BILINGUAL MEMORY: A LIFESPAN APPROACH

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*“A controversial idea in science,
as everyone knows, means that
some people love it,
some could not care less, and
some are highly opposed to it.”*

Tulving (2002)

ABSTRACT

Bilingualism and its effect on individuals have been studied by many researchers in different disciplines. Although the first psychological study of bilingualism was carried out by Cattell as early as 1887, there are only few studies that have exclusively investigated the effect of bilingualism on memory systems' functioning. In the field of cognitive psychology of bilingualism, there is some evidence for the positive influence of bilingualism on children's cognitive ability across a variety of domains but there is little knowledge about the relationship between bilingualism and memory in a lifespan perspective. The main aim of this thesis was to investigate memory systems' functioning and development in bilingual individuals. For this purpose, two studies were performed: a cross-sectional study of bilingual children (Study I) and a longitudinal study of young and older adults (Study II). The purpose of the Studies I and II was to determine whether there are any differences between monolinguals and bilinguals with regard to various memory systems' functioning. The first study compared monolingual and bilingual children's performance on episodic and semantic memory, and in the second study the performance on episodic and semantic memory in bilingual younger and older adults was investigated. Specifically, these studies aimed to examine: a) which memory systems will be affected more as a function of language, and b) to what extent the differences would manifest themselves during a participant's lifespan. The purpose of Study III was to explain the relation among word representations, lexical access and lexical selection in a bilingual word production paradigm. In the process of this study, a model of bilingual production was developed to explain the obtained results as well as to clarify the role of automatic and controlled processes in using two languages. The results of the first and second studies showed a superiority of bilinguals over monolinguals as well as the fact that the association between memory performance and bilingualism is varied across different periods of adulthood. It appears that the lifelong experience of managing two languages enhances control processes, which in turn play an important role in enhancing recall performance. In the third study, the efficiency of inhibitory processing when having two languages activated has been explained using a "dual mechanism model".

Key words. Bilingual model, children, elderly, memory, control, lexical selection

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Stockholm, May 2006
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LIST OF STUDIES

The present thesis is based on the following studies, which will hereafter be referred to by their Roman numerals.

- I. Kormi-Nouri, R., Moniri, S., & Nilsson, L.-G. (2003). Episodic and semantic memory in bilingual and monolingual children. *Scandinavian Journal of Psychology*, 44, 1, 47-54.
- II. Moniri, S., & Nilsson, L. G. (2006). Episodic and semantic memory in bilingual younger and older adults. Submitted to *Scandinavian Journal of Psychology*.
- III. Moniri, S. (2006). Exploring the asymmetry phenomenon in bilingual word production. Submitted to *Consciousness and Cognition*.

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I. INTRODUCTION

Bilingualism can be observed everywhere in the world. Among the reasons fostering bilingualism are various kinds of migration, intermarriages and education/vocational opportunities. It is said that “*more than half of the world’s population is bilingual and two-thirds of the world’s children grow up in a bilingual environment*” (Crystal, 1997, cited in Bhatia & Ritchie, 2004).

According to a release from the US Census Bureau (2005), the foreign-born population in the United States numbered 34.2 million in 2004, which accounted for 12% of the total US population and was 2.3% higher than it was in 2003. Interestingly enough, among the foreign-born population, there were different language minority groups that use their mother tongues at home. In Sweden, too, according to the SCB (Statistiska centralbyrån, 2004), the foreign-born population comprised 12.2% of the total population in 2004. Along the same lines, a report from the Swedish National Agency for Education (Skolverket, 2005) indicates that the number of children enrolled in preschool (ages 1 to 5 years) in 2004 who had a mother-tongue other than Swedish was 14.2% of the total number of preschool-aged children. This number was 1.4% higher than it was in 2002/2003, and included more than 30 different minority languages.

In recent years, bilingualism as a research area has been studied extensively in a wide variety of disciplines such as psychology, linguistics, education and sociology (see Bhatia & Ritchie, 2004, for a detailed development of research on bilingualism). I will not attempt to go through and discuss all aspects of bilingualism in different disciplines here, but will instead focus specifically on the cognitive psycholinguistic studies, beginning with a brief historical review of methodological progresses in bilingual research.

The field of bilingualism is a relatively old topic in psychology. The first psychological study of bilingualism was conducted by Cattell (1887), who compared processing times in the first language (L1) and second language (L2) in several tasks such as naming pictures, reading pictures’ names and translation. Despite the fact that only two bilingual persons (one English-German and the other German-English) participated in this study, the results showed that more time was needed to name pictures in L2 than in L1. In addition, it took longer to

translate in either direction than to name pictures. From Cattell until the 1950s, bilingualism was discussed exclusively by linguists emphasizing educational and/or linguistic issues. During the 1950s and 1960s, psychologists applied recall and recognition as measures of explaining the results of the studies. In the 1980s, with the development of information processing theory, bilingual researchers using reaction time measures attempted to investigate how word representation was processed in the bilingual's different languages. Through introduction of indirect tests of implicit memory in the early 1990s, cross-language lexical decision task (LDT) and semantic priming became the most frequently used paradigms in the study of bilinguals' lexical and conceptual processing (see Keatley, 1992, for a history of bilingualism research in cognitive psychology; see also Appendix for a summary of selected empirical findings across a wide set of memory tasks). In the past decade, along with cognitive neuroscience becoming one of the most studied areas in psychology, bilingual researchers using neuroimaging techniques attempted to find answers to the unresolved issues in the field of bilingualism (see Abutalebi, Cappa, & Perani, 2005, for a comprehensive review of neuroimaging studies in the field of bilingualism).

DEFINITION OF BILINGUALISM

What is meant by bilingual and who is a bilingual? In order to classify bilinguals into different categories, bilingualism research created dichotomies such as compound/coordinate (Weinreich, 1974), fluent/less fluent (Vaid, 1986), additive/subtractive (Mohanty & Perregaux, 1997; Hamers, 2004), simultaneous/successive (McLaughlin, 1984) and early/late bilingualism (Genesee, Hamers, Lambert, Mononen, Seitz, & Starck, 1978). Although all these definitions range from a "native-like competence in two languages" (Bloomfield, 1933, p. 56) to a "minimal proficiency in a second language" (Macnamara, 1967) and from a broad definition to a narrow definition of bilingualism, none of them can represent all types of individuals who are called "bilingual".

In Mackey's (1968, p. 555) words, "*bilingualism is simply the alternate use of two or more languages*". He also specifies four criteria for the description of bilingualism: degree (level of proficiency), function (use for the languages), alternation and interference.

Hamers and Blanc (2000, pp. 23-24) identify three main limitations of the definitions used in the bilingualism research as follows: (a) they are unidimensional, meaning that bilingualism is defined in terms of competence only, (b) they ignore different levels of analysis (i.e., individual, interpersonal and societal), and finally (c) definitions are not supported by a general theory of language behaviour.

To summarize, despite numerous empirical studies there is still no general consensus on a single definition of bilingualism. The bilingualism definition adopted hereafter and throughout this thesis is the “*regular use of two or more languages and bilinguals as those individuals who need and use two or more languages in their everyday lives*” (Grosjean, 1992, p. 51).

MEASUREMENT AND TESTING OF BILINGUALISM

Since there are very different kinds of bilinguals, researchers should take into account the degree of bilingualism when investigating the different aspects of bilingual abilities. The questions are: What are the criteria for assessing bilingualism, ability in two languages, the use of two languages and/or age of second language learning? How can we measure bilingualism objectively? What are the different methods of measurement and which one is more reliable?

Since a bilingual uses two languages for different purposes, in different domains of life and with different people, equal competence in both languages is a myth. It should be noted that language proficiency in both monolinguals and bilinguals consists of a diverse combination of skills (i.e., speaking, writing, listening and reading) that are not necessarily correlated. An individual's proficiency may vary across the different skills. While some bilinguals show very high levels of proficiency in both languages in the written and oral abilities, others' comprehension or speaking skills are related to the specific domains of experiences with using two languages. Therefore, proficiency needs to be assessed in a variety of areas.

Although, there is no definite test of the degree of bilingualism; a variety of tests have been used by bilingualism researchers to assess the relative dominance of one language over the

other in particular areas. The most widely used and practical method of evaluating the degree of bilingualism is self-rating scales in which the participants are asked to assess their ability in both languages in relation to various skills on a five or seven-point scale. There are also a number of dominance tests that are used to measure, for example, reaction time in a word association task, time taken to read and amount of mixing and borrowing.

Verbal fluency tasks (i.e., letter and semantic fluency) also constitute one of the commonly used tests, especially in neuropsychological assessments. In these tasks, the participants are asked to generate as many words in a given category as they can within one minute. These tasks are easy to administer and interpret.

CONSEQUENCES OF BECOMING A BILINGUAL

Research on the effects of bilingualism on cognitive development began with the use of IQ tests (i.e., from the 19th century to the 1960s), and most studies reported negative effects of bilingualism on children's intellectual development. As stated by Romanie (1995, p. 111), *"most of the studies done before the 1960s indicated that monolingual children were up to 3 years ahead of bilingual children in various skills related to verbal and non-verbal intelligence"*. Methodological limitations and design issues (e.g., conducting tests in the weaker language and/or using non-matched groups) within these early studies cast doubt on their results. The study of Peal and Lambert (1962) was a turning point in this area of research, showing a bilingual advantage in cognitive flexibility, creativity and divergent thinking.

Recent research findings regarding this question have shown mixed results in adult bilinguals. Cognitive disadvantages have been observed in three studies with tip-of-the-tongue (TOT) and verbal fluency tasks (Gollan & Acenas, 2004; Gollan, Bonanni, & Montoya, 2005; Gollan, Montoya, & Werner, 2002). In TOT studies, bilinguals produced more TOTs than did age- and education-matched monolinguals, and in the study using verbal fluency tasks fewer exemplars on 9 of 12 semantic categories and 6 of 10 letter categories were produced by bilinguals. But, using proper names (Gollan, Bonanni, & Montoya, 2005) and cognates (Gollan & Acenas, 2004), the TOT effect disappeared. Similarly, Rosselli, Ardila, Araujo;

Weekes, Caracciolo, Padilla, and Ostrosky-Solis (2000) argued that although aging reduced both semantic and letter fluency scores in monolinguals, in bilinguals only semantic fluency scores decreased with age. In contrast to these studies, in a study of elderly fluent Yiddish-English bilinguals, Obler and Albert (1986) found superior performance by bilinguals not only in a semantic fluency task, but also in fluency tasks using letters beginning with certain letters.

The results of two recent studies (Juncos-Rabadán, 1994; Juncos-Rabadán & Iglesias, 1994) with elderly bilinguals revealed that all language capacities were impaired as a consequence of decline in attentional abilities in normal aging. Demonstrating that decline in linguistic competence occurred equally with both languages, the authors attributed the results to the attentional impairment and an increasing lack of inhibition capacity.

However, Ransdell, Arecco, & Levy (2001) found bilingual advantage in suppression on a test of writing quality and fluency, showing that monolingual performance suffered in the presence of irrelevant speech, but that bilingual performance did not.

Evidence of a bilingual advantage in elderly and adult bilinguals comes from two studies (Bialystok, Craik, & Wisvanathan, 2004, Bialystok, Craik, Grady, Chau, Ishii, Gunji, & Pantev, 2004) on the Simon task, in which bilinguals demonstrated enhanced cognitive control. This task is a nonverbal task that requires stimulus-response compatibility and assesses the extent to which the existing association to irrelevant spatial information (e.g., position) affects participants' responses to task-relevant non-spatial stimulation (e.g., colour or shape). To be able to perform this task successfully, the participant needs to inhibit the irrelevant information while attending only relevant cues.

Considering bilingual children, recent research findings indicate that bilingual children are more advanced than are monolingual children in solving problems requiring the inhibition of misleading information. Superiority of bilingualism can be found in tasks and processes demanding a high level of selective attention as well as inhibitory control (see Bialystok, 2005, for a comprehensive review of studies investigating consequences of bilingualism for children's development on three cognitive domains: concepts of quantity, task switching and concept formation, and theory of mind).

The positive effects of bilingualism on episodic and semantic memory with bilingual children were also found in two recently conducted studies (Kormi-Nouri, Moniri, & Nilsson, 2003; Kormi-Nouri, Shojaei, Moniri, Gholami, & Nilsson, submitted). The first study compared school-aged Persian-Swedish bilingual and Swedish monolingual children (for more information, see Study I) and the second study, a follow-up of Study I, investigated memory performance in two groups of Turkish-Persian and Kurdish-Persian bilingual children.

Disadvantage in receptive vocabulary (not universally accepted) in bilingual children is another issue that has been discussed in many studies. Since bilingual children use their two languages in different contexts, a bilingual child may not have as large a vocabulary in each of the languages as an age-matched monolingual child. However, the bilingual child's total vocabulary will usually be larger than that of the monolingual child (Pearson, Fernandez, & Oller, 1993; see Bialystok, 2001, for a review).

LANGUAGE DEVELOPMENT IN BILINGUAL CHILDREN

Systematic investigation of childhood bilingualism began about one hundred years ago with a case study by Ronjat (Ronjat, 1913, cited in Meisel, 2004). Language development in bilingual children and processes of acquisition appear to be very similar in monolingual and bilingual children who are regularly exposed to two languages from birth (i.e., active bilinguals). Although there is no difference between young children and adult bilinguals regarding mixed utterances, the mixed utterances in the adult bilinguals appear to be more varied in nature. It should be noted that language mixing is not evidence of language confusion as some researchers repeatedly point out. In other words, language mixing should not be considered as a sign of a lack of language proficiency, but as language-choice possibilities that occur, usually deliberately, in order to be better understood (Heredia & Altarriba, 2001; Meisel, 2004, see also De Houwer, 2005 for a comprehensive review of recent studies of simultaneous bilingual children under the age of 6 years).

Comparing bilingual language development to monolingual development, De Houwer (2005) proposes a separate development hypothesis (SDH). According to this hypothesis, bilingual children acquire two separate morphosyntactic systems (i.e., grammatical differentiation) in

production, assuming that the morphosyntactic development of one language does not have any fundamental effect on the morphosyntactic development of the other language. Despite this functional separation, it seems that the two linguistic systems interact with each other through transfer and code mixing (see MacWhinney, 2005).

On the contrary, in a three-stage-model of bilingual language development, Volterra and Taeschner (1978) propose a single-system hypothesis in which children go through three stages of morphosyntactic development. In the first stage, the bilingual child is assumed to have only one lexical system that comprises words from two languages. In the next stage, while children are still relying on one syntax for both languages, distinct lexical systems develop. And, finally at the last stage, with developing separate grammatical systems, the two linguistic systems will be differentiated. According to Arnberg and Arnberg (1992), awareness of the two languages plays an important role in differentiation of the languages.

In relation to childhood bilingualism, many researchers have investigated the role of a critical period for learning a second language and its effect on the development of children's and adults' second language acquisition and development. Critical period hypothesis (CPH) was first proposed by Lenneberg (1967) suggesting that there is a biologically determined critical period around puberty, before which second language acquisition can occur easily, but after which it becomes more difficult to learn a new language. This hypothesis holds that near puberty, not only does the brain lose its plasticity and flexibility, but the two hemispheres also become more specialized; therefore, it would be increasingly difficult to acquire another language after these cerebral changes. The most compelling evidence for this hypothesis is that some adult second language learners hardly become proficient in their second language.

Despite mixed evidence in this research area, there is still an extensive debate about the existence of critical period in second language learning (see Birdsong, 1999; Dekeyser & Larson-Hall, 2005; Hyltenstam & Abrahamsson, 2003; for a detailed review of empirical findings and theoretical explanations, but see also Bialystok & Hakuta, 1999; Hakuta, 2001). According to the proponents of the CPH, age of acquisition is strongly negatively correlated with ultimate second-language proficiency, not only for pronunciation but also for grammar. One problem with the CPH is that there is no agreement about the age at which the critical period ends. The researchers point out to a cut-off point ranging from the age of five-years (Krashen, 1973) to the age of 15-years (Johnson & Newport, 1989).

The difference between language developmental patterns in bilingual children and bilingual adults is attributed to the fact that children learn implicitly and adults learn explicitly. Consequently, adults are faster in the initial stages of second language learning, because they can use their previously acquired linguistic knowledge about fundamental principles of language structure. Although children lack this cognitive experience and need to form concepts as well as lexical representation in both languages, they appear to become better learners in the long run (for recent reviews see Birdsong, 1999; Harley & Wang, 1997; Hyltenstam & Abrahamsson, 2003; Marinova-Todd, Marshall, & Snow, 2000). It seems that young children acquire phonological and syntactic systems of a new language better than adults do (Bialystok & Hakuta, 1994; Flege, MacKay, & Piske, 2002; Flege, Yeni-Komshian & Liu, 1999).

MEMORY DEVELOPMENT IN CHILDREN

Memory is a primary focus of cognitive functioning and development. Research on memory development in children has a long history and dates back to more than one century ago. Experimental evidence reveals that general development in childhood appears to occur between six and 12 years of age with changes in basic capacities, memory strategies, meta-cognitive knowledge and domain knowledge, and develops up to adolescence (Schneider, 2002, see also Rovee-Collie, 1995, 1999 for a review of infant memory development and Schneider, 2000 for a comprehensive review of research trends on children's memory development within the past 120 years).

More recent work on the metamemory and metacognitive competences has provided evidence for rather strong relations between metamemory and memory performance. It should be noted that this relationship does not emerge until children reach elementary school (Lange & Guttentag, 1990), and is not stable until age ten (Hasselhorn, 1995). The full development of metamemory competences takes place between grade five and grade eight (see Schneider, 1999).

In cross-sectional studies, strategy development is seen as a regular, gradual and continuous process. Strategies can be executed either at the time of encoding (i.e., rehearsal, organization,

and elaboration) or at the time of retrieval (i.e., using retrieval cues). The role of memory strategies in memory performance has also been pointed out in many cross-sectional studies. It appears that although younger children have access to strategies, they fail to use them spontaneously. As children grow older, both the number of strategies and the efficiency with which children use these strategies increases (Cowan, 1997; Schneider & Pressley, 1997).

In two longitudinal studies (i.e., Würzburg Longitudinal Memory Study and Munich Longitudinal Study), investigating children's verbal memory development from the beginning of elementary school to late adolescence, it was found that (a) recall performance improves continuously over the school years, (b) the strategy acquisition process with respect to organizational strategy is fully developed by the age of 12, (c) the relation among different verbal memory tasks over the period from early childhood to late adolescence does not change, and (d) although learning experiences in school have an effect on memory development, differences in educational level within a given school system do not seem to play a major role (for detailed information see Schneider, Knopf, & Stefanek, 2002; Schneider, Kron, Hünnerkopf, & Krajewski, 2004).

MODELS OF MEMORY SYSTEMS

The idea that memory is not unitary but is instead composed of multiple systems has a long history. It extends back to more than a century ago when William James (1890) proposed the distinction between a long-term secondary memory and a brief primary memory. However, despite William James' suggestion, memory was treated as a unitary phenomenon until the late 1960s (for a review of memory research, see Bower, 2000).

In 1968, Atkinson and Shiffrin proposed three different memory storage systems: sensory stores (i.e., iconic, echoic and haptic), a short-term store and a long-term store (for detailed properties of these systems see Atkinson & Shiffrin, 1968).

Four years later, Baddeley and Hitch (1974) introduced working memory as a multi-component short-term store composed of (a) articulatory or phonological loop, (b) visuospatial sketchpad, and (c) central executive (for detailed description of these components

see Baddeley, 1992, 2000, 2003). According to Baddeley, working memory is a temporary storage of information in connection with performing other complex tasks. In the latest version of the working memory model (Baddeley, 2000), Baddeley proposed a fourth component called “episodic buffer”, which differs from the central executive in being principally concerned with the storage of information rather than with attentional control. The episodic buffer is assumed to form a basis for conscious awareness that allows information from a number of different sources to be combined with that from long-term memory into integrated chunks.

Considering long-term memory, the distinction between episodic and semantic memory was originally made by Tulving (1972). Later, by adding two other memory systems to the long-term memory (i.e., procedural memory, perceptual representation system), Schacter and Tulving (1994) distinguished among five major separate categories: episodic memory, semantic memory, procedural memory, perceptual representation system (PRS) and primary (short-term) memory (see also Schacter, Wagner, & Buckner, 2000, for an overview of memory systems).

There is much evidence from both behavioural and neuroimaging data, for the existence of multiple memory systems (Nyberg & Tulving, 1996; see also Squire, 2004 for a minireview). Experimental evidence also indicates that although these five memory systems operate independently, they interact with each other and in parallel to support behaviour (Gabrieli, 1998; Nyberg, Forkstam, Petersson, Cabeza, & Ingvar, 2002; Tulving & Schacter, 1990; Squire, 1992, 2004).

I do not attempt to discuss all the distinctions that have been made in the field of memory systems, nor do I attempt to relate these to the neuroscience of bilingualism. Both of these topics are important but are beyond the scope of this thesis. Specifically, I will focus on functioning of two memory systems (i.e., episodic and semantic memory) in relation to bilingualism.

In Tulving’s (2000, p. 598) words, “*although there are many proposed differences between episodic and semantic memory, there is one attribute that best discriminates between them, the conscious awareness that occurs during retrieval. Only episodic retrieval involves*

autonoetic awareness and the mental reexperience of a previous moment in the past. Semantic memory, by contrast, is characterized by noetic (knowing) awareness only”.

Distinguishing between the development of episodic and semantic memory, Tulving (2002) states that “*semantic memory appears long before episodic memory in young children, while episodic memory evolves out of semantic memory and it is impaired sooner than semantic memory in old age*”.

Two other frequently used dichotomies in the memory system research that should be noted here are: (a) declarative/non-declarative, and (b) explicit/implicit distinctions.

Declarative memory involves knowledge that can be verbalized. Semantic and episodic memory are categorized together as declarative memory and the two other long-term memory systems (i.e., procedural memory and PRS) as non-declarative memory (Squire, 1992, 2004). Non-declarative memory is expressed through performance rather than recollection, and includes information that is acquired during skill learning, habit formation, simple classical conditioning and priming.

Explicit memory refers to a memory that requires conscious recollection of prior experiences (i.e., episodic memory and primary memory). Recall and recognition are two means of assessing explicit memory performance. In contrast to explicit memory, implicit memory is the unintentional retrieval of previously studied information (Graf & Schacter, 1985). In other words, implicit memory occurs when memory influences our behaviour without our conscious awareness. Priming, that is a facilitative effect of prior experience on indirect tests of memory such as word completion, word identification and lexical decision task, is assumed to demonstrate implicit memory (for a comprehensive review of implicit memory, see Roediger & McDermott, 1993).

MODELS OF BILINGUAL MEMORY

In the 1960s and 70s an extensive debate took place about whether bilinguals have one language-independent store (single-store models) or two language-dependent stores (dual-

coding models). According to dual-coding models, representations of the words in different languages are stored in two different and distinct memory stores, meaning that there is one memory for each language, so that each system can function independently from the other system. The model also assumes that these two distinct memory stores are interconnected indirectly via translation equivalent (TE) words.

Using a variety of experimental tasks, contradictory results were obtained from early studies. To explain these results, researchers changed their approach, suggested different levels of language processing and introduced hierarchical models. Hierarchical models distinguish between two levels of word representation (i.e., lexical and conceptual) and propose two separate lexical stores and one shared conceptual store across languages. These models are used to explain how words and their meanings are represented in bilingual lexicosemantic organisation. They can therefore be categorized as models of bilingual representations (for a recent review of models of bilingual memory and their development, see Francis, 1999; French & Jacquet, 2004; Kroll & Tokowicz, 2005).

Another category of bilingual memory models that devote attention to the mechanisms for lexical access and lexical selection can be grouped together as models of bilingual processing (e.g., BIA and Inhibitory control model). These models are interested in the issues of bilingual lexical access and two main issues in question are: (a) whether access to the bilingual lexicon is basically language selective or non-selective, and (b) What are the underlying mechanisms for lexical access and lexical selection?

Much progress can be observed in recent years' bilingual memory research. A full consideration of all existing bilingual models is beyond the scope of the present thesis and only selected models will be described briefly as follows.

Revised Hierarchical model (RHM). This model of bilingual representation is the most frequently cited model of bilingual memory and was originally proposed by Kroll and Stewart (1994). The model assumes that (a) there is a stronger connection between L1 words and concepts than between L2 words, and (b) the connection between L2 words to their corresponding TEs in L1 (lexically-mediated link) is stronger than the reverse (conceptually-mediated link). Along with these assumptions, three predictions are also specified: (a) since there is a direct lexical connection between L2 words and their TEs in L1, L2-L1 translation

would be faster than L1-L2 translation (i.e., asymmetry effect), and (b) since L1 words are more strongly connected to concepts than L2 words, L1-L2 translation would be more affected by the semantic manipulation than L2-L1 translation, (c) with increasing proficiency in the L2, there would be a developmental shift from lexical to conceptual processing (Kroll & Tokowicz, 2001; Kroll & Dijkstra, 2002; for evidence supporting this model see Kroll & Tokowicz, 2005, but see also Altarriba & Mathias, 1997; De Groot & Poot, 1997; Frenck-Mestre & Prince, 1997; La Heij, Kerling, & Van der Velden, 1996).

The distributed feature model (De Groot, 1992, 1995; De Groot, Dannenburg, & Van Hell, 1994; Van Hell & De Groot, 1998). This model hypothesizes that the degree to which concepts are shared across languages is a function of characteristics of words, with more overlap for concrete than abstract nouns and for cognates than for noncognates' translations. Support for this model comes from studies of translation recognition, translation production, and word association. The results of these studies indicate consistently that concrete words and cognates are translated from one language to the other faster than abstract words and non-cognates, an effect termed as word-type effect.

Inhibitory control model (Green, 1993, 1998). This model postulates that suppression and inhibitory control are central characteristics of bilingual language processing. Selection of one language includes activation of that language and suppression of the other language at the same time. This model proposes a set of external control mechanisms (i.e., Supervisory attentional system and Task schema) and hypothesizes that these mechanisms work together with the output from the system to accomplish the goal. Supervisory attentional system (SAS) controls the activation of task schemas for particular language processing goals. The task schema activates lemmas (words' lexical representations) in the intended language and inhibits lemmas in the unintended language. According to this model, two translation tasks impose differential inhibitory demands, meaning that greater inhibition of L1 is required to allow L2 processing to take place than the reverse. Empirical evidence for this model comes from experiments on deliberate language switching (Mueter & Allport, 1999; Thomas & Allport, 2000), indicating that switch costs are greater when bilinguals switch to their L1 than when they switch to the L2.

Bilingual interactive activation (BIA) model (Grainger & Dijkstra, 1992; Dijkstra & Van Heuven, 1998, 2002a, 2002b). This model explains lexical access and selection in a bilingual

word recognition process, assuming that there is a single, integrated bilingual lexicon, and non-selective access. Lexical access is defined as the process of activation of the right word in a given context. According to this model, words in both languages are accessed simultaneously during bilingual word recognition, but this access is sensitive to task demands and context aspects. It also assumes two language nodes, one for L1 and the other for L2, responsible for the activation of all words from one lexicon and inhibition of all words in the other lexicon. Support for this model comes from studies using three types of stimulus materials: interlingual homographs (e.g., the English-French word *pain*, meaning “bread” in French), cognates (e.g., *tomato* in English and *tomaat* in Dutch), interlingual neighbours (e.g., *start* and *stark*, the latter meaning “strong” in Swedish) in LDT (see Dijkstra, 2005, for a detailed description of the characteristics and assumptions of the bilingual word recognition models as well as for an overview of studies using three types of materials in support of non-selective access in bilingual word recognition).

A revised version of the BIA model, termed *BIA*⁺ (Dijkstra & Van Heuven, 2002b), was recently presented to explain phonological and semantic representation in bilingual visual word recognition. According to this model, bilingual word recognition is affected by orthographic similarity effect as well as phonological and semantic overlap. The model also distinguishes between the effects of non-linguistic context (such as instruction, stimulus list composition and participants’ expectations and strategies) and linguistic context (such as semantic and syntactic effects of sentence context) and assumes that while linguistic context directly affects the word identification system, non-linguistic context will affect the task/decision system.

Language mode model (Grosjean, 1997, 1998, 2001). Holding a holistic view of bilingualism, language mode is a central concept in this model. Language mode is defined as the state of activation of the bilingual’s two languages at a given point in time. Distinguishing between the “monolingual mode” (when bilinguals communicate with monolingual speakers) and “bilingual mode” (when bilinguals communicate with other bilinguals), Grosjean proposes a situational continuum of language processing in which at the one end, bilinguals find themselves in a monolingual language mode (when only one language is active) and at the other end, bilinguals are in a bilingual language mode (when both languages are active, but the main language of communication is more active than the other). In addition to these end

points, bilinguals can place themselves at any point at this monolingual-bilingual continuum mode depending on the circumstances. Support for this model comes from studies investigating code-switching, language borrowing and language transfer in bilingual processing.

At the end, as stated by Costa (2005, p. 308), “much less research has been devoted to developing models of language production in bilinguals”, despite the fact that processes involved in L2 comprehension and production underlie different demands (see Kroll & Dijkstra, 2002, for a discussion of the similarities and differences between bilingual language comprehension and bilingual language production).

COGNITIVE NEUROSCIENCE OF BILINGUALISM

Cognitive neuroscience combines the experimental designs of cognitive psychology with various techniques to examine human brain function and structure. Neuroimaging techniques, such as PET (Positron Emission Tomography) and fMRI (functional Magnetic Resonance Imaging), have been widely used to investigate language and memory systems (see Raichle, 2001, for a historical review of functional neuroimaging). Both PET and fMRI measure brain activity indirectly by taking advantage of a physiologic property: when a region of the brain increases activity, both blood flow and the oxygen content of the blood in that region increase (see Buckner & Logan, 2001; Buckner & Tulving, 1995; Cabeza & Nyberg, 2000; Raichle, 1994, for a detailed analysis on the method and limitations of neuroimaging studies).

Use of the imaging techniques will help bilingualism researchers find answers to a set of ongoing questions, such as “How does the brain represent and organize different languages?”, “Is cerebral organisation different in bilinguals and in monolinguals?” and “Is there any factor that may affect the cerebral organization of two languages, for example, age of L2 acquisition, level of proficiency in L2 and/or the degree of usage of L2?”.

Abutalebi, Cappa, and Perani (2005) have reviewed one-decade of neuroimaging studies in normal adult bilinguals, investigating language production (p. 503, Table 24.1, including nine studies), language comprehension (p. 507, Table 24.2, including seven studies) and neural

basis of translation and language selection mechanisms (p. 511, Table 24.3, including three studies), and found that level of proficiency in L2 and language exposure are more important than the age of L2 acquisition for determining the cerebral representation of bilinguals' languages. The results of these studies also suggested that age of L2 acquisition may affect the cortical representation of grammatical processing (see also Wartenburger, Heekeren, Abutalebi, Cappa, Villringer, & Perani, 2003; Weber-Fox & Neville, 1996, 1999). According to Ullman (2001), acquisition of an L2 late in life often involves explicit learning of L2 grammar and thus relies on brain regions that typically process declarative memory (i.e., temporal lobe structures), but if both languages are learned early in life grammatical processing will take place in brain regions associated with procedural memory (i.e., left frontalbasal-ganglia structures).

To summarize, the conclusion to be drawn from the above-mentioned production and comprehension studies is that there are no differences in brain activity for very early bilinguals and no differences for late bilinguals if they are highly proficient in both languages (Chee, Tan, & Thiel, 1999; Illes, Francis, Desmond, Gabrieli, Glover, Poldrack, Lee, & Wagner, 1999; Klein, Zatorre, Milner, Meyer, & Evans, 1995, but see Kim, Relkin, Lee, & Hirsch, 1997). Available evidence suggests that brain activation during a language task depends on the participant's proficiency in the language, which in turn depends roughly on the age at which the language was acquired.

GOALS OF THIS THESIS

General goal

The main aim of this research was to investigate memory systems' functioning and development in bilingual individuals. For this purpose, two studies were performed: one cross-sectional with bilingual children (Study I) and the other (Study II), a longitudinal study with young and older adults. The focus of these studies was on functioning and development of episodic and semantic memory in bilingual participants.

Specific goals

The purpose of the Studies I and II was to determine whether there are any differences between monolinguals and bilinguals regarding various memory systems' functioning. The first study compared monolingual and bilingual children's performance on episodic and semantic memory, and in the second study the performance on episodic and semantic memory in bilingual younger and older adults was investigated. Specifically, these studies aimed to examine: a) which memory systems will be affected more as a function of language, and b) the extent to which the differences would manifest themselves during the participant's lifespan.

The purpose of Study III was to explain the relation among word representations, lexical access and lexical selection in a bilingual word production paradigm. In the process of this study, a model of bilingual production was developed to explain the obtained results as well as to clarify the role of automatic and controlled processes in using two languages.

II. OVERVIEW OF THE EMPIRICAL STUDIES

Study I

Introduction and method

Experimental studies investigating the consequences of becoming bilingual in recent years have revealed that bilingual children outperform monolingual children in some types of cognitive tasks, but not necessarily in all types of tests. The most compelling evidence for bilingual advantage comes from those tasks that place high demands on the ability to control attention and inhibit irrelevant perceptual information. Inhibition and control of attention are two aspects of executive functioning that develop gradually through childhood (see Bialystok, 2005, for a review of experimental evidence and theoretical implications).

The main aim of this study was to investigate bilingual and monolingual children's performance in two long-term memory systems (i.e., episodic memory and semantic memory). The second goal of this study was to determine whether there are any developmental effects on memory performance.

We used action memory as a form of episodic memory, and four letter fluency tasks (two in each language) were used to assess semantic memory performance. An action memory paradigm usually consists of two tasks: subject-performed tasks (SPT) and verbal tasks (VTs). SPT tasks refer to a type of encoding in which participants are required to perform simple tasks (e.g., read a book, open the box) with either real or imaginary objects. The results with SPT studies consistently show superior recall or recognition performance in SPT encoding in comparison with verbal encoding. This superiority is usually termed the SPT effect or the enactment effect and has been observed in many studies, with both children and adults and under all testing conditions (see Engelkamp, 1998; Nilsson, 2000; Zimmer & Cohen, 2001, for a review of studies and theoretical explanations).

Participants in this study were 120 primary school students in grades 2, 4 and 6 of whom half were native speakers of Swedish and the other half were Persian-English bilinguals. All stimulus materials, presented auditorily, were composed of 20 SPTs (10 with real objects and

10 with imaginary objects) and 20 verbal tasks (VTs). Children's performance was measured with a free-recall and a cued-recall test (verb or noun as cues). Two additional tests were also administered, one for measuring participants' vocabulary size (Standardized Swedish Vocabulary Test) and one for gathering information about language proficiency and use of L2 (Language History Questionnaire).

Results and discussion

The key findings of the study were: (a) a positive effect of bilingualism on both episodic memory and semantic memory, especially in grade 6, (b) in cued-recall condition, bilingual children outperformed monolingual children in SPTs for objects, and (c) there was a developmental effect for both free recall and cued-recall of SPTs, especially for the second and sixth graders in the cued recall condition.

The authors attributed the results to the "integration view of enactment" (Kormi-Nouri, 1995), claiming that the encoding of action events is strategic in nature. Furthermore, it was suggested that integration of memory and language in bilinguals could have an important role in enhancing bilingual children's memory performance.

According to the "Integration view of enactment" (Kormi-Nouri, 1995), acting improves recall because semantic and episodic integration is enhanced. In SPT experiments, semantic integration is defined as previously acquired general knowledge about the relationship between the verb and the noun. On the other hand, episodic integration that is produced by encoding enactment is special knowledge of the relationship between the verb and the noun at the time of study. The superior memory performance for action memory compared to verbal memory is, therefore, due to combination of semantic and episodic integration and better self-involvement in the action encoding. The occurrence of developmental differences in SPTs also indicates that action memory underlies a strategic process.

Study II

Introduction and method

The presence of developmental effects in Study I, as well as evidence for cognitive advantages with childhood bilingualism motivated the author to explore whether findings obtained from experimental studies for children of different ages could be generalised to adult populations.

There are only a small number of studies that have investigated influence of bilingualism on memory performance in older adults. The results of these studies are mixed and are restricted to only specific tasks of memory. In contrast, there is extensive literature on memory function and changes in normal and pathological aging, including both cross-sectional and longitudinal studies.

Most previous research on normal cognitive aging indicates age-related decline in memory functioning of normal healthy adults; but this impairment of memory performance is not general and uniform across different types of memory systems. Whereas some memory systems (i.e., episodic memory and working memory) are severely affected in old age, other memory systems appear to be less impaired (i.e., semantic memory) and still another (i.e., perceptual representation system) is relatively preserved or only slightly disrupted across age (see Verhaeghen, Marconen, & Goossens, 1993 for more information; see also Nilsson, 2003, for a comparison of findings obtained from cross-sectional and longitudinal studies).

The main goal of the present study was to investigate whether knowledge of more than one language can affect performance on episodic and semantic memory in old age groups. The study also aimed to determine a) which memory systems (i.e., episodic memory and semantic memory) and/or subsystems (i.e., recall/recognition, and knowledge/fluency) is affected more as a function of language across the different adult ages; and b) whether the impact of age on memory and bilingualism varied across periods of younger and older adulthood.

For this purpose, the memory performance of bilingual participants was compared with that of monolingual participants in a large-scale longitudinal study (i.e., Betula study, see Nilsson, et

al., 1997 and Nilsson, Adolfsson, Bäckman, De Frias, Molander, & Nyberg, 2004 for a detailed description of this study).

Based on the answers to the "Language History Questionnaire", the participants (504 healthy normal adults) were classified into two groups: a) monolingual group who speak and use only one language (i.e., Swedish); and b) bilingual/multilingual group who use two or more languages in their everyday life (cf. Grosjean, 1992). Then, monolinguals and bilinguals were subdivided into three age groups (i.e., middle-aged adults, young-old adults, and old-old adults). It is necessary to emphasize that in contrast to Study I, the participants in Study II were young and older adults who had learned their second language (i.e., English) through formal education from the age of 10 years.

A battery of memory tasks for measuring performance in episodic and semantic memory systems was then selected among the tests administered in the original longitudinal study. The tests included in the present study were episodic memory tests including recall/recognition of studied words and sentences and semantic memory tests including recall of general knowledge and fluency tests (see Nilsson et al., 1997, for a full description of tests, Table 2).

Results and discussion

The results of this study indicated that bilingual participants' performance were superior to that of monolingual participants under all conditions. Demographic data showed that bilingual participants in general had a higher degree of education. However, even when number of years in formal education was controlled for by means of ANCOVAs, the bilingual superiority remained.

It was also noticed that there is a significant interaction between language condition and different age groups in episodic memory, showing that episodic memory is impaired in both monolingual and bilingual old-old groups, even though age differences were much larger in monolinguals than in bilingual participants.

In addition to observing monolinguality-bilinguality dissociation in overall memory performance, the results revealed episodic-semantic distinction as well as recall-recognition and knowledge-fluency dissociations regarding memory functioning.

The obtained result was attributed to the crucial role of bilingualism in developing more effective learning strategies because of enhanced attentional control and it was concluded that the effects of bilingualism on cognitive processing persist through adulthood and into aging.

Finally, it was suggested that in order to increase our understanding of bilingual advantage/disadvantage in different aspects of cognition and in different age groups, there is a need for future theorizing that is applicable in both clinical and educational frameworks.

Study III

Introduction and method

The main concern of the models of bilingual memory is to explain how bilinguals' languages are represented and processed. In recent years much progress can be observed in bilingual memory research, resulting in developing different models for bilingual comprehension and production.

Given that representation and processes cannot be studied independently, the main goal of the study was to explore the relationship between bilingual lexico-semantic organization and the process of lexical access to the bilingual's two language systems in a word-production task. Understanding the relationship between structure view and function view will bridge organizational and operational considerations in existing models of bilingual memory. To accomplish this, using a masked cross-language word-stem completion task, the present study examined the effect of conscious and unconscious processing in bilingual memory to determine how this automatic or controlled process manifests itself in forward (L1-L2) and backward (L2-L1) translation conditions.

The main rationale for using a word-stem completion task was that it is an indirect implicit memory test that requires word production. In earlier monolingual studies, this task has been used to examine the effect of unconscious processing on memory performance (Debnar & Jacoby, 1994, see also Jacoby & Kelley, 1991).

The rationale for manipulating automaticity of the processing was that activation processing, both automatic and controlled, may play an important role in natural language understanding and production (Segalowitz, 2003; see also Segalowitz & Hulstijn, 2005, for a review of studies investigating automaticity in bilingualism).

Two experiments were conducted with Swedish-English bilinguals, presenting a mixed list of stimuli from both languages within a block in order to make prediction of the target's language impossible. In the mixed lists, the incoming information may initially be directed to the inappropriate language system, but only after a conscious search through information the appropriate language system could be selected. Therefore, response time will be longer in the mixed condition than in the monolingual condition. Using a mixed-language paradigm makes it possible to simultaneously manipulate both conceptual and lexical-level features of target words (see Basden, Bonilla-Meeks, & Basden, 1994; Gerard & Scarborough, 1989; Grainger & Beauvillain, 1987; Jiang, 1999, Exp. 4; Kirsner et al., 1984, Exp. 3; Tzelgov & Henik, 1990, for findings from mixed-list studies).

The automaticity was manipulated by the presentation duration (long vs. short) at encoding in the first experiment and by the attention (full vs. divided) in the second experiment, employing a dual-task procedure. As is known, controlled processes are source demanding and are under direct conscious control, but automatic processes, in contrast, are said to be effortless and involuntary (Hasher & Zacks, 1979; Schneider & Chien, 2003).

It was supposed that in the long duration and the full attention conditions, participants are given the chance to process the words strategically by controlling the lexical activation of both languages. Thus, a translation asymmetry effect (i.e., translation from L2 to L1 is faster translation from L1 to L2) was predicted to occur only in these conditions. On the other hand, all processing under the short duration and the divided attention was expected to happen unconsciously (i.e., automatic processing) and, therefore, there would be no asymmetry effect.

In line with predictions of RHM, translation asymmetry effect has been found in many earlier cross-language studies using different tasks and stimulus material (e.g., Kroll & Curley, 1988; Kroll & Stewart, 1994; Kroll & Sholl, 1992; Sholl, Sankaranarayanan, & Kroll, 1995).

Results and discussion

The results of RTs in the Experiment I showed: (a) a significant asymmetry effect only in the long presentation, (b) a significant interaction between word-stem language and prime-target relations, indicating that Swedish words were completed faster in the within-language condition than in the between-language condition, and (c) a significant interaction between duration and word-stem language reveals that Swedish words were completed faster in the long duration than in short duration. The results of error rates and reaction time were similar.

Main findings regarding RTs in Experiment II, can be summarized as follows: (a) full-attention condition produced almost the same pattern of results as found in the first experiment with RTs for L1-L2 and for L2-L1 in long duration, (b) a significant interaction between attention and prime-target relation indicates that participants performed better when completing word-stem in within-language under full attention, and (c) in between-language condition, although there was an asymmetry effect in full attention as well as divided-attention, it was not statistically significant.

The analysis of error rates observed in the Experiment II were: (a) participants made fewer errors in within-language conditions than between-language conditions and in full-attention condition than divided-attention condition, (b) a significant main effect of language in between-language condition was observed showing that participants produced more correct Swedish words, and (c) in between-language condition, although the main effect of attention was not significant, participants in the divided attention produced more Swedish words than English words.

The overall results show a clear dissociation between performance under short duration presentation/divided attention and performance under long duration presentation/full attention, as was expected. It seems that manipulating automaticity at encoding affects the bilingual word production. As is shown, there was no significant difference in within-

language conditions, showing that level of automaticity does not affect the processing of words in the within-language condition, and it does not matter if the response language is the participant's first or second language. But, level of automaticity may affect the processing of words in a between-language condition, especially when a person needs to access a word in L2 via his/her L1 (i.e., L2- L1 lexical access).

III. DISCUSSION

In both Studies I and II, bilinguals outperformed monolinguals in both episodic and semantic memory tasks, although this superiority was more pronounced in episodic memory. The results of these two studies raise two important questions that need to be discussed.

The first question that comes to mind is what is special with episodic memory? How is it related to semantic memory? As discussed earlier, episodic and semantic memory are two forms of declarative memory that appear to operate independently while interacting with each other. The nature of interaction between these two memory systems has been debated in models of memory for a long time. Tulving (1995) proposed a model for describing the relationship between episodic and semantic memory. The model is termed SPI (serial encoding, parallel storage, independent retrieval) and postulates process-specific relations among the memory systems, meaning that information gets into episodic memory only through semantic memory. But, how semantic memory develops on the basis of episodic memory and how the formation of episodic memory codes depends on the nature of semantic memory are important questions that need to be investigated very carefully.

The differential performance on episodic and semantic memory has been shown in many earlier studies (Bäckman & Nilsson, 1996; Nilsson, 1999, 2003; see also La Voie & Light, 1994; Verhaeghen & Salthouse, 1997, for meta-analyses).

It should also be noted that despite the functional dissociation between these two memory systems, recent neuroimaging studies reveal a common prefrontal activation during working memory, episodic memory and semantic memory (Nyberg, et al., 2003).

The second question is: do the observed cognitive advantages in these studies depend on the type of task used? As mentioned in earlier sections, the bilingual advantage has been found in tasks that required a high degree of attentional control and suppression and, which is consistent for both children and adults (for a review see Bialystok, 2005). On the other hand, to my knowledge, cognitive disadvantages of bilingualism are restricted only to TOT studies and verbal fluency tasks with adult bilinguals (Gollan & Acenas, 2004; Gollan, Bonanni, & Montoya, 2005; Gollan, Montoya, & Werner, 2002).

Memory research has shown that attentional control and development of cognitive strategies are two important factors in memory performance (Hasher & Zacks, 1988; Hasher, Zacks, & May, 1999; Zacks & Hasher, 1994, 1997; Zacks, Hasher, & Li, 2000; see also Verhaeghen & Cerella, 2003, for a review of meta-analyses). Along the same lines, aging research attributes memory decline in old adults, especially episodic memory impairments to the decline in executive functions as well as a frontal cortex impairment (Souchay & Isingrini, 2004; Souchay, Isingrini, & Espagnet, 2000; see West, 1996 for a review).

Bilinguals need control to prevent interference from one language when planning and processing the other language and since they practice this attentional control during a long period of their life, it appears that bilingualism improves suppression and inhibitory control skills which in turn fosters memory performance.

In memory research, suppression ability is also connected to working memory. The relationship between working memory capacity and its effect on bilingual language processing has been examined in many studies (for a review of experimental evidence see Michael & Gollan, 2005); discussion of this issue is beyond the scope of this thesis.

Keeping in mind the role of attentional control and suppression in bilingual memory, Study III was designed to investigate the effect of automatic and controlled processes in lexical access and lexical selection of the two languages. Here, too, the key role of an inhibitory mechanism was clearly apparent.

Assuming that the conceptual system activates the two languages of a bilingual simultaneously and by controlling the activation level, bilingual participants could select the right lexicon only in the conditions in which they could use strategies (i.e., long duration and full attention conditions). Earlier studies have indicated that lexical selection in the intended language is achieved only by means of active inhibition of the words in the non-target language (Green, 1998; Meuter & Allport, 1999).

Based on the results obtained from Study III, it was attempted to explain the relationship between bilingual memory representation and bilingual language processing in a model of bilingual word production. The model clearly points out the roles of activation and inhibition as two important concepts in lexical access and lexical selection.

METHODOLOGICAL ISSUES

As with all bilingual studies, an important issue in all three studies was the assessment of language proficiency of participants. In all studies, self-rating scales were used to measure the level of proficiency. For bilingual children in Study I, the Standardized Swedish Vocabulary Test was also used as another measure of language proficiency. It should be noted that this test, originally constructed for monolingual children, includes many culturally-related items. Since some bilingual children did not have the opportunity to use some of these words in their everyday life, this could have affected the result. Despite this fact, we found differences only in younger bilingual groups (grade 2), which is in line with earlier studies on bilinguals' receptive vocabulary disadvantage (see Bialystok, 2001).

Regarding Study III, it should be noted that although unrelated control trials were not included in the design explicitly, the number of solutions in stem decision was calculated and has been used for comparing different conditions (see Table 3, Study III). In a recent study, Barnhardt (2005) investigated the effect of number of solutions in a monolingual stem-completion task and found that while many-solution stem completion relies on production processes, single-solution stem completion relies on identification processes. All stems used in Study III were many-solution stems and there was no significant difference in the number of solutions in different conditions.

It is also necessary to emphasize that the results in this thesis should be interpreted with caution. In all three studies, a bilingual person is defined as a person who uses both his/her two languages interchangeably on a daily basis. Thus, the results are generalizable only to those bilinguals who encompass this definition.

CONCLUDING REMARKS

Research on bilingualism has a long history, and interest in bilingualism has been growing in many disciplines. During the past two decades, there has been great progress in the development of models of bilingual memory as well as in methodological techniques. However, there are a number of factors that should be taken into account in bilingual memory

research. These factors are depicted in the Figure 1 and are discussed throughout the thesis in different contexts.

Figure 1. Bilingual memory research schema

Perhaps the most important issue is the definition and clarification of the existing controversial concepts in order to reach an agreement. There are many questions that should be asked, but the researchers do not have simple answers. For example, Who is a bilingual? What is the lexicon? What does the lexicon include? What do we mean by semantic representation?

Other important questions that should not be ignored concern the level of proficiency in a given language. How can we measure level of proficiency? Which criteria should account for various levels of proficiency? Should the level of proficiency be determined in quantitative or qualitative terms? Unfortunately, there is still no universally accepted method for assessing bilinguals' proficiency level in L2 that could be applicable in all research domains.

Another caution that should be taken into account is the role of individual differences (e.g., Van Hell, 2002) and developmental effects. Some of the findings can be attributed to intra-individual development and inter-individual differences. There are a number of critical factors (e.g., level of proficiency, type of stimuli, learning strategy) that will determine the memory organization and representation structure, so that they may produce different patterns of word representation not only across different groups of bilinguals but also within individual bilinguals (see De Groot, 1995, for a review). It is needless to say that an individual's two languages are never static but are ever changing, as is also true of monolinguals' language development.

Yet another issue of interest is the type of stimulus material being used in the early and recent behavioural studies. In bilingual memory research, most studies have applied words or word pairs as experimental material, and little attention has been devoted to larger linguistic units such as sentences and texts (see Appendix, for a detail information). Bilingual sentence processing would be a promising area for future research (see Heredia & Altarriba, 2002, for a comprehensive review of studies in this area). Unlike the behavioural studies, neuroimaging studies on bilingual processing have used sentences (e.g., Chee, et al., 1999; Kim, et al., 1997) and short stories (e.g., Dehaene, Dupoux, Mehler, Cohen, Paulesu, Perani, Van de Moortele, Lehericy, & Le Bihan, 1997; Perani, Dehaene, Grassi, Cohen, Cappa, Dupoux, Fazio, & Mehler, 1996; Perani, Paulesu, Gellex, Dupoux, Dahanne, Bettinardi, Cappa, Fazio, & Mehler, 1998) as well as words (e.g., Hernandez, Martinez, & Kohnert, 2000; Illes, et al., 1999; Klein, Milner, Zatorre, Zhao, & Nikelski, 1999; Klein, et al., 1995; Price, Green, & Von Studnitz, 1999) as linguistic stimuli.

More importantly, task variations might contribute to the inconsistent findings across different studies (Dijkstra, Van Jaarsveld, & Ten Brinke, 1998; Durgunoglu & Roediger, 1987; Francis, 1999).

Finally, types of language can also influence the pattern of results. Since different languages have different structures, using different language combinations or language tasks may produce different results in different studies. As evident in the Appendix, previous studies have included a variety of languages, both alphabetic (e.g., Dutch, English, French, German, Spanish) and logographic languages (e.g., Chinese, Korean). In addition, some of the languages used in the studies appear to share the same-script (e.g., English and Spanish) while

some come from different language families and have different scripts (e.g., English and Hebrew or French and Chinese).

Keeping these cautions as a checklist, the results of this thesis can hopefully contribute to both educational and clinical implications for future research. Knowing that the regular use of two languages improves memory performance, educators can consider this notable finding in their language development programs as well as in their educational policy. Similarly, since the results of Study I indicated a superiority of bilinguals over monolinguals on action memory tasks, this area of research may offer a medium for investigating the processes of cognitive development in sign-language users in general and deaf individuals who use both sign-language and spoken language in their daily life, in particular. Recent research (e.g., Zimmer & Engelkamp, 2003) suggests that signing improves memory performance as enactment does. This enhancement effect was observed in both recall and recognition, although it was greater for recognition than for recall.

QUESTIONS OF INTEREST FOR FUTURE RESEARCH

Is there a need for a new bilingual model?

The existing models of bilingual memory can be divided in two categories. The first category includes models of memory representation (e.g., RHM) and the second comprises models of memory processing (e.g., Green's Inhibitory control model). Most models of bilingual memory are developed to explain bilingual comprehension and there are a few production models of bilingual memory. Some of these models have been adapted from monolingual models. For example, BIA is an extension of *Interactive activation* (IA) model (McClelland & Rumelhart, 1981, 1988). The IA model of monolingual word recognition distinguishes between three levels of word representation: orthographic (letter information), lexical (word information) and conceptual (representation of meaning). The model also proposes two types of activation for connecting these different levels, namely, a bottom-up activation from the orthographic to the lexical to the semantic level, as well as a top-down activation in the reverse order.

In recent years much progress can be observed in the development of models of bilingual memory resulting in the emergence of computational and connectionist models (see French & Jacquet, 2004, for a review). Still there are many issues that should be identified and explained in a theoretical framework (for a review of methodological and conceptual issues see Grosjean, 2004). Our knowledge of bilingualism as it interacts with aging is still at an early stage and may provide a promising focus for future research, for both theoretical and practical implications, such as clinical work with elderly bilingual patients.

Although neuroimaging techniques can provide important advances in theory development, a number of issues are still under debate regarding the limits of application of functional imaging methods. Some bilingual researchers (Grosjean, Li, Münte, & Rodriguez-Fornells, 2003, p. 160) have criticized the bilingual imaging studies for their ignorance of crucial factors in bilingualism research and their failure to interpret their data in terms of current theories of bilingual processing.

To summarize, further research is required to develop an integrated model of representation and processing applicable in both comprehension and production of second language. To accomplish this, there is a dire need for more behavioural and neuroimaging studies in a variety of tasks and with various participant groups.

Longitudinal or cross-sectional studies: which one and why?

Cross-sectional studies are easy to perform and can provide valuable descriptions of processes operating at a single point in time but they have problems in eliminating many extraneous variables. Employing a longitudinal design not only helps researchers to remove these confounding variables, but also makes it possible to explore intra-individual development as well as inter-individual differences in the processing of the first and second language as a function of time. Longitudinal data is also essential to decompose different influences that impact age-related changes. However, conducting a longitudinal study requires considerable founding, allocation of time, as well as careful planning.

It thus appears that the most informative and promising method in bilingual memory research is going to be a combination of cross-sectional and longitudinal approaches. Cross-sectional

studies make it possible to test specific hypotheses about differences between monolingual and bilingual groups who are at different developmental stages while a longitudinal design will allow the gathering of information about the bilinguals' language and memory development from birth through adulthood and old age.

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V. GLOSSARY

Activation model of bilingualism. This model assumes one integrated lexicon for both languages with parallel access to the different words of both languages in which lexical and semantic codes in both languages activate simultaneously.

Additive bilingualism. Situations where both languages are supported and develop in parallel. In such a situation, the child's cognitive development will benefit from the bilingual experience, leading to greater cognitive flexibility compared to his monolingual peers.

Analysis. The ability to represent increasingly explicit and abstract structures in the development of children's mental representation.

Automatic processes. Those processes that are assumed to be fast, to require minimal processing resources, and to occur without conscious control.

Backward translation. Translation production from a non-native (L2) and weaker language to the native (L1) and strongest language.

Between-language priming. A priming effect by which the target is a translation of a previously presented prime.

Between-language semantic priming effect. A priming effect of a word presented in the one language on a semantically related word presented in the second language, suggesting that the two languages under consideration are integrated at the conceptual level of representation.

Categorization task. The task in which participants are asked to express their knowledge about the super-ordinate category to which an exemplar belongs. This can be done in a variety of ways: by pronouncing the name of the category when the exemplar is presented, by indicating whether a pair of items belong to the same or different categories, or by making a yes/no judgment about whether an exemplar belongs to a target category presented prior to the item's presentation.

Category fluency task. A task in which the participant is requested to generate as many instances of a particular category as possible in a specified period of time to produce as many words as one can generate.

Central executive. The component of working memory that coordinates the other elements of working memory such as phonological loop and the visuospatial sketchpad.

Code switching. Language mixing that occurs when a word or a phrase in one language substitutes for a word or phrase in another language.

Cognates. Words with exactly the same form and meaning across languages, for instance *rico* in Spanish and *rich* in English. They are more likely to have a single translation equivalent than noncognates.

Cognate status. A measure of the orthographic and phonological similarity of the words in a translation pair.

Cognitive neuroscience. The branch of neuroscience that seeks to localize cognitive functions (such as memory, attention and language etc.) in the brain.

Compound bilingual. A person who has learnt two languages simultaneously in the same context, so that there is one single conceptual system for two linguistic systems attached to it.

Concreteness effect. The advantages for processing concrete words over abstract words that have been found in a variety of cognitive tasks, including paired association learning, translation, comprehension tests and free recall.

Control. The ability to selectively attend to specific aspects of a representation, particularly in misleading situations, in the development of children's mental representation.

Controlled processes. Those processes that are slow, resource demanding and under direct conscious control.

Coordinate bilingual. A person who has learnt L2 before puberty in separate contexts and developed two conceptual systems, one for each language.

Cued-word translation. A task in which the subjects are given the first letter of the to-be-produced translation in order to help them in their task.

Developmental hypothesis. With increasing proficiency in a second language, it occurs a development from one word-association structure to concept-mediation structure within the same individual.

Direct memory tasks. A task in which participants make explicit reference to their particular study experience with the prior item to perform the task (e.g., free recall, cued recall, and recognition tasks).

Dual-code (separate-code or dependence) view of bilingual memory. Holds that words in one language and their translations in another access different underlying conceptual representations or systems.

Episodic memory. Personal memory for specific episodes or events that is tied to particular times and places.

Facilitation paradigm. An experiment in which, effects of unconscious processing served to facilitate performance on a task.

Forward translation. Translation from the native (L1) and strongest language to a nonnative (L2) and weaker language.

Functional independence. The observation that an independent variable has a certain effect on a task assumed to tap one memory system and either no effect or a different effect on a task presumed to tap a different system.

Gerontology. The study of aging process from maturity into old age, as well as the study of the elderly as a special population.

Holistic view of bilingualism. Holds that a bilingual person should be regarded as an integrated whole, not as two monolinguals inside one person.

Homographic noncognates (or interlingual homographs). Words that are spelled identically in the two languages but with totally different meaning, for instance, "four" in English and "four", meaning "oven" in French, or "red" in English, which means "net" in Spanish.

Indirect memory tasks. Tasks in which, without reference to the prior study list, participants are asked to retrieve the first word that comes to mind.

Inhibitory mechanism. The selection or control process involving suppression of irrelevant, interfering or disturbing information.

Interlingual homographs. Words with the same written form across languages but with a completely different meaning (e.g., red is a colour word in English but means "net" in Spanish).

Lag. The number of items that intervene between the first and second presentation of an item.

Language priming effect. It is easier to recognize a word for bilinguals when it is immediately preceded by a word in the same language rather than when it is immediately preceded by a word in their other language.

Language-selective access hypothesis. Holds that bilinguals process two independent lexicons that are accessed selectively, depending on language cue information.

Letter fluency task. A task in which the participant is required to produce as many word as he/she can generate, beginning with a special letter (e.g., "S") in a specified period of time.

Lexical access. The process by which we are able to activate the right word in a given context.

Lexical decision task. A task in which the participants are asked to judge whether or not a string of letters form a real word.

Masked priming task. A task in which the prime is visually pre- and postmasked. Under these conditions, the priming stimulus is unavailable for conscious report.

Metamemory. One's knowledge and beliefs about one's own memory and memory processes in general.

Mixed list. A list that contains words of both languages.

Naming task. A task in which the participant is asked to pronounce the target words as quickly as possible. The speed of naming words that have been preceded by related or unrelated words serves as the evidence for priming.

Noncognate prime-target pairs. Translation pairs with a similar meaning, but dissimilar phonology and orthography.

Non-selective access hypothesis. Holds that bilinguals possess an integrated lexicon in which lexical representations from both languages are simultaneously activated during the processing of word input.

Nonword. A string of letters created by changing one or two letters of a real word.

Postlexical meaning integration. A process in which a participant tries to integrate the meanings of prime and target, after the recognition of both words in a pair of semantically related words, but before the response. When prime and target are related, this process facilitates a "yes" response on the LDT, but when prime and target are unrelated, it inhibits a "yes" response.

Prelexical strategic processing. A process in which the participants, using predictive strategies, generate semantically related candidate words from the prime before the target is represented.

Priming effect. The facilitative effect resulting from better performance on studied items than on non-studied items.

Psycholinguistics. A branch of psychology devoted to the study of verbal behaviour.

Pure list. A list that contains words from one language.

Repetition priming effect. A faster and more accurate responses to previously studied words than responses to words that have not been studied previously.

Retrieval. The active processes of accessing and bringing stored information into consciousness.

Semantic priming paradigm. A paradigm in which participants are required to respond as quickly as possible to a target word (e.g., cat) by either reading it or making a lexical decision about it, while a word termed the prime precedes the target. Participants respond more quickly to the target when it follows a semantically related prime (e.g., mouse) compared to an unrelated prime (e.g., chair).

Semantic priming effect. A facilitation in the speed and accuracy of responses to a word (e.g., doctor), produced by prior presentation of a semantically related word (e.g., nurse).

Simultaneous bilingualism. The acquisition of two or more languages during early childhood.

SPT-effect (or enactment effect). The enhancement of memory produced by an encoding condition in which subjects perform the actions themselves. Subject-performed actions (SPTs) are usually compared to verbal tasks (VTs).

Stimulus onset asynchrony (SOA). Interval between prime and target presentation in a priming paradigm.

Subtractive bilingualism. Refers to a situation characterized by a gradual loss of the first language as a result of increasing proficiency and use of the second language.

Successive bilingualism. Refers to all cases of bilingualism developed after the age of three.

Tip-of-the-tongue (TOT) experience. An explicit feeling of knowing the correct word, but an inability to actually produce it from memory.

Translation asymmetry. Translation from L2 to L1 is reliably faster than translation from L1 to L2.

Translation priming (or between-language repetition effect). A priming effect of a word presented in one language on its translation equivalent in the second language.

Translation production task. A task in which the participant is visually presented with a word in one of his/her languages and is required to produce its translation in the other language.

Translation recognition task. A task in which pairs of words are presented, each consisting of a word in one language and a word in the other language. The participants then have to decide whether or not the words within a pair are translations of each other.

Within-language priming. A priming effect by which the prime and target are presented in the same language.

VI. APPENDIX

Table 1. Studies investigating lexicosemantic organization in bilinguals

Author(s) & Date	Exp.	Language	List (Materials)	Task	SOA (ms)	Results	Conclusion
Abunuwara (1992)	1	Ar- He- En	pure (7)	Stroop	2000	L1-L3 > L3-L1 (interference) L1-L2 < L2-L1 (interference)	common LS separate LS
	2	Ar- He- En	pure (4)	Picture- naming	1000	intra < picture < inter L2-L3 > L1-L2	L2 & L3: separate LS L1 & L2: shared LS
Altarriba (1992)	1	En-Sp	pure (4) (TE)	LDT	200 1000	L1-L2 translation priming L1-L2 > L2-L1	separate LS common CS
Basden, et al. (1994)	1	En-Sp (HF)	mixed (1) (TE)	WFC (En, 22 s)		FC (written > mental > read)	transfer appropriate processing
		En-Sp (LF)	mixed (1)	WFC (En, 22 s)		FC [(written = mental) > read]	
		En-Sp (HF)	pure (3)	WFC (En)		FC (written > mental > read)	
	2	En-Sp (LF)	pure (3)	WFC (En)		FC (written = mental = read)	concept mediation
		Sp-En (HF)	mixed (1)	WFC + free recall		FC (written > mental > image > read)	
		Sp-En (HF)	pure (4)	WFC + free recall		FC [written > mental > (image = read)]	
Beauvillain & Grainger (1987)	1	En-Fr	pure (2) (homographs)	LDT	150 750	priming effect no priming	non-selective lexical access
	2	En-Fr En-Fr	pure (2) (homographs)	LDT	150	HF: priming	non-selective lexical access

Caramazza & Brones (1980)	1	Sp-En	3 category	categorization 2s	RT (W) = RT (B)	common CS
	2	Sp-En	3 category	categorization simultaneous	RT (W) = RT (B)	common CS
Chen (1990)	1	Ch-En (4 groups)	pure (4X12)	picture-naming translation	RT: L1 words < L1 pictures L2-L1 < pictures; L1-L2 > pictures grade 2 > grade 4 > grade 6 > college low-learning group: L1-L2 < pictures high learning group: L1-L2 = pictures word-learning group: words < pictures picture-learning group: pictures < words L1-L2 = picture naming in L2 for both groups in session 3	
	2	Ch-Fr (2 groups)	pure (4X10)	picture-naming translation		
	3	Ch-Fr (2 groups)	pure (3X10)	picture-naming translation		
Chen & Leung (1989)	1	Ch-En (prof.) Ch-Fr (beg.) Ch-En (beg.)	pure (4X15) pure (4X15) pure (4X15)	picture-naming/translation	L1-L2 = pictures L1-L2 < pictures pictures < L1-L2	
	2	Ch-En (beg.)	pure (4X12)	picture-naming/translation	L2-L1 < pictures L1-L2 > pictures	
	3	Ch-En (beg.)	pure (2X16)	category-matching	intermediate hypothesis	
Chen & Ng (1989)	1	Ch-En	mixed (2X30) (SR & TE)	LDT	300	RT: translation < semantically related RT: L1-L2 > L2-L1 translation priming > semantic priming
	2	Ch-En	mixed (6X16) (SR & pictures)	LDT	300	semantic priming: L1 = L2, W = B & pictures = words shared CS
Cristoffani, et al. (1986)	1	Sp-En (C)	mixed (2)	LDT	3s	WLP > BLP
	2	Sp-En (C)	mixed (2)	recognition		NC > C

De Groot & Nas (1991)	1	Du-En	pure (4) (C & SR)	LDT	240	WLRP > BLRP L1-L2 > L2-L1	
	2	Du-En	pure (4) (C & SR)	masked LDT	60	WLRP > BLRP unmasked P > masked P unmasked P > masked P	
	3	Du-En	pure (2) (NC)	LDT masked LDT	240 60	masked C = masked NC RP > AP WLRP > BLRP	
	4	Du-En	pure (2) (C & NC)	masked LDT	60	WLRP & BLRP for C & NC BLAP for C	shared CS for C
Dufour & Kroll (1995)	1	En- Fr	pure (4) (8 categories)	categorization	300 650	more fluent: L2-L1 < L1-L2 RT: more fluent < less fluent L2-L1 < L1-L2 RT: more fluent < less fluent RT“no” response: short SOA < long SOA	concept mediation by more-fluent bilinguals
Durgunoglu & Roediger (1987)		Sp-En	pure (5) (TE, HF)	WFC (50 min) free recall (15 min) recognition		read (Sp & En) = translation > image read (Sp & En) = translation = image > WL read (Sp & En) = translation > WL	separate common blend
Fox (1996)	1	En- Fr	pure (2) (SR)	LDT	550	only L1-L2 CLNP (-35 ms)	
	2	En- Fr	pure (2) (TE)	LDT	550	L1-L2 CLNP > L2-L1 CLNP (-44 ms) (-23 ms)	shared CS
Gerard & Scarborough (1989)	1	Sp-En	pure (1) (C, NC, & homographic NC)	LDT	500	HF: NC < C < homographic NC LF: NC < C < homographic NC LF: C < NC	separate LS
		En-Sp					

Gollan, Forster, & Frost (1997)	1	He- En	pure (2) mixed (1) (C & NC)	masked LDT	50	L1-L2 priming: C > NC within-language: C = NC	different script, translation priming for NC
	2	En-He	pure (2) mixed (1) (C & NC)	masked LDT	50	L1-L2 priming: C > NC within-language: C = NC priming: C (B) > C (W)	
	3	He-En	pure (2) mixed (1) (C & NC)	masked LDT	50	L2-L1 priming: C = NC within-language: C = NC priming: C (W) > C (B)	translation priming only in L1-L2, separate LS orthographic cue hypothesis
	4	En-He	pure (2) mixed (1) (C & NC)	masked LDT	50	no L2-L1 priming at all within-language: C = NC	
Grainger & Beauvillain (1988)	1	En-Fr	pure (2) (SR)	LDT	150 750	no AP AP	predictive strategy separate LS indirect lexical link
	2	En-Fr FE-En	pure (4) (SR)	LDT	150 750	AP: W but not B AP: B < W	
Guttentag et al. (1984)	1	Fr-En	pure (TE & SR)	SC (verbal)	simultaneous simultaneous simultaneous	TE & same cat < diff.cat	parallel semantic processing parallel semantic processing parallel semantic processing
	2	Fr- En	pure (2) (TE & SR)	SC (manual)		TE & same cat < diff.cat	
	3	Fr-En	pure (4) (TE & SR)	SC (manual)		diff.cat (W) < diff.cat (B)	
Jiang (1999)	1	Ch-En	pure (2) (TE)	masked LDT	50	L2-L1 (568 ms) < L1-L2 (710ms)	
	2	Ch-En	pure (2) (TE)	masked LDT	50	L2-L1 (632 ms) < L1-L2 (746ms)	
	3	Ch-En	pure (2) (TE)	masked LDT	100	L2-L1 (579 ms) < L2-L2 (704ms)	

	4	Ch-En	pure (2) (SR)	masked LDT	250	related (534 ms) < unrelated (541ms)	
	5	Ch-En	mixed (2) (TE)	masked LDT	100	L2-L1 (627 ms) < L2-L2 (697ms)	
Jiang & Forster (2001)	1	Ch-En	pure (2) (TE)	recognition masked LDT	3s /word 250	L2-L1 priming no L2-L1 priming	episodically mediated association
	2	Ch-En	pure (2) (TE)	masked LDT	250	no L2-L1 priming	
	3	Ch-En	pure (2) (TE)	recognition masked LDT	250 250	L2-L1 priming no L2-L1 priming	episodic priming only in long SOA
	4	Ch-En	pure (2)	recognition masked LDT	50 50	weak L1-L2 priming strong L1-L2 priming	
	5	Ch-En	pure (2)	recognition	250	weak L1-L2 priming	episodic model of L2
Jin (1990)	1	Ko- En	mixed (1) (TE & AP)	LDT	150	L1-L2 & L2-L1 translation priming L1-L2 associated priming translation > associated concrete > abstract	shared CS
	2	English	pure (1) (AP)	LDT	150	WLP: concrete = abstract	
Kearley & De Gelder (1992)	1	Fr-Du	pure (4) (AP)	LDT	200	WLP & BLP	shared CS
	2	Fr-Du	pure (4) (AP)	fast-rate R	200	WLP, no BLP	separate CS
	3	Du-Fr	pure (4) (AP)	fast-rate R	200	WLP, no BLP	separate CS
	4	Du-Fr	pure (2) (TE)	fast-rate R	200	L1-L2 > L2-L1	separate CS?

Kearley, et al. (1994)	1	Ch- En	pure (2) (AP)	LDT	250 2000	only L1-L2 priming no priming	asymmetry
	2	Du-Fr	pure (4) (AP)	LDT	200	only L1-L2 priming + WLP RT: WL < BL	asymmetry
	3	Du-Fr	pure (2) (TE)	LDT	200	priming: L1-L2 > L2-L1	separate interconnected
Kirsner, et al. (1980)	1	Hi-En	pure (4) (TE)	LDT	2s	WLP, no BLP	separate LS
Kirsner, et al. (1984)	1	En-Fr	mixed (2) (TE)	LDT		WLP > BLP	separate LS
	2	En-Fr	mixed (2) (TE)	LDT		WLP & BLP	separate LS
	3	En-Fr	mixed (2) (TE)	SC		no BLP	separate LS
	4	En-Hi	pure (1) mixed (1) (SR)	two word-LDT simultaneous		RT mixed = RT pure WLP & BLP	
	5	Fr-En	mixed (2) (TE)	LDT	0,2,32(lag)	WLP > BLP at lag 0	separate LS
Kolers (1963)		Ge-En Sp-En Thai-En	pure (4)	word association translation		concrete > abstract intralingual > interlingual	separate LS
Kolers (1966 a)		Fr-En	mixed (3) (T, NT, mixed)	free recall	1 word/s	translated > non-translated separate lists = mixed lists translations = exact repetitions	interdependence common CS

Kolers & Gonzalez (1980)	1	Engilsh	pure (20) (synonyms)	free recall (2 min)	1 word/s	exact repetitions > synonyms	
	2	Sp-En	mixed (2X20) (TE)	free recall (2 min)	1 word/s	L1-L2 = L2-L1 translations = exact repetitions	
	3	Sp-En	mixed (2X20) (TE)	recognition (2 min)		translations = exact repetitions	development of strategic skills
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Kroll & Curley (1988)		En-Ge	pure (6) mixed (6) (categories)	picture-naming word-naming		En: words < pictures more fluent: picture in L2 = L1-L2 less-fluent: picture in L2 > L1-L2	conceptual mediation lexical mediation
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Kroll & Stewart (1994)	1	English	pure (4X30) (categories)	picture-naming 500 word-naming recall (3 min)		pictures: categorized > randomized	category interference
	2	English	mixed (4X30) (categories)	picture-naming 500 word-naming recall (3 min)		RT: word < pictures pictures > words pictures: categorized = randomized RT: word < pictures	concept-mediation
	3	Du-En (fluent)	pure (4X18) (8 categories)	translation word-naming recall (3 min)		RT: translation > naming L1-L2 > L2-L1 categorized: L1-L2 > L2-L1 translation > words categorized > randomized categorized: L1-L2 < L2-L1	translation asymmetry category interference category advantage in recall
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Macnamara (1967)		Ir-En En-La	pure	naming L1 & L2 switching translation		naming > switching > translation	separate LS language-independence
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Meyer & Ruddy (1974)		En-Ge	mixed (SR)	LDT	simultaneous	WLP > BLP L1-L2 > L2-L1	common-code
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Potter et al. (1984)	1	Ch-En (fluent)	pure (6X16) (29 categories)	word-naming 250 picture-naming translation recall (5 min)		L1 word-naming < L1 picture-naming picture-naming: L1 < L2 picture-naming = L1-L2 translation L1 < L2 & pictures	concept-mediation
	2	En-Fr (nonfluent)	pure (4X24) (pictures)	word-naming 350 picture-naming translation recall		L1 word-naming < L1 picture naming picture-naming: L1 < L2 L2 picture-naming < L1-L2 translation L1 < L2 & pictures	shared CS
Sánchez-Casas et al. (1992)	1	Sp-En	pure (3) (C & NC)	categorization 60		CP, no NCP	C: shared LS
	2	SP-En	mixed (4) (C)	repetition blindness 130		no C effect	
	3	SP- En	pure (4) (C & NC)	cued translation 500		C < NC NC: L1-L2 > L2-L1	C: shared LS
Scarborough et al. (1984)	1	Sp-En	pure (2) (TE)	LDT 1s		WLP, no BLP	separate
	2	Sp-En	pure & mixed (TE)	LDT		mixed RT > pure RT	separate LS
Schwanenflugel & Rey (1986)	1	En-Sp	mixed (2) (SR)	LDT 300		WLP = BLP priming: L1-L2 > L2-L1	shared CS
	2	En-Sp	mixed (2) (SR)	LDT 100		WLP = BLP priming: L1-L2 > L2-L1	
Sholl, et al. (1995)	1	En-Sp	pure (2) (pictures)	picture-naming translation (transfer paradigm)		RT: L2 > L1 L1-L2 > L2-L1	asymmetry effect L1-L2: conceptual mediation L2-L1: lexical mediation

Smith (1991)	1	En- Fr (TE)	pure (4) (sentences)	WFC		BLP	separate LS shared CS
	2	Fr-En (TE)	pure (4) (sentences)	WFC (immediate) WFC (+30 min)		BLP = WLP BLP = WLP	
Taylor (1971)		En-Fr	mixed (6X3)	free association switching		L1 > L2 & W L > BL L2-L1 > L1-L2 frequent switches => less words	strong intra-language link; separate store
Tulving & Colotla (1970)	1	En-Fr-Sp	pure (54) (lists in 3 lengths: 12,18,24 words)	free recall	500	unilin > bilin > trilin (in SM) unilin = bilin = trilin (in PM)	separate
					2000	unilin > bilin > trilin (in SM) unilin = bilin = trilin (in PM) fast rate < slow rate	separate
Tzelgov & Eben-Ezra (1992)	1	He-En	pure (4) (SR)	LDT	240 & 840	WLP = BLP L2-L1 < L1-L2	common-code
	2	He-En	pure (4) (SR)	pronunciation	240 & 840	WLP = BLP	common-code
Tzelgov, Henik & Leiser (1990)	1	Ar- He	mixed (4) (SR)	Stroop		interference: WL > BL L1-L1=L2-L2	concept-mediation
	2	He-Ar	mixed (4) (SR)	Stroop		cognate < noncognate, L1< L2 L1-L1>L2-L2	word-association
Watkins & Peynircioglu (1983)	1	Sp-En	mixed (TE)	successive WFC	1 word / 1 sec	WL > BL > unrelated	no concept-mediation
	2	Tu-En	pure (TE)	WFC (15 sec)	1 word / 4 sec	WL > BL = unrelated	

Williams (1994)	1a	En-Fr	pure (4) (SS & AP)	masked LDT (15s) 728	SSP (34 ms) > APP (-9ms)	common CS
	1b	En-Fr	pure (2) (SS & AP)	LDT (20s) 720	APP	
	2a	Ge, It, Fr- En	pure (2) (SS)	masked LDT (15s) 50	related (707 ms) < unrelated (733 ms)	
	2b	Ge, It, Fr- En	pure (2) (TE)	masked LDT (15s) 50	related (690 ms) < unrelated (723 ms)	
	2c	Ge, It- En	pure (2) (AP)	masked LDT (15s) 50	related (641 ms) = unrelated (643 ms)	
	2d	Ge, It, Fr- En (AP)		LDT (15s) 240	related (656 ms) < unrelated (699 ms)	

Note. AP= associative priming, associated pairs; Ar = Arabic; BLP = between-language priming; C = cognate; Ch = Chinese; CP = cognate priming; CS = conceptual store; Du = Dutch; En = English; FC = fragment completion; Fr = French; Ge = Germany; He = Hebrew; HF = high-fluent; Hi = Hindi; Ko = Korean; L1 = first language; L2 = second language; LDT = lexical decision task; LF = low-fluent; LS = lexical representation; NC= noncognate; NCP = non-cognate priming; PM = primary memory; RP= related pairs, repeated priming; SOA = stimulus onset asynchrony; SC= semantic classification; SM = secondary memory; Sp = Spanish; SR = semantically related; SS = semantically similar; T = translated; NT = non-translated; TE = translation equivalents; Tu = Turkish; WFC = word fragment completion; WSC = word-stem completion; WLP = within language priming.