous studies.

1) In this study, MM showed naming difficulties that is due to damage of damage to a lexical retrieval mechanism. However, because not all linguistic components of this difficulties were similar in the two languages, it could not be suggesting that MM had a single retrieval mechanism that accessed both lexicons. Assuming that the spreading activation principle has been widely adopted when characterizing the dynamics of processing between the semantic level and the lexical level, the result could be explained by both the discrete stage models of lexical access (Levelt 1989; Levelt et al 1999), which assume that the activation of phonological properties is restricted to those of the selected lexical node. And by the cascaded models of lexical access (Caramazza 1997; Dell et al 997), which assume that all the lexical nodes activated from the semantic levels have proportional activation to their phonological segments.

This finding is in line with the findings gained in the former case study of MH (Ibrahim, submitted), and both converge with our study on semantic priming effects (Ibrahim and Aharon-Perez 2005) and other reports established in cross-lingual semantic priming and repetition

priming (de Groot and Nas 1991). The investigation of our patient with semantic disorders has indicated that no significant anatomical correlation can be observed. Damage to both left and right hemispheres affect semantic level in both languages at a similar rate, while the lexical level in specific language is usually associated with damage to specific cortical areas (Saffran and Schwartz 1994). These findings indicated a possible relationship between the two L1 and L2 via the semantic level. This formulation fits the hybrid model of lexical representation in the bilingual brain (de Bot 1992; de Groot 1992). According to this model, a common semantic system is connected to two independent lexical systems corresponding to each of the two languages known by the bilingual patient. The ease of access to each lexicon from semantic memory depends on such factors as the age at which the lexical item was acquired and the frequency and recency of access (Snodgrass and Tsivkin 1995). This will create a preference for choosing the native lexical item, particularly in the presence of aphasic disturbances. MM demonstrated such preference for Arabic in all the naming tasks. MM's perception deficits suggest that bilinguals may possess two separate switching mechanisms: a lexical/semantic mechanism. MM provides evidence that Hebrew as a second language has a subsystem that is independent from Arabic and that this subsystem was more fragile, and, therefore, more sensitive to brain damage.

2) In a recent study, Eviatar and Ibrahim (2007) examined the relationship between the morphological structure of a language and the performance asymmetries of native speakers in a lateralized lexical decision task. They presented a study in which native Hebrew and Arabic (which have a nonconcatenative root+wordform structure) were presented with a lateralized lexical decision task in which the morphological structure of both words and nonwords were systematically manipulated. In the first condition stimuli were presented unilaterally. In the second condition, two stimuli were presented bilaterally, and participants were cued to respond to one of them. Lateralization patterns in the two languages revealed both common and language-specific patterns. The results revealed a pattern of similarities and differences in the processing of Hebrew and Arabic. For Arabic speakers, and to a smaller extent for Hebrew speakers, we see opposite effects of morphological complexity for words and for nonwords. We defined complex words in Arabic as those in which the root and word-form structure was transparent, making them more 'unpackable'.

This characteristic resulted in faster responses to these stimuli than to words in which the root structure is not apparent, and this effect was stronger in the LVF. For nonwords, morphological 'unpackability', or transparency resulted in slower response times in the RVF. However, the bilateral effect was significant for both simple and complex words. Recall that Boles (1990) and Iacoboni and Zaidel (1996) interpret this effect as reflecting interhemispheric transfer of information. Two out of the three measures we used support the following model for reading in Arabic: the LH is sensitive to the structure of psuedowords, because we see an effect of morphological complexity only when a legal word-form makes a nonword harder to recognize as such. The RH is sensitive to the root structure of words, as words with transparent roots are identified faster than words without such structure. The data further suggest that this sensitivity in the RH is specific to roots, and does not include sensitivity to word-forms. For Hebrew speakers the patterns are somewhat less clear-cut. The unilateral presentation condition revealed only effects of lexicality, and a morphological complexity effect for words (where, similar to Arabic speakers, complex words with a transparent root structure were recognized faster than simple words with a morphologically opaque structure). Given that none of these effects interacted with visual field of presentation, we were not able to interpret these patterns in terms of hemispheric functioning and suggested that both hemispheres participate in lexical decisions in Hebrew. The whole data revealed somewhat different patterns of hemispheric functioning in a lateralized lexical decision task that were a function of the language of the test.

Conclusions

Given that MM had residual focal left brain damage, evinced more deficits in L1 perception and production than L2, and given the recent case report, where MH provided a dissociation between processing L1 and L2, the data supports the position that distinct brain regions are involved in the representations of multiple languages of a bilingual speaker. This supports the conclusion that a patient with a more prominent L1 impairment usually has a lesion centered on the left hemisphere areas, while a more prominent L2 impairment are observed in patients with damage limited to right hemisphere areas. Also, the cases of MH and MM, both native Arab speakers who acquired Hebrew (both Semitic languages), joins experimental data in

neurolinguistics and shed light on the relationship between language and mechanisms of neurobiology, and offers new psycholinguistic evidence to understand the dynamics of processing two languages in bilingual patients.

Disclosure

The author reports no conflicts of interest in this work.

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