

PSYCHOLINGUISTIC MODELS OF SPEECH PRODUCTION IN BILINGUALISM AND MULTILINGUALISM

Andrea Marini¹ – Franco Fabbro²

Introduction

Bilingualism is a complex psychological and socio-cultural phenomenon encompassing a number of individual and social dimensions (Butler and Hakuta, 2004). It constitutes a widespread phenomenon, as in the world approximately 7000 languages are spoken in just 160 countries. Therefore over 50% of the world population is bi- or even multilingual (Tucker, 1998; Grosjean, 1982, 1994). Moreover, in many countries the number of spoken languages is constantly growing due to massive immigration.

The issue of language representation and use in multilingual speakers and the related problem of multilingual competence can be approached at different levels of description. Indeed, they constitute a matter of interest not only for sociolinguistic models of language use and stratification, but also for psycholinguistic theories of language development and functioning, as well as neurolinguistic models of language representation in the brain.

In this chapter some of the most influential psycholinguistic models of language representation and speech production in multilingual speakers are introduced. The results from psycholinguistic and neurolinguistic investigations will be taken into account in order to discuss the assumptions of such models.

¹ University of Udine, Udine, Italy; IRCSS “E. Medea” “La Nostra Famiglia”, San Vito al Tagliamento (UD), Italy; IRCSS “S. Lucia”, Roma, Italy

² University of Udine, Udine, Italy; IRCSS “E. Medea” “La Nostra Famiglia”, San Vito al Tagliamento (UD), Italy

Models of language representation in monolingual individuals

Psycholinguistics investigates the functional architecture of language and the processes involved in both oral and written language production and comprehension. Language is considered a complex cognitive function involving interaction of a number of different levels of processing: a word level for lexical processing; a sentence level for syntactic processing; a pragmatic level where words or sentences are contextualized and inferences are drawn; a text/discourse level where those sentences that constitute a written text or a spoken discourse are integrated in order to retrieve its general meaning or gist (Marini et al., 2005a, b; Marini and Nocentini, 2003; Caplan, 1992; Kintsch and van Dijk, 1978). Lexical and syntactic processing form the within-sentence or microlinguistic dimension of language responsible for intra-phrasal functions. Lexical processing organizes phonological or graphematical patterns into morphological strings and words, and determines the morphosyntactic context each word requires. All these aspects of lexical knowledge are assumed to be represented in a mental lexicon where phonetic, phonological, morphophonological, morphological, morphosyntactic and semantic information are stored for each word. Syntactic processing organizes the morphosyntactic contexts required by words in phrases and clauses in order to generate well-formed sentences. Pragmatic and discourse processing form the between-sentence or macrolinguistic dimension of language. They are responsible for inter-phrasal functions and utterance contextualization.

Each aspect of language processing is subserved by neurofunctionally distinct systems that can be separately compromised, inhibited or preserved following a brain lesion or after transient inhibition due to electrical stimulation, paroxysmic charge or pharmacological inhibition (e.g. Ojemann, 1991). According to the Declarative/Procedural model (Paradis, 1994; 2004; Ullman, 2001; 2004), language learning and representation are assumed to be subserved by two anatomically and functionally distinct long-term memory systems

(declarative and procedural, respectively). Procedural memory is a type of implicit memory subserved by frontal/basal ganglia circuits as well as portions of the parietal cortex, superior temporal cortex and the cerebellum (Fabbro, 1999; Ullman, 2001). Procedural memory underlies implicit linguistic competence. In the course of first language acquisition, it is involved in the process of learning and consequently executing sensori-motor and cognitive skills such as, for example, those involved in the articulation of the sounds of a language (*i.e.* phones) and in syntax. Declarative (or explicit) memory is subserved by bilateral medial and temporo-parietal structures, including the hippocampal region and the parahippocampal cortex (Fabbro, 1999; Ullman, 2001). It is implicated in conscious learning of facts and events and consists of two subtypes, semantic and episodic memory, respectively. *Semantic memory* is the system storing one’s encyclopedic knowledge of the world (*e.g.* knowledge about the meaning of words, as well as knowledge about historical, geographical, social facts). *Episodic* (or *autobiographical*) *memory* refers to one’s past experiences that can be consciously recalled. It is assumed that grammar (*i.e.* syntactic and morphosyntactic implicit competence) is acquired incidentally through procedural memory, whereas lexical-semantic explicit knowledge is overtly learned and stored in declarative memory (Paradis, 1994; Ullman, 2001; Fabbro, 1999; 2001). For example, procedural memory acquires and applies implicit syntactic rules such as principles of government and binding (Chomsky, 1988; 1995; Pinker, 1999) or procedures of syntactic parsing (Frazier and Fodor, 1978), but it is declarative memory that deals with lexico-semantic aspects of the words that form the sentences. Furthermore, the procedural system “learns” and applies word formation rules to morphemes and lexical items stored in declarative memory. Moreover, once the access to a lexical item is granted, implicit memory procedures automatically generate the argument structure of that particular word and assign the thematic roles to the required arguments (morphosyntactic processing). As to phonetics, the articulatory programs necessary to produce the target phones of a language

become automatized and are transferred to procedural memory, so that the speaker does not have to think about the articulatory movements while speaking.

According to Levelt (1989), the process of speech production is mediated by the central role of the mental lexicon and involves three subsystems: a pre-linguistic conceptual system (conceptualizer); a linguistic system (formulator); an output system (articulator) where production actually takes place. In the conceptualizer the speaker retrieves from long-term declarative memory all available data to formulate a mental model of the intended message. Indeed, declarative memory provides knowledge about what to say (message planning), what has previously been said (linguistic context) and the particular situation, place and time in which the communicative exchange takes place (Marini, 2001; Levinson, 1983; Johnson-Laird, 1980). During the phase of message planning, a supervisory attentional system (SAS: Green, 1998) is in charge of controlling the speakers' communicative intentions. Moreover, such system modulates the amount of information that the speaker intends to communicate and its relevance with respect to what has previously been said (Grice, 1975). This conceptual information is then sent to the formulator where the preverbal message is converted into a speech plan. At this stage, lexical processing matches the intended meaning formulated in the pre-linguistic phase with the corresponding lexical items stored in the mental lexicon. This match is performed through a multi-stage process which entails a phase of lexical selection and one of lexical access. The process of lexical selection, allows speakers to select the lexical items that correspond to the intended meaning (Levelt, 1989; Levelt, Roelofs and Meyer, 1999). How exactly this selection takes place is still debated, but it is likely achieved through an activation/inhibition mechanism (Green, 1986; 1998; Paradis, 1989; 1993). Each word is supposed to have its own specific activation thresholds as a function of its frequency of use and time elapsed since last activation (Luria, 1973; Paradis, 1989; 1993): The lower the threshold level, the easier the access; The higher the threshold level, the more difficult the

access. In Green's theory, the activation of the target word is achieved through the co-occurring inhibition of its semantically-related competitors. Such inhibition would be obtained by raising the competitors' activation thresholds. For example, if the speaker's intention is to speak out the word "banana" (*e.g.* in a picture naming task), the activated concept corresponding to the idea of "banana" enters the lexicon where a selection mechanism is needed in order to select the target word ("banana") among all other semantically related lexical items ("pear", "orange", "apple", etc...). Consequently, the activation threshold of the competitors is raised while the target word ("banana") gets selected. At the end of the lexical selection process, the target word has been activated and the formulator gains access to its semantic, morphosyntactic and morphological features (lemma level of word representation) and then to its phonological form (lexeme level of word representation). In case of single word production (*e.g.* picture naming tasks) the lexical information is then transmitted to the output system where articulatory configurations corresponding to the phonemes to be uttered are programmed and then implemented. In case of sentence production, the process of lexical selection and the access to a word's lemma form the "functional level" of sentence processing, where the morphosyntactic structures requested by the selected lexical item (*i.e.* its argumental structure) guides the process of sentence generation by means of thematic roles assignment and phrase generation (noun phrase [NP], verbal phrase [VP], adjective phrase [AP], prepositional phrase [PP]). At the second level of sentence processing, the "positional level", the information contained in the lemmas of the selected lexical items is used to generate the grammatical relations among the phrases and to build up well-formed syntactic representations (Chomsky, 1988; 1995; Pinker, 1999; Caplan, 1992). It is now possible to access the syllabic and phonologic representations of the lexical items (their lexemes) and this information is sent to the output system where articulatory

configurations corresponding to the phonemes to be uttered are programmed and then implemented.

What is multilingualism?

There is no accepted definition of bilingualism and/or multilingualism among researchers as our intuitive knowledge of “bilingualism” falls short of a precise definition. According to Bloomfield (1933), bilinguals are those people who have a native-like control of two languages. We might therefore extend such interpretation to multilingual speakers, suggesting to consider multilinguals those people who have native-like control of more than two languages. However, such a rigid account of bilingualism and multilingualism introduces to the problem of the definition of quite abstract notions such as “balanced”, “ideal” or even “perfect” bilingualism. Who is a perfect bilingual or multilingual? It is no doubt hard to find completely balanced or “perfect” bilinguals. When we turn to consider multilinguals, the issue becomes even more complex because we should be obliged to exclude from the count of multilingual speakers all those people who know three or more languages but simply not as much as they know their mother tongue (L1). Such a view of bilingualism (and consequently multilingualism) has been fiercely challenged by a number of studies. Rather, the focus has been shifted toward the degree of proficiency in two or more languages within the same individual. According to Weinreich (1953), a bilingual is a person who can use alternatively two languages to communicate, whereas Haugen (1953) introduced the notion of bilingualism as the simple ability to produce well-formed meaningful utterances in a second language (L2). According to Grosjean (1989; 1994; 1995; 1999), bilinguals are those people who use two or more languages in their every-day lives. However, not all multilingual speakers use their two languages all the time. Therefore an additional distinction must be introduced between multilinguals who use their languages daily and dormant multilinguals who know more than

one language but use only one of them in their ordinary communicative interactions. Furthermore, Grosjean (1989) points out that bilinguals must not be considered as the sum of two complete or incomplete monolinguals, because the interaction of two or more linguistic competences in the same person produces a different but complete linguistic entity. It is an integrated whole with its own characteristics that cannot be simply reduced to the sum of the parts. Indeed, multilingual individuals can acquire their languages at different times and in different ways. Furthermore, they can use them with different people in different situations. Therefore, bilinguals find themselves at various points of "a situational continuum which induce a particular speech mode. At one end of this continuum, bilinguals are in a totally monolingual speech mode ... At the other end of the continuum, they are with bilinguals who share their two languages ... and with whom they normally mix languages (code-switch and borrow): they are here in a bilingual speech mode ... we should keep in mind that intermediary modes exist between the two" (Grosjean, 1989, 8).

Results from neuropsychological and neuroimaging investigations suggest that also at the neuroanatomical level the languages spoken by multilingual individuals have a complex neurofunctional organization (Fabbro, 2001). For example, several studies on bilingual or polyglot aphasic patients provide indirect arguments in favour of the hypothesis that in multilingual speakers the different languages are represented in distinct brain regions. Indeed, in some cases polyglot patients lose only one of the languages mastered before the insult (Albert and Obler, 1978; Paradis, 1995) and the different languages can be recovered at different degrees (Paradis, 1978). Neurosurgical studies provide further evidence for distributed cortical organization of the languages in multilingual speakers (Gomez-Tortosa et al., 1995). However, electrical stimulation and neuroimaging studies suggest that the cortical representation of the different languages in multilingual speakers may be complicated by several factors. For example, Ojemann and Whitaker (1978) and Rapport, Tan and Whitaker

(1983) report the case of bilingual and polyglot epileptic patients who underwent language assessment while receiving cortico-electrical stimulation before neurosurgery. Interestingly, the authors detected centers *common* to all languages known by the patients along with centers showing *differential* inhibition effects. Furthermore, the L2 tended to have a more diffuse representation in the left hemisphere as opposed to the mother tongue. More recently, several studies have shown that the cortical representation of languages in multilingual speakers varies in function of two major factors: age of L2 acquisition and proficiency in the second language (*e.g.* Perani et al., 1998; Perani et al., 1996; Dehaene et al., 1997, Kim et al., 1997) (see below). Overall, results from neuroimaging investigations support the hypothesis that bilinguals are not simply two monolinguals in one person suggesting that even the multilingual brain is not the sum of two or more monolingual language systems “but is rather a unique and complex neural system which may differ in individual cases” (Abutalebi, Cappa and Perani, 2001, 188).

In what follows, a pragmatic definition of multilingualism will be privileged. Namely, multilingualism (or multilingual competence) will be intended as the command and use of two or more linguistic systems, whatever the level of proficiency and the age of acquisition of those languages. Bilingualism (or bilingual competence) will be considered a type of multilingualism, that is the command and use of two linguistic systems whatever the level of proficiency and the age of acquisition of both languages.

Factors affecting the acquisition of languages in multilingual speakers

Several classifications have been proposed to distinguish among different types of bilingualism (Butler and Hakuta, 2004; Edwards, 2004). When the focus is on the proficiency in the two languages, a distinction has been introduced between balanced and dominant bilinguals (Peal and Lambert, 1962): a *balanced bilingual* masters the two languages to the

same extent, whereas a *dominant bilingual* is more fluent in one language than in the other. As to when a second language has been acquired, it has been proposed to distinguish between early and late bilingualism: the expression *early bilingualism* refers to the early acquisition (in infancy) of both languages, whereas *late bilingualism* designates that the L2 has been acquired much later than the mother tongue. As to the effect that a second language exerts on the mother tongue, Lambert (1974) proposed to distinguish between additive and subtractive bilingualism, where *additive bilinguals* are those who improve their L2 without losing L1 proficiency, and *subtractive bilinguals* those who lower the proficiency in their L1 while achieving a second language.

Some of these distinctions have proved empirically useful to distinguish among groups of bilingual participants for psycholinguistic and neurolinguistic experiments (Hamers and Blanc, 1990; Vaid, 1986). Indeed, several investigations have demonstrated that factors such as context and modalities of L2 acquisition (*e.g.* acquiring a second language in a Country where that language is currently spoken by means of its continuous use in real-life contexts, rather than learning it at school by means of conscious and effortful assimilation of rules and words) or the age when it has been learnt are particularly critical to determine good levels of proficiency in that language (Neville, Mills and Lawson, 1992; Neville, Coffey, Lawson, et al., 1997; Weber-Fox and Neville, 1996; Kim et al., 1997; for a review see Fabbro, 2001). One of the challenges for second language learners is the difficulty (in most cases impossibility) to acquire a native-like pronunciation of the L2. As to this respect, second language learners are faced with three main problems: an articulatory problem, consisting in the difficulty to acquire the correct articulatory configurations that allow them to produce the target phones; a word-level prosody problem, that is the production of words with correct intonation; a sentence-level prosody problem, consisting in the difficulty to learn how to correctly produce the intonation pattern of sentences during a conversation. Results from a

number of investigations suggest that only those children who have been adequately exposed to the second language before the age of 8 will acquire native-like control of articulatory and prosodic aspects of speech production in L2 (Fabbro, 2004). For example, two groups of children who migrated to the USA and to The Netherlands when they were younger than 8 are reported to have acquired native-like phonetic/phonological competence in English and Dutch, respectively (Asher and Garcia, 1969; Snow, 1987; Flege and Fletcher, 1992). Interestingly, the accuracy in L2 pronunciation gets gradually lower for those people who moved to other Countries when they were older than 8 and lower than 21 years of age and remains low for those who have migrated after the age of 22. Therefore, it is possible to postulate three critical periods for the acquisition of native-like pronunciation in a second language: 1) Multilingual speakers acquiring two or more languages between 1 and 8 years of age will have a native-like pronunciation in all those languages; 2) Multilingual speakers learning a second, a third (or even more) languages between 9 and 21 years of age will develop a relatively good pronunciation in all of them; 3) Multilingual speakers learning two or more languages after the age of 22 will probably have a marked foreign accent. The existence of a "critical period" for language learning has been reported also for what regards grammatical development. For example, results from a series of experiments, where bilingual participants were tested with L2 grammaticality judgment tasks, showed a significant reduction in accuracy for those who had learnt the second language after the age of 8 (Johnson and Newport, 1989; Long, 1990). Further evidence for age-related effects on bilingual acquisition comes from electrophysiological studies where the cortical organization of the mother tongue and a second language was assessed using event-related potentials (ERPs) in a group of early bilingual participants compared to a group of late bilingual volunteers who had acquired the L2 after 7 years of age (Neville et al., 1992; 1997; Weber-Fox and Neville, 1996). In the early bilingual group the authors found that for both languages

closed-class words were represented in the left frontal lobe, whereas open-class words usually involved post-rolandic cortical structures. Conversely, in late bilinguals L2 closed-class words were represented together with open-class words in post-rolandic areas and not in left frontal areas. Moreover, in an fMRI study, Kim et al. (1997) compared twelve proficient bilingual participants with diverse first and second languages in covert production tasks. The volunteers were divided in two groups: an early acquisition group, formed by six participants who had been exposed to both L1 and L2 during early infancy, and a late acquisition group, formed by six subjects who had learnt the second language after puberty. In the early bilingual group the authors found similar activation of Broca's and Wernicke's areas for both languages. In the late bilingual group, L1 and L2 shared similar activations of Wernicke's area but different activations (separated by approximately 8 mms) within Broca's area. These results suggested that the age of acquisition is a major factor affecting the cortical organization of a second language. It is noteworthy, however, that the authors did not specify in detail the levels of L2 proficiency for the participants involved in the experiment. This is a significant omission because the differences registered in Broca's activation in the late acquisition group may reflect differences at the morphosyntactic (functional and/or positional) and phonetic (articulatory) levels of sentence processing (see also Abutalebi et al., 2001; Fabbro, 2001). In a subsequent fMRI study, Chee, Tan and Thiel (1999) investigated the cerebral activation in two groups of Chinese (Mandarin) – English highly proficient bilinguals during word-stem completion tasks. The first group included fifteen participants who learned English before the age of 6 (early bilingual group). The second group included nine bilinguals who learned English after age 12 (late bilingual group). In this experiment, the authors found no group-related difference in the activation of frontal areas (left prefrontal region including the inferior frontal gyrus, left supplementary motor area and bilateral occipital and parietal regions). The divergent results obtained by Kim et al. (1997) and Chee et al. (1999) may depend not on the

age of L2 acquisition (early vs. late acquisition), but on the levels of proficiency in the two languages and on the time spent speaking them. Therefore, the differential activation of left frontal areas reported by Kim et al. (1997) may reflect different levels of L2 proficiency between the two groups rather than the age of L2 acquisition. A possible solution to this problem can be found in the results of a recent fMRI experiment where three groups of Italian-German bilingual participants were compared in a series of grammatical and semantic judgment tasks (Wartenburger et al., 2003). The first group (Early Acquisition High Proficiency group [EAHP]) was formed by 11 bilingual participants who learned the two languages together since birth and showed high proficiency in both of them. The second group (Late Acquisition High Proficiency group [LAHP]) included 12 bilingual participants who learned German (L2) before 6 years of age but with high proficiency in both languages. The third group (Late Acquisition Low Proficiency group [LALP]) consisted of 9 bilingual volunteers who learned German (L2) after the age of 6 and had were low proficient in that language. The EAHP and LAHP groups had a perfect phonetic and morphosyntactic competence in the L2, whereas the participants included in the LALP group made a number of morphosyntactic errors coupled with a strong foreign accent. On the grammatical judgement task, the LAHP group showed greater activation in language-related areas than the EAHP group. At the same time, with respect to the LALP group, greater activation was found in the left temporo-parietal junction, the right lingual gyrus and right inferior parietal lobule in the LAHP group. These results suggest that age of acquisition and, to a lesser degree, proficiency level affect the cortical representation of grammatical processes in L2.

Models of language representation in bilingual and multilingual individuals

The first systematic investigations of bilingualism began approximately 100 years ago as diary studies by researchers reporting on the linguistic development of their own children.

Ronjat (1913) described the linguistic development of his son in a bilingual German-French environment. Leopold (1939; 1949) provided a detailed report of his daughter Hildegard’s simultaneous acquisition of English and German. These studies represent a rich source of observations. However, the analyses of bilingual language development performed by the authors lacked of a systematic linguistic approach and were based on subjective impressions rather than rigorous scientific methodology.

One of the first attempts to formulate a model of lexical representation in bilinguals is the “compound-coordinate model” of bilingualism initially proposed by Weinreich (1953) and then revised by Ervin and Osgood (1954). In its original configuration, this model assumes that in bilingual individuals the phonological (“signifier”) and semantic (“signified”) aspects of the words in the two languages are represented in three possible configurations: coordinate, compound and subordinate, respectively. In a coordinate system the phonological representation of translation equivalents (*i.e.* words of different languages sharing the same meaning) matches two different meaning representations. In such a system, the bilingual individual would have two separate conceptual representations and two separate word forms for the Italian word “casa” and the corresponding English word “house” (fig. 1). In a compound representation, the two phonological forms are identified with a common meaning representation. Therefore, the two word forms “casa” and “house” are represented in the same conceptual system (fig. 2). A subordinate system is a word association model where the meaning representation of an L2 word (*e.g.* “house”) is accessed through the meaning representation of the word of the mother tongue (*e.g.* “casa”) (fig. 3).

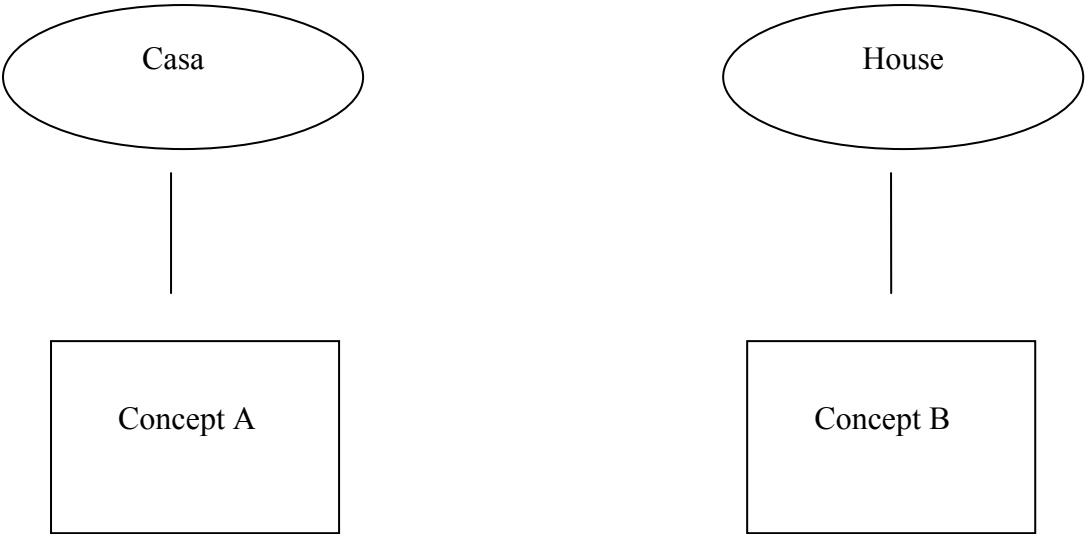


Figure 1. Representation of a coordinate system (adapted from Woutersen, Cox, Weltens, and De Bot, 1994).

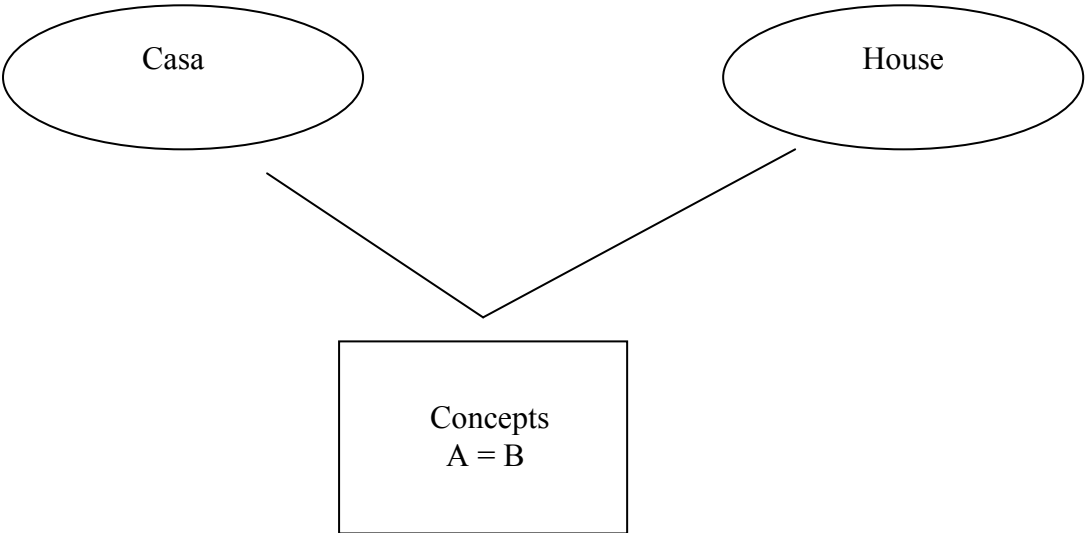


Fig. 2. Representation of a compound system (adapted from Woutersen, Cox, Weltens, and De Bot, 1994).

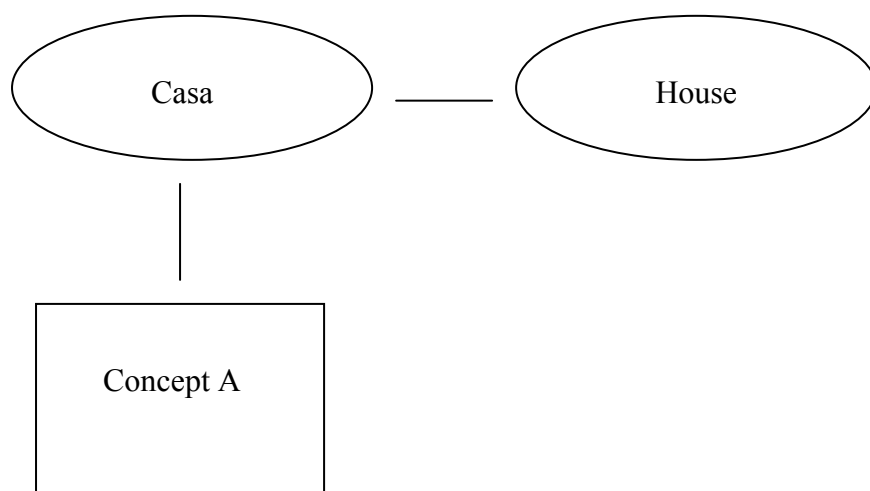


Fig. 3. Representation of a subordinate system (adapted from Woutersen, Cox, Weltens, and De Bot, 1994).

Erving and Osgood (1954) suggested that coordinate or compound representation of two languages depends on the modalities of L2 acquisition. An individual learning two languages in separate cultural environments will develop a coordinate representation. This is for example the case of an English child who learns English as his mother tongue in an English-speaking Country and then Italian as L2 in an Italian-speaking environment. In contrast, a child learning two languages together in the same context will develop a compound structure. An individual learning a second language after a certain age in formal contexts will develop a subordinate representation. While speaking, subordinate bilinguals formulate what they want to say in their L1 and then translate it into L2. Therefore, in a subordinate representation the meanings of the L2 words are accessed only through a translation process.

The coordinate-compound model introduced important theoretical issues on the debate about language representation in bilingual individuals such as the hypothesis of a distinction between conceptual and lexical representation of words, and the problem of language storage in bilingual speakers.

As to the first problem, results from psycholinguistic and neurolinguistic studies support the hypothesis that the two languages of a bilingual individual access a common semantic system (*e.g.* Illes et al., 1999; Costa, Miozzo and Caramazza, 1999; Hermans, Bongaerts, de Bot and Schreuder, 1998; Potter, So, von Eckardt, and Feldman, 1984). For example, in an fMRI study aimed at investigating the brain activation patterns during semantic judgement tasks (concrete/abstract judgements) in a group of 8 late Spanish-English bilingual speakers who had learned their L2 after the age of 10, Illes et al. (1999) identified a shared frontal lobe system for semantic processing for both languages (left inferior frontal gyrus; in six of the participants the activation included also the right inferior frontal gyrus).

As to the problem of whether lexical knowledge of bilinguals’ two languages is merged into one large lexical system or is kept separate in two distinct lexicons (*i.e.* a lexicon for L1 and a lexicon for L2), there is much less agreement, as two opposite hypotheses have been put forward and are currently debated (Grosjean, 1995): a two-lexicons view opposed to a one-lexicon view. Proponents of the two-lexicons hypothesis (Potter et al., 1984; De Groot, 1993; Kroll and Stewart, 1994) claim that the lexical representations in bilingual speakers are stored in two different lexicons and that information acquired in one language is available in the other only through a translation process. In contrast, according to the one-lexicon view (*e.g.* De Bot and Schreuder, 1993; De Bot, 1992; Paradis, 1987), the two languages of a bilingual speaker are stored in different subsystems of the same lexicon which can be activated to different extents, depending on which language is currently being used.

Within the theoretical framework of the two-lexicons view, the coordinated-compound model proposed by Weinreich has been extended and reformulated. Such models are usually defined “hierarchical” as they postulate that a word’s conceptual representation (its “meaning” in the broadest sense) is separated from its lexical representation and that the words of the two languages of a bilingual individual are stored in two separate lexicons, one

for the words of the L1, the other for those of the L2. Potter et al. (1984) proposed a Word Association Model and a Concept Mediation Model based on Weinreich's subordinate system and compound system, respectively. According to the Word Association Model, L2 words do not have a direct access to the corresponding concepts but must first be translated in the corresponding L1 lexical representations that, in turn, have direct access to the conceptual system. This model is assumed to represent the organization of the two languages in non-fluent low proficient bilinguals such as for example second language learners in the early stages of L2 acquisition. In the Concept Mediation Model the lexical items of both lexicons (L1 and L2) are supposed to have direct access to the conceptual system by means of direct conceptual-lexical links. This system is hypothesized to reflect the competence of bilinguals who have reached high levels of proficiency in their L2. Taken together, the Word Association Model and the Concept Association Model entail a developmental hypothesis of language representation in bilinguals, as the shift from lexical to conceptual mapping is assumed to reflect growing levels of proficiency in the L2. Such hypothesis has been tested in a number of studies (see Kroll and de Groot [1997] for an extensive review on this issue). For example, Chen and Leung (1989) and Kroll and Curley, (1988) compared the reaction times (RTs) of more and less fluent bilinguals in a picture naming task and a word translation task. Under the assumption that picture naming is achieved through concept mediation, it was hypothesized that similar RTs in both tasks would imply the recourse to a concept mediation strategy, whereas shorter RTs at the word translation task would imply the recourse to a lexical translation strategy. Indeed, less proficient bilingual individuals at earlier stages of L2 acquisition were faster in the word translation task than in the picture naming task (use of the lexical translation strategy), whereas in the more proficient bilinguals the RTs were comparable across the two tasks (recourse to the concept mediation strategy). Therefore, experimental results seem to support the proficiency-related shift from a Word Association to

a Concept Association representation of the bilinguals' two languages. However, neither of the two models could account for the translation asymmetry effect (Kroll and Dussas, 2004; Kroll and Sholl, 1992) reported in both early and advanced bilinguals in a number of empirical observations, that is the fact that bilinguals usually translate faster and more accurately in the L2 to L1 rather than in the L1 to L2 direction. In order to explain the translation asymmetry effect, Kroll and Stewart (1994) proposed a Revised Hierarchical Model where both the Word Association and the Concept Association Model were incorporated (fig. 4).

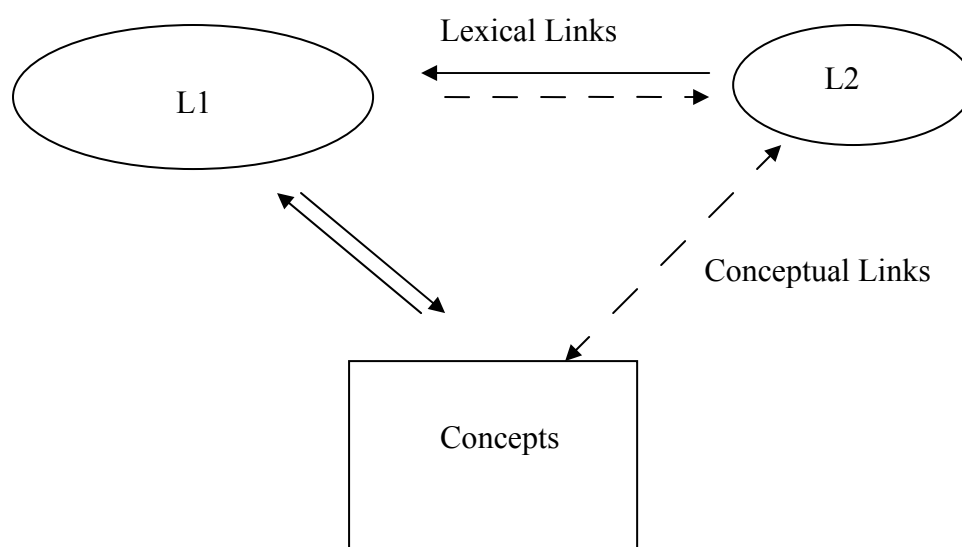


Fig. 4. The Revised Hierarchical Model (adapted from Kroll and Stewart, 1994).

The Revised Hierarchical Model maintains the idea of independent lexical representations for the two languages known by the bilingual and of a shared conceptual system for both languages. However, it also introduces some important innovations to the previously presented models. We will briefly consider some of the main assumptions of the model. It is assumed that the extension of the lexicon of the L1 is larger than that of the L2, as even

highly proficient bilinguals usually know more words in the native language than in their subsequently learned languages. In order to account for the translation asymmetry effect, the connections between the two languages (L1 and L2) and the concept-system are supposed to be asymmetrical and to reflect the modalities of L2 acquisition. It is postulated that translating from L2 to L1 entails a direct access to the L1 lexical form, whereas translating from L1 to L2 is supposed to activate not only the corresponding translation equivalent in L2, but also the conceptual representation of the L1 word thus engaging a semantic route as well. The forward translation direction (from L1 to L2) is assumed to be particularly challenging for less proficient bilinguals, because in these individuals the link between the second language and the conceptual store is still weak. Indeed, experiments on translation generally support these predictions (e.g. Kroll, Michael, Tokovicz, and Dufour, 2002).

Even if appealing, the two-lexicons view has been challenged by a number of neurophysiologic and neuroimaging studies that, at least at the macroscopical level, evidenced a similar cerebral representation for L1 and L2 lexicons in both early and late bilinguals (Klein et al., 1999; Chee et al., 1999; Illes et al., 1999; Hernandez et al., 2000). For example, in a Positron Emission Tomography (PET) study Klein et al. (1999) found that Chinese (L1) – English (L2) bilinguals showed similar cerebral activation patterns for both languages when involved in verb generation tasks (left inferior frontal, dorso-lateral frontal cortex, temporo-parietal cortices, and right cerebellum). Furthermore, results from the afore mentioned study by Chee, Than and Thiel (1999) provide additional evidence in favour of the hypothesis that the cortical representation of words even in typologically different languages such as English and Mandarin may involve the same cortical areas. Overall, as it will be shown in the next paragraph, results from both experimental and clinical studies suggest that age and modalities of acquisition, as well as language use probably affect the neuroanatomical and functional organization of the lexicon.

The functional architecture of the bilingual speech production system

Several hypotheses have been put forward to account for the functional architecture of the bilingual speech production system. In most cases these are the reformulation of models originally proposed for monolingual speakers. Indeed, psycholinguistic theorizing has usually held monolingualism as the canonical form of language use (Vaid, 2002), implicitly assuming that monolingual acquisition and processing are the norm. Such monolingual prejudice has proved to be misleading in cognitive research on multilingualism and has conditioned the modelling of bilingual and multilingual competence. In fact, quite no one can be considered purely monolingual as even monolingual children usually grow up in a social environment where more than one variety of the same language is spoken (e.g. the so-called “dialects”). Therefore, they learn to use a certain variety of the language they are exposed to in specific linguistic and/or extra-linguistic contexts, and other varieties in different contexts. In other words, even those children who are generally regarded as monolingual will develop a multilingual competence, based on lexical, grammatical and pragmatic/discursive knowledge relative to each of the varieties of the language to which they are exposed. Let’s consider the case of a Canadian born in Quebec. He may acquire Quebecois as his mother tongue (L1) and use it in familiar contexts, standard French as a second language (L2) used as language of education and in formal contexts, and eventually English as a third language (L3), used not in daily/life interactions but, for example, to write scientific articles or to give lectures at international congresses.

The issue of language production in polyglots raises several problems. A major question concerns the functional architecture of the multilingual lexicon, that is how words are represented, selected and accessed in multilingual speakers. One of the most influential models of language production is the “bilingual production model” (de Bot, 1992; de Bot and Schreuder, 1993), based on Levelt’s “speaking model” (1989). In what follows we will

attempt to integrate the model proposed by de Bot (1992) with data from recent psycholinguistic, neurophysiologic and neuroimaging investigations.

De Bot’s bilingual production model hypothesizes the existence of three subsystems for language production (a conceptualizer, a formulator and an articulator, respectively), a subsystem for comprehension (speech-comprehension system), and a lexicon involved in both production and comprehension.

In multilingual speakers, the conceptualizer is assumed to be language independent. It elaborates the conversational conventions and the contextual information in order to signal “which language to choose”. It is at the level of the formulator that the language to be used in the interaction will be chosen. The formulator is considered a procedural system working on a system of declarative knowledge: the lexicon. Adopting Paradis’ (1987) subset hypothesis, De Bot (1992) proposed that L1 and L2 words form different subsets within one and the same lexicon. Experimental and clinical studies suggest that age and modalities of acquisition, as well as language use probably affect the organization of both formulator and lexicon. In multilingual individuals who have acquired two or more languages from birth, the formulator is probably represented in common cortico-subcortical cerebral structures. In this case the different languages would be maintained separate merely by neurofunctional mechanisms. When a second language is learned after the age of 8, however, the neurofunctional systems accounting for grammar and phonology are most likely to be separate also at the neuroanatomical level (Fabbro, 1996; Kim, Relkin, Lee and Hirsch, 1997). Furthermore, in fluent bilinguals the lexicon is probably represented in common neural structures (parieto-temporal areas) and the neurofunctional separation between languages might depend on word use relationships.

In the formulator the preverbal message is converted into a speech plan by means of two processes: lexical selection and lexical access, respectively. When considering multilingual

competence, it becomes important to explain how a multilingual speaker selects the correct lexical node in the target language preventing cross-language interference. As to this respect, two major hypotheses have been proposed. The first states that the intended meaning in the preverbal message selectively activates the lexical items only of the selected language and not those of the other language(s) (Soares and Grosjean, 1984; Macnamara and Kushnir, 1971). Such view has been generally abandoned in favour of an alternative hypothesis claiming that the intended meaning activates the subsets of words belonging to the languages mastered by the speaker and that the target word is selected by creating an imbalance in their activation levels (De Bot, 1992; Green, 1986, 1998). It is postulated that each subset has its own specific activation thresholds³ (Luria, 1973; Green, 1986, 1998; Paradis, 1989; 1993) and can be selected by means of activation and inhibition processes⁴ (Inhibitory Control Model, Green, 1998). Inhibition is generally automatic and avoids interferences among the languages that form the multilingual competence. The selection of the target lexical node is obtained by creating a differential level of activation in the two or more lexicons of the multilingual speaker by means of both activation of the target words and reactive inhibition of its competitors. In other terms, the selection of a word in one language automatically triggers an

³ A cerebral lesion can lower the activation threshold of a language, which is thus not lost, but simply inaccessible through the usual activation threshold. Generally, such activation threshold is lower for comprehension than for expression. For this reason, there are cases of bilingual aphasic patients with preserved comprehension of a language associated to impaired production in it (Paradis, 1996).

⁴ It is likely that inhibitory relations among languages are organized differently in simultaneous interpreters in which both languages are concurrently activated for many hours a day. In this particular profession, the activation thresholds of the two languages are thus quantitatively different as opposed to those of the other polyglots.

inhibition process of the competitors in the other language(s). Consider the case of a trilingual individual who knows Italian (L1), English (L2) and Dutch (L3). In this case, the activation of the word 'bike' (L2) will inhibit the corresponding lexical items in L1 (*i.e.* Italian "bicicletta") and L3 (*i.e.* Dutch "fiets") as well as semantically and phonologically similar words in the three languages. The multilingual speaker's languages can receive three states of activation (Green, 1986). They can be selected, active or dormant depending on the communicative situation. A language is selected when it has been chosen for the interaction. The selected language controls the speech output. A language is active when it has not been chosen as the main code for the communicative exchange but is kept active during the whole interaction. It works in parallel to the selected language but has no direct access to the outgoing speech processing. A dormant language does not receive any activation and consequently does not play a role in ongoing processing. In the multilingual competence, one language is always selected while the other(s) language(s) can be either active or dormant. In this framework it is possible to explain the code-switching phenomenon. Language switching occurs quite commonly for instance in bilingual communities where both languages have the same social status (see Grosjean, 1998). The habit of bilingual individuals to alternate between languages within one coherent discourse may determine low thresholds of activation of switching phenomena and a reduction in both languages' mutual inhibition. In such bilingual communities, it is quite normal for individuals to switch from one language to the other while speaking informally. In other communities, however, such behavior is intentionally avoided for sociolinguistic reasons. For example, in Brussels, where both French and Flemish are official languages, a public official or a bank employee would never switch between the two languages and would stick to his/her interlocutor's language, even though most natives understand and speak both languages. In Belgium each linguistic community has a strong identity which is fiercely defended also through language use. This switching mechanism is

not peculiar only to polyglot speakers, but also to monolingual individuals who use it to select among different linguistic registers according to the communicative context. For example, an individual may ask his/her interlocutor to close the door by using a courtesy form ("Will you please close the door?") or a direct form ("Close the door"). In Paradis' (1993) opinion, the system accounting for the selection of one of the two registers is similar to that accounting for the selection of one language rather than another. Many neurologists and neurolinguists have discussed the possible neurological organization of the switch mechanisms. Some of them, generally defined as *localizationists*, claim that the activation of a specific language (for example L1) and the concurrent inhibition of the other languages (*e.g.* L2, L3, and the like) is subserved by specific brain areas. For example, Leischner (1943) claimed that this center is localized in the left supramarginal gyrus, whereas, according to Stengel and Zelmanovicz (1933) and Zatorre (1989), it is localized in anterior structures of the left hemisphere. In Lebrun's opinion (1971), the switching mechanism is localized in the right hemisphere. Other authors have criticized the idea of an anatomical center governing language switching. Goldstein (1948), for example, suggested that any cerebral lesion impairs switching between mental processes, and that the faculty of switching is only an example of the more general faculty of abstraction. Paradis (1993) claims that switching mechanisms are only one aspect of a more general system involved in decision-taking processes. In Paradis' opinion, the switch function is part of a general system responsible for the selection of behaviors such as standing up or sitting down, speaking Italian or English, etc. Recent evidence suggests that the language switching mechanism involves the dorsolateral prefrontal cortex (Fabbro, Skrap, & Aglioti, 2000; Hernandez, Dapretto, Mazziotta, & Bookheimer, 2001; Holtzeimer, Fawatz, Wilson, & Avery, 2005). Indeed, Fabbro et al. (2000) report the case of a bilingual patient with a lesion to the left anterior cingulate and to the frontal lobe (marginally involving also

the right anterior cingulate area). After that lesion, the patient presented pathological switching between languages in the absence of any other linguistic impairment.

Once the target lexical node has been selected, the formulator gains access to its semantic, morphosyntactic and morphological features (lemma level) and then to its phonological form (lexeme level). In case of single word production the lexical information is directly transmitted to the articulator. In case of sentence production, however, the information stored in the lemma level of word representation is used to generate the argumental structure and hence the syntactic organization of the sentence. At this point, the articulator converts the speech plan into actual speech. During speech production in bilinguals both selected and active languages are simultaneously activated at all levels with the exception of the articulatory subsystem, which remains inactive for the non-selected language (de Bot, 1992). The articulator transforms the strings of syllables of the selected language in articulatory patterns. It is assumed that syllable articulatory programs are automatized and that the level of automatism correlates with the level of proficiency which, in turn, is a function of age of L2 acquisition. In other words, a multilingual speaker can pronounce as a native speaker words and sentences in two or more languages only if he/she has correctly automatized the syllable articulatory programs before the age of 8. Advanced bilinguals, usually early bilinguals, may have only one large articulatory system containing all syllable articulatory programs for all the languages they master, whereas less proficient bilinguals, usually late bilinguals, may have independent stores for each language (*e.g.* Flege and Fletcher, 1992).

References

- Abutalebi J, Cappa SF & Perani D (2001). The bilingual brain as revealed by functional neuroimaging. *Bilingualism Lang. Cogn.*, 4: 179-190
- Albert, M.L., & Obler, L.K. (1978). *The bilingual brain*. New York: Academic Press.
- Asher J, & Garcia R (1969). The optimal age to learn a foreign language. *Modern Language Journal*, 28: 334-341
- Bloomfield L (1933). *Language*. New York: Holt, Rinehart & Winston
- Butler YG & Hakuta K (2004). Bilingualism and Second Language Acquisition. In T K Bhatia and W C Ritchie (eds.) *The Handbook of Bilingualism*. (pp. 114-144). Blackwell Publishing. Malden , MA
- Caplan D (1992). *Language. Structure, processing and disorders*. Cambridge, Massachusetts: MIT Press
- Chee, M. W. L., Tan, E. W. L., & Thiel, T. (1999). Mandarin and English single word processing studied with functional magnetic resonance imaging. *The Journal of Neuroscience*, **19**, 3050–3056.
- Chen H-C. & Leung Y.S. (1989). Patterns of lexical processing in a nonnative language. *J. Exp. Psychol. Learn. Mem. Cogn.*, 15, 316-325.
- Chomsky N (1988). *Language and problems of knowledge: the Managua Lectures*, MIT Press, Cambridge, Massachusetts
- Chomsky, N. (1995). *The minimalist program*. Cambridge, MA: MIT Press.
- Costa, A., Miozzo, M., & Caramazza, A. (1999). Lexical selection in bilinguals: Do words in the bilingual's two lexicons compete for selection? *Journal of Memory and Language*, 41, 365–397.

- Costa A, & Caramazza A (1999). Is lexical selection in bilingual speech production language-specific? Further evidence from Spanish–English and English–Spanish bilinguals. *Bilingualism: Language and Cognition*, 2, 231–244.
- Costa A, & Santesteban M (2004a). Bilingual word perception and production: Two sides of the same coin? *Trends in Cognitive Sciences*, 8(6), 253.
- Costa A, & Santesteban M (2004b). Lexical access in bilingual speech production: Evidence from language switching in highly proficient bilinguals and L2 learners. *Journal of Memory and Language*, 50, 491–511.
- de Bot K (1992). A bilingual production model: Levelt's speaking model adapted. *Applied Linguistics*, 13, 1–24.
- de Bot, K., & Schreuder, R. (1993). Word production and the bilingual lexicon. In R. Schreuder & B. Weltens (eds.), *The bilingual lexicon* (pp. 191-214). Amsterdam: John Benjamins.
- de Groot A.M.B. (1993). Word-type effects in bilingual processing tasks: Support for a mixed-representational system. In R. Schreuder and B. Weltens (eds.) *The bilingual lexicon* (pp. 27-51). Amsterdam: John Benjamins
- Dehaene, S., Dupoux, E., Mehler, J., Cohen, L., Paulesu, E., Perani, D., van de Moortele, P.F., Lehericy, S., & Le Bihan, D. (1997). Anatomical variability in the cortical representation of first and second language. *Neuroreport*, 8(17):3809-15
- Edwards, J.V. (2004). Foundations of bilingualism. In T.K.Bhatia & W.C. Ritchie (eds.), *The handbook of bilingualism* (pp. 7-31). Blackwell Publishing. Malden, MA
- Erwin, S., & Osgood, C. (1954). Second language learning and bilingualism. *Journal of abnormal and social psychology. Supplement*. 49, 139-146
- Fabbro, F. (1996). Neurofunctional aspects of bilingual aphasia. *Journal of the Israeli Speech Hearing and Language Association*, 19: 13-15.

- Fabbro F (1999). *The neurolinguistics of bilingualism: An introduction*. Hove, UK: Psychology Press.
- Fabbro F (2001). The bilingual brain, cerebral representation of languages. *Brain and Language*, 79, 211–222.
- Fabbro F (2004). *Neuropedagogia delle lingue*. Astrolabio, Roma, Italy
- Fabbro F, Skrap M, & Aglioti S (2000). Pathological switching between languages after frontal lesions in a bilingual patient. *Journal of Neurology, Neurosurgery, and Psychiatry*, 68, 650–652.
- Flege, J.E. & Fletcher, K.L. (1992). Talker and listener effects on degree of perceived foreign accent. *Journal of the Acoustical Society of America*, 91: 370-389.
- Frazier L, & Fodor JD (1978). The sausage machine: a new two-stage parsing model. *Cognition*, 6, 291–325.
- Goldstein, K. (1948). Disturbances of language in polyglot individuals with aphasia. In *Language and language disturbances* (pp. 138-146). New York: Grune and Stratton.
- Green DW (1986). Control, activation and resource. *Brain and Language*, 27, 210–223.
- Green DW (1998). Mental control of the bilingual lexico-semantic system. *Bilingualism: Language and Cognition*, 1, 67–81.
- Grice HP (1975). Logic and conversation. In Cole P, Morgan JL (eds.) *Syntax and semantics: Vol. 3: Speech acts*, Academic Press, New York , 41-58
- Grosjean F (1982). *Life with Two Languages. An Introduction to Bilingualism*. Cambridge: Harvard University Press
- Grosjean F (1989). Neurolinguists beware! The bilingual is not two monolinguals in one person. *Brain and Language*, 36, 3-15
- Grosjean F (1994). Individual bilingualism. In: Asher R E (ed.) *The Encyclopaedia of Language and Linguistics*. Pergamon Press, Oxford: 1656-60

- Grosjean F (1995). A psycholinguistic approach to code-switching: The recognition of guest words by bilinguals. In L. Milroy & P. Muysken (eds.), *One speaker, two languages* (259-275). Cambridge: Cambridge University Press.
- Grosjean, F. (1998). Studying bilinguals: Methodological and conceptual issues. *Bilingualism: Language and Cognition*, 1: 131-149.
- Grosjean F (1999) Individual bilingualism. In B. Spolsky (ed.) *Concise Encyclopaedia of Educational Linguistics*, pp. 284-90. London: Elsevier
- Hakuta K (1986) *Mirror of language: The debate on bilingualism*. New York: Basic Books
- Hamers JF, & Blanc MHA (1990). *Bilinguality and Bilingualism*. Cambridge: Cambridge University Press.
- Haugen, E. (1953). *Bilingualism in the Americas*. Montgomery, AL: University of Alabama Press.
- Hermans, D., Bongaerts, T., de Bot, K., & Schreuder, R. (1998). Producing words in a foreign language: Can speakers prevent interference from their first language? *Bilingualism: Language and Cognition*, 1: 213-229.
- Hernandez A.E., Martinez, A., & Kohnert, K. (2000). In search of the language switch: An fMRI study of picture naming in Spanish-English bilinguals. *Brain and Language*, 73: 421-431.
- Hernandez, A.E, Dapretto, M., Mazziotta, J., & Bookheimer, S. (2001). Language switching and language representation in Spanish-English bilinguals: An fMRI study. *Neuroimage*, 14: 510-520.
- Holtzeimer, P., Fawatz, W., Wilson, C., & Avery, D. (2005). Repetitive transcranial magnetic stimulation may induce language switching in bilingual patients. *Brain and Language*, 94, 274-277.

- Illes, J., Francis, W., Desmond, J., Gabrieli, J., Glover, G., et al. (1999). Convergent cortical representation of semantic processing in bilinguals. *Brain and Language*, 70: 347-363.
- Johnson, J.S. & Newport, E.L. (1989). Critical period effects in second language learning: The influence of maturational state on the acquisition of English as a second language. *Cognitive Psychology*, 21: 60-99.
- Johnson-Laird PN (1980). Mental models in cognitive science. *Cognitive Science*, 4, 71-115.
- Kim, K.H.S., Relkin, N.R., Lee, K.-M. & Hirsch J. (1997). Distinct cortical areas associated with native and second languages: *Nature*, 388: 171-174.
- Kintsch W, & Van Dijk T (1978). Toward a model of text comprehension and production. *Psychological Review*. 85, 363-394
- Klein, D., Milner, B., Zatorre, R., Zhao, V., & Nikelski, J. (1999). Cerebral organization in bilinguals: A PET study of Chinese-English verb generation. *NeuroReport*, 10: 2841-2846.
- Kroll J.F. & Curley J. (1988). Lexical memory in novice bilinguals: the role of concepts in retrieving second language words. In P.M. Gruneberg and R. Sykes (eds.) *Practical Aspects of Memory* (Vol. 2): John Wiley and Sons. London, UK
- Kroll J.F. & Dussas P.E. (2004). The comprehension of words and sentences in two languages. In T.K. Bhatia and W.C. Ritchie (eds.) *The handbook of bilingualism* (pp. 169-200). Blackwell Publishing. Malden, MA
- Kroll, J.F., & de Groot, A.M.B. (1997). Lexical and conceptual memory in the bilingual: Mapping form to meaning in two languages. In A. de Groot & J. Kroll (eds.), *Tutorials in bilingualism: Psycholinguistic perspectives* (pp. 169-199). Mahwah, NJ: Lawrence Erlbaum Associates.

- Kroll J.F., Michael E., Tokovicz N. & Dufour R. (2002). The development of lexical fluency in a second language. *Second Language Research*, 18, 137-171
- Kroll J.F. & Sholl A. (1992). Lexical and conceptual memory in fluent and nonfluent bilinguals. In R.J. Harris (ed.) *Cognitive processes in bilinguals* (pp. 191-206). Amsterdam: Elsevier Science.
- Kroll JF, & Stewart E (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language*, 33, 149–174.
- Lambert WE (1974). Culture and language as factors in learning and education. In F F Aboud and R D Meade (eds.) *Cultural Factors in Learning and Education*. Bellingham, W A: Western Washington State University.
- Lebrun, Y. (1971) The neurology of bilingualism. *Word*, 27 (1-3), 179-186
- Leischner, A. (1943). Aphasia of deaf-mutes. In Paradis, M. (Ed.), *Readings on Aphasia in Bilinguals and Polyglots*. Montreal: Didier, 1983, pp.423-444.
- Leopold W. (1939-1949). *Speech development of a Bilingual Child* (4 vols.) Evanston, IL: North-western University Press
- Levelt WJM (1989). *Speaking: From intention to articulation*. Cambridge, MA: MIT Press.
- Levelt WJM, Roelofs A, & Meyer AS (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*, 22, 1–37.
- Levinson S (1983). *Pragmatics*. Cambridge University Press, Cambridge
- Long MH (1990). Maturational constraints on language development. *Studies in second language acquisition*, 12: 251.285
- Luria, A.R. (1973). *The working brain: An introduction to neuropsychology*. New York: Penguin Education.

- Macnamara, J., & Kushnir, S.L. (1971). Linguistic independence of bilinguals: The input switch. *Journal of Verbal Learning and Verbal Behavior*, 10: 480-487.
- Marini, A. (2001). *Elementi di psicolinguistica generale*, Springer Verlag, Milano, Italy
- Marini A., Carlomagno S., Caltagirone C., & Nocentini U. (2005a). The role played by the right hemisphere in the organization of complex textual structures. *Brain and Language*. 93/1, 46-54
- Marini A., Boewe A. & Carlomagno S. (2005b). Assessment of age-related differences in the processing of textual descriptions. *Journal of Psycholinguistic Research*. 34/5, 439-463
- Marini, A., & Nocentini, U. (2003). *Comunicazione verbale e emisfero destro*. Springer Verlag, Milano, Italy
- Martin R C, Newsome M R and Vu H (2002). Language and lexical processing. In V S Ramachandran (Ed.) *Encyclopaedia of the Human Brain*. Vol. 2 (pp. 631-643). Academic Press. San Diego.
- Meisel J M (2004). The Bilingual Child,. In T K Bhatia and W C Ritchie (eds.) *Handbook of Bilingualism*. pp. 91-113. Blakwell Publishing. Malden , MA
- Neville, H.J., Mills, D.L. & Lawson, D.S. (1992). Fractionating language: different neural subsystems with different sensitive periods. *Cerebral Cortex*, 2: 244-258.
- Neville, H.J., Coffey, S.A., Lawson, D.S., Fischer, A., Emmorey, K. & Bellugi, U. (1997). Neural systems mediating American Sign Language: Effects of sensory experiences and age of acquisition. *Brain and Language*, 57: 285-308.
- Ojemann, G.A. (1991). Cortical organization of language. *The Journal of Neuroscience*, 11: 2281-2287
- Ojemann, G.A., & Whitaker, H.A. (1978). The bilingual brain. *Archives of Neurology*, 35: 409-412.

- Paradis, M. (1978). Bilingual linguistic memory: Neurolinguistic considerations. Paper presented at the Annual Meeting of the Linguistic Society of America, Boston, 28 December.
- Paradis, M. (1987). Neurolinguistic perspectives on bilingualism. In M. Paradis & G. Libben, *The assessment of bilingual aphasia* (pp.1-17). Hillsdale, NJ: Lawrence Erlbaum.
- Paradis, M. (1989). Bilingual and polyglot aphasia. In F. Boller & J. Grafman (eds.), *Handbook of Neuropsychology*. Vol. 2, 117-140. Amsterdam: Elsevier.
- Paradis, M. (1993). Linguistic, psycholinguistic, and neurolinguistic aspects of 'interference' in bilingual speakers: The activation threshold hypothesis. *International Journal of Psycholinguistics*, 9: 133-145.
- Paradis, M. (1994). Neurolinguistic aspects of implicit and explicit memory: implications for bilingualism and second language acquisition. In N. Ellis (Ed.), *Implicit and Explicit Language Learning*. London: Academic Press, 393-419
- Paradis, M. (1995). The need for distinctions. In M. Paradis (ed.), *Aspects of bilingual aphasia* (pp. 1-9). Oxford: Pergamon Press.
- Paradis, M. (1996). The cognitive neuropsychology of bilingualism. In: A. De Groot & J. Kroll (Eds.), *Tutorials in Bilingualism: Psycholinguistic Perspectives..* Hillsdale, NJ: Erlbaum.
- Paradis M (2004). *A neurolinguistic theory of bilingualism*. Amsterdam: John Benjamins.
- Peal E & Lambert WE (1962). The relation of bilingualism to intelligence. *Psychological Monographs*, 76, 1-23
- Perani, D., Paulesu, E., Sebastian-Gallés, N., Dupoux, E., Dehaene, D., Bettinardi, V., Cappa, S., Fazio, F., & Mehler, J. (1998). The bilingual brain: Proficiency and age of acquisition of the second language. *Brain*, 121: 1841-1852.

- Perani, D., Dehaene, S., Grassi, F., Cohen, L., Cappa, S., Paulesu, E., Dupoux, E., Fazio, F., & Mehler, J. (1996). Brain processing of native and foreign languages. *NeuroReport*, 7: 2439-2444.
- Pinker S (1999). Words and rules: the ingredients of language. New York: Basic Books.
- Potter M.C., So K., Eckardt V. & Feldman L. (1984). Lexical and conceptual representation in beginning and proficient bilinguals. *Journal of Verbal Learning and Verbal Behavior*, 23, 23-38
- Rapport, R.L., Tan, C.T., & Whitaker, H.A. (1983). Language function and dysfunction among Chinese- and English-speaking polyglots: Cortical stimulation, Wada testing, and clinical studies. *Brain and Language*, 18: 342-366.
- Ronjat J. (1913). *Le développement du langage observé chez un enfant bilingue*. Paris : Champion.
- Snow C (1987). Relevance of the notion of a critical period to language acquisition. In Bornstein MH (ed.) *Sensitive Periods in Development: Interdisciplinary Perspectives*, Erlbaum, Hillsdale, NJ
- Soares, C. & Grosjean, F. (1984). Bilinguals in a monolingual and a bilingual speech mode: The effect of lexical access. *Memory and Cognition*, 12: 380-386.
- Stengel, E. & Zelmanowicz, J. (1933). Über polyglotte motorische Aphasie. *Zeitschrift für die gesamte Neurologie und Psychiatrie*, 149: 292-311.
- Tucker GR (1998). A global perspective on multilingualism and multilingual education. In J Cenoz and F Genesee (eds.) *Beyond bilingualism: Multilingualism and multilingual education*. Clevedon, England: Multilingual Matters. 3–15
- Ullman MT (2001). The declarative/procedural model of lexicon and grammar. *Journal of Psycholinguistic Research*, 30(1), 37–69.

Ullman MT (2004). Contributions of memory circuits to language: the declarative/procedural model. *Cognition*, 92, 231-270

Vaid J (Ed.) (1986). *Language Processing in Bilinguals: Psycholinguistic and Neuropsychological Perspectives*. Hillsdale, NJ.: Erlbaum.

Vaid J (2002). Bilingualism. In V S Ramachandran (ed.) *Encyclopaedia of the Human Brain*. Academic Press, Elsevier. Vol. 1, 417-434

Wartenburger I, Heekeren HR, Abutalebi J, Cappa SF, Villringer A, & Perani D (2003) Early settings of grammatical processing in the bilingual brain. *Neuron*, 37:159-170

Weber-Fox, C.M. & Neville, H.J. (1996). maturational constraints on functional specializations for language processing: ERP and behavioral evidence in bilingual speakers. *Journal of Cognitive Neuroscience*, 8: 231-256.

Weinreich U (1953). *Languages in contact*. New York: The Linguistic Circle of New York

Woutersen M., Cox A., Weltens B. & De Bot K. (1994). Lexical aspects of standard dialect bilingualism. *Applied Psycholinguistics*, 15, 447-473.

Zatorre, R.J. (1989). On the representation of multiple languages in the brain: Old problems and new directions. *Brain and Language*, 36: 127-147.