

LANGUAGE PROCESSING IN BILINGUAL SPEAKERS

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ABSTRACT

A brief review of concepts of bilingualism, its definitions, bilingual acquisition and findings of some psycholinguistic research studies that have been done to uncover the processes and representations that bilinguals use when they are processing language are presented in this article. It can be concluded that the different languages of bilinguals strongly interact during processing. Bilingual speakers and listeners seem to take advantage of the many universal characteristics between the languages they know, by representing their languages in a highly integrated way. In line with this conclusion, from a short overview of some recent research on language control and language switching, it seems that keeping interference from the different languages under control comes with a small but measurable cognitive cost.

Keywords: Language control, code-switching, language context, bilingualism, multilingualism, polyglotism, bilingual acquisition, interlocutor

INTRODUCTION

Little is known in cognitive neuroscience about the brain mechanisms and brain representations involved in bilingual language processing (Rodriguez-Fornells, Antoni et al., 2006).

Weinreich argued that it is difficult to give complete definition of the phenomenon of bilingualism, since one of the most significant features of bilingualism (multilingualism) - degree of proficiency of each given language - not only is unique in different bilingual individuals, but even cannot be considered a stable characteristic of the same speaker at different stages of mastering a foreign language (Weinreich, 1972).

About half of the world's population has some knowledge of more than one language (Grosjean 1982, p. vii). Widespread bilingualism is not a privilege but a necessity or unavoidable automatically acquisition of an L2 in addition to speaker's mother tongue. In the countries of the Commonwealth of Independent States (former Soviet Union), for example, majority of the population speaks Russian as fluently as their native language (Uzbek, Kazak, Kirgiz etc.).

According to a number of research studies, 'bilinguals activate both languages while processing words presented in one language' (Dijkstra and Van Heuven, 2002; Kroll and Stewart, 1994; Martin et al., 2009; Midgley et al., 2011; Wu and Thierry, 2012) Moreover, one of the most striking abilities of bilinguals is that of separating their two languages during the production of speech (Costa & Santesteban 2004). It means that they can speak both languages equally fluently. Bilinguals can produce words by selecting them from their L1 and L2 lexicons. Some bilinguals are even more proficient in their L2 rather than L1 due to everyday output in L2. They can control both languages equally and switch from one to another automatically.

What is bilingualism?

Defining bilingualism in just a few words is not easy, as each bilingual is an individual and has different bilingual features. There certain distinctions between ability and use of a language, or differences in proficiency between the two languages might be observed.

The terms “bilingualism” and “bilingual” are defined in a number of studies and change from source to source. Grosjean formulated bilingualism as ‘the regular use of two (or more) languages, and bilinguals are those people who need and use two (or more) languages in their everyday lives’ (1992:51). Bloomfield (1933:56) formulated it as “native-like control of two languages”.

‘Bilingualism is the phenomenon of speaking and understanding two or more languages’. The term can refer to individuals (individual bilingualism) as well as to an entire society (social bilingualism). ‘Bilingualism, multilingualism and polyglotism can all be used as synonyms for the same phenomenon’. (<https://www.smart-words.org/bilingualism.html>)

Bilingualism is the existence of two different languages within the speech repertoire of either an individual or a society. (<https://akademia.com.ng/what-is-bilingualism-and-diglossia/>) Briefly speaking, we can define bilingualism as the ability to express oneself without any difficulty in two languages.

Bilingual speakers might be proficient in both languages or their one language can be dominant. People usually become bilingual because they need it in their day-to-day lives. As a result the degree of bilingualism may vary from one individual to another. Bilinguals are not necessarily perfectly fluent in their languages; it is in fact quite common to have a dominant language.

It is to be noted that being able to express yourself in two languages takes time. It is not after studying a language for six months that one can become bilingual. A specific bilingual person is not necessarily “completely” coordinated, compound or subordinate. Indeed, a bilingual can be coordinated for certain parts of the linguistic system, at the level of syntax and semantics, for example, but subordinate to the phonological level. It has a strong accent in its L2, while having impeccable syntax and a rich lexicon.

Thus, an ideal coordinated bilingual would have two completely separate linguistic systems and there would never be a mix of languages at any level. It should also be noted that the organization of the linguistic system and thus the state of bilingualism of a person can change depending on his or her experiences during life. Therefore, “there can be degrees of bilingualism - at one extreme there are those people who have native-like control over two languages and at the other extreme are those people who have just begun to acquire a second language” (Liddicoat, 1991). These degrees can be assessed in speaker’s command of language in all four skills. For some children of immigrant families or people residing in postcolonial countries, where official language is not their native one, an L2 is dominant, whereas only oral skills of listening comprehension and speaking of their L1 are developed well enough.

People should not compare bilingual speakers’ linguistic abilities of using certain languages to monolinguals’ ones. “The bilingual should not be considered as the sum total of two complete or incomplete monolinguals. The presence of two languages and their interaction in the bilingual produces a different but complete language system which responds to the individual’s needs to communicate using one or other language or, in some settings, a mixture of both languages” (Liddicoat, 1991).

A number of researches on L2 learning show that there is transfer from the native language (L1) to the weaker L2 (e.g., Kroll & Stewart, 1994; MacWhinney, 2005, Kroll J. et al., 2012). However, ‘if all that develops during L2 acquisition is the L2 itself, then the L1 should remain relatively constant, imposing constraints that may shape L2 learning depending on the structural relations between the two languages’ (e.g., Pienemann, Di Base, Kawaguchi, & Hakansson, 2005), but otherwise enabling the L2 learner to enjoy all of the native language privileges normally associated with monolingual use of the L1 is that the bilingual is not two monolinguals in one (e.g., Grosjean, 1989; Malt & Sloman, 2003), with consequences not only for the L2 but also for the native language’ (Kroll J. et al., 2012). These changes reflect L2 learning, increasing L2 proficiency, and the context of language use.

Kroll J. et al. (2012) in their late study state that ‘bilinguals cannot switch off one of the two languages at will. When they listen to speech, read, or prepare to speak in only one of their two languages, information about the language not in use is also active and influences performance’. (Dijkstra, 2005; Kroll, Bobb, & Wodniecka, 2006; Marian & Spivey, 2003; Kroll, Dussias, Bogulski & Kroff, 2012) These cross-cultural interactions can be seen for highly skilled bilinguals, they are not restricted to individuals at low levels of proficiency. Similar interactions can be observed for bilinguals whose two languages differ in script, such as Japanese and English (Hoshino & Kroll, 2008) and for bimodal bilinguals who use one written or spoken language and another signed language (Emmorey, Borinstein, Thompson, & Gollan, 2008a; Morford, Wilkinson, Villwock, Pin˜ar, & Kroll, 2011; Kroll, Dussias, Bogulski & Kroff, 2012). Besides, there is also a possibility of parallel activation of the bilingual’s two languages which leads to creating cross-language interactions.

Bilingual acquisition

The concept of bilingualism is interpreted differently in the field of SLA versus fields such as psychology and education. Gass et al. (2013) claim that “L2 researchers reserve use of the term for only those that are truly, as shown through some linguistic measure, the equivalent of NSs of two languages. Thus, from the perspective of L2 researchers, bilingual refers to someone whose language is in a steady state and who has learned and now knows two languages”. In general, SLA researchers are most interested in individuals who are in the process of learning, not those who have learned two languages earlier. Edwards (2006) discusses bilingualism by saying: “Everyone is bilingual. That is, there is no one in the world (no adult, anyway) who does not know at least a few words in languages other than the maternal variety. If, as an English speaker, you can say *c’est la vie* or *gracias* or *guten Tag* or *tovarisch* – or even if you only understand them – you clearly have some command of a foreign tongue... The question, of course, is one of degree” (Edwards, 2006:7). Bhatia (2006) with this in his mind, states it in an interesting way when he says, “the process of second language acquisition – of becoming a bilingual”. Gass et al. (2013) interpreted Bhatia’s (2006) expression as “the result of SLA is a bilingual speaker”. However, Valdes (2001a) states that “the term bilingual implies not only the ability to use two languages to some degree in everyday life, but also the skilled superior use of both languages at the level of the educated native speaker”. She also defines the bilingual as someone who can “do everything perfectly in two languages and who can pass undetected among monolingual speakers of each of these two languages” and referred it to as the “mythical bilingual”. Taking into account all the above-mentioned definitions it could be concluded that the “term bilingualism can refer to the process of learning as well as the end result, the product of learning” (Gass et al., 2013).

Deuchar and Quay (2000) define bilingual acquisition as “the acquisition of two languages in childhood” (p.1), although they point to the difficulties involved in this definition, given the

many situations where bilingualism takes place. They point to De Houwer (1995), who talks about bilingual first language acquisition, referring to situations when there is regular exposure to two languages within the first month of birth, and bilingual second language acquisition, referring to situations where exposure begins later than one month after birth but before age 2. Wei (2000, pp. 6-7) presents a useful table of various definitions/ types of bilinguals.

Table 1. Definitions of Bilingualism
(Source: From The bilingual reader by L. Wei, 2000)

Achieved bilingual	Same as late bilingual
Additive bilingual	Someone whose two languages combine in a complementary and enriching fashion
Ambilingual	Same as balanced bilingual
Ascendant bilingual	Someone whose ability to function in a second language is developing due to increased use
Ascribed bilingual	Same as early bilingual
asymmetrical bilingual	See receptive bilingual
Balanced bilingual	Someone whose mastery of two languages is roughly equivalent
Compound bilingual	Someone whose two languages are learnt at the same time, often in the same context
Consecutive bilingual	Same as successive bilingual
Co-ordinate bilingual	Someone whose two languages are learnt in distinctively separate contexts
Covert bilingual	Someone who conceals his or her knowledge of a given language due to an attitudinal disposition
Diagonal bilingual	Someone who is bilingual in a non-standard language or a dialect and an unrelated standard language
Early bilingual	Someone who has acquired two languages early in childhood
Functional bilingual	Someone who can operate in two languages with or without full fluency for the task in hand
Horizontal bilingual	Someone who is bilingual in two distinct languages which have a similar or equal status
Incipient bilingual	Someone at the early stages of bilingualism where one language is not fully developed
Late bilingual	Someone who has become a bilingual later than childhood.
Maximal bilingual	Someone with near native control of two or more languages
Minimal bilingual	Someone with only a few words and phrases in a second language
Natural bilingual	Someone who has not undergone any specific training and who is often not in a position to translate or interpret with facility between two languages
Passive bilingual	Same as receptive bilingual
Primary bilingual	Same as natural bilingual
Productive bilingual	Someone who not only understands but also speaks and possibly writes in two or more languages
Receptive bilingual	Someone who understands a second language, in either its spoken or written form, or both, but does not necessarily speak or write it
Recessive bilingual	Someone who begins to feel some difficulty in either understanding or expressing him or herself with ease, due to lack of use
Secondary bilingual	Someone whose second language has been added to a first language via instruction
Semibilingual	Same as receptive bilingual
Semilingual	Someone with insufficient knowledge of either language.
Simultaneous bilingual	Someone whose two languages are present from the onset of speech

Subordinate bilingual	Someone who exhibits interference in his or her language usage by reducing the patterns of the second language to those of the first
Subtractive bilingual	Someone whose second language is acquired at the expense of the aptitudes already acquired in the first language
Successive bilingual	Someone whose second language is added at some stage after the first has begun to develop
Symmetrical bilingual	Same as balanced bilingual
Vertical bilingual	Someone who is bilingual in a standard language and a distinct but related language or dialect

It could be seen from the Table 1, according to Gass et al. (2013) that ‘the terminology used in bilingualism is far-reaching and overlaps to some extent with SLA. For example, successive bilingual describes the scope of SLA research. Importantly, however, it is difficult to pigeon-hole all types of bilingualism, because there are numerous situations in which individuals use two languages, from growing up with two to achieving bilingual status as adults, to having the L2 as virtually their only language (e.g., displaced refugees, immigrants). Further, there are different combinations of ability. For example, there are those who function well in some contexts (talking with one’s family), but who are not literate in that language, versus those who function well academically in both languages’.

Gass et al. (2013) claim that there have been and continue to be misunderstandings regarding the advantages of being bilingual. One can think of advantages in a number of domains. Baker and Prys Jones (1998) discuss **communicative** advantages, **cultural/economic** advantages, and **cognitive** advantages. With regard to the first of these, some are fairly obvious, including talking to immediate and extended family members. One can imagine a situation in which families emigrate to a country where another language is spoken; the children learn the new language and, for all practical purposes, are NSs of that language; they only barely understand the language of their parents, having become fluent in the language of the new country, whereas the parents do not learn the language of the environment. The communication gap widens between children and parents, with the unfortunate result of virtual non-communication between the two generations. Beyond these instances of family communication, bilinguals, living in a world of regular language monitoring, often show greater sensitivity to the communicative needs of others. Similarly, having experience in more than one culture provides an understanding of cultural differences among peoples. Further, it is obvious that **economic** advantages abound in all areas of work.

Finally, there are **cognitive** advantages, including divergent thinking, creative thinking (e.g., Adi-Japha et al., 2010), and metalinguistic awareness. Metalinguistic awareness is the ability to think about (and manipulate) language. In other words, metalinguistic ability allows one to think about language as an object of inquiry, rather than as something we use to speak and understand language. Bialystok (2001a, 2001b) has found bilingual children to have superior abilities in judging grammatical accuracy compared to monolingual children. Bialystok (1987) also investigated bilingual and monolingual children’s abilities to count words, which reflects knowledge of what a word is and knowledge of the relationship between word and sentence meanings. She found that bilinguals were advantaged over monolinguals in both of these domains: “Bilingual children were most notably advanced when required to separate out individual words from meaningful sentences, focus on only the form of or meaning of a word under highly distracting conditions, and re-assign a familiar name to a different object” (Bialystok, 1987, p. 138).

According to Gass et al. (2013), “bilinguals tend to have better abilities in areas that demand selective attention, because that is what one has to do when there is competing information (e.g., two languages). Thus, bilinguals’ awareness of language comes at an early age. Knowing two languages provides them with the skills to separate form from meaning, which in turn facilitates reading readiness. Advantages are found even as early as 7 months. Kovacs and Mehler (2009) found that bilingual children at 7 months of age are significantly faster at adapting to new conditions, as evidenced by looking at a new location when hearing puppets speaking a new language”.

Language control process and code-switching in bilingualism

Language control is a unique process which is being discussed by a number of researchers and psycholinguists. Speaking one language rather than another involves selecting and articulating words that meet the intended meaning. The precise way in which this process is controlled may depend on the language context. We contrast a context in which a speaker uses just one of their languages to name objects in an experimental session with one where they are required to switch between languages on the basis of a color cue. For example, blue may signal that the picture is to be named in Italian whereas red may signal that it is to be named in German. In principle, only one language need be active in the single language context whereas both languages must be active in the dual language context. However, research indicates that the languages of bilingual speakers can be jointly active (e.g., Dijkstra et al., 1998; Van Hell and Dijkstra, 2002; Von Studnitz and Green, 2002, see van Heuven and Dijkstra, 2010 for a review) at least to the level of phonology even in a context that requires just a single language (Wu and Thierry, 2010b).

It is commonly believed that “switching and mixing languages are frequent in many bilingual speakers, especially when the interlocutor is able to understand both languages”. However, it is appropriate mention here that “fluent bilinguals switch from one language to the other and are able to separate both languages completely and without too much effort” (Rodriguez-Fornells A. et al, 2006). Nevertheless, code-switching is also frequently observed, as bilinguals tend to introduce words from the other language into the language that they are currently using. It has been argued that “both switching proficiency and code-switching are related to the degree of activation of the target and non target languages at a given moment” (Grosjean, 1997; Paradis, 1989; Rodriguez-Fornells A. et al., 2006).

Wei (2000) discussed the control requirements for speaking one language (L1) rather than the other language (L2). According to him, ‘it is evident that the devices for recognizing words in L1 must be active and that the device for producing them must be selected. Selection is partially a matter of increasing the activation of L1 but, principally, it is a matter of suppressing the activation of L2 words so that words from that system do not get produced. The output from L2 could be suppressed within the system itself (internal suppression) or by the L1 system externally suppressing the activity of L2 (external suppression). Internal suppression restricts the retrieval of word sounds from L2. External suppression, indicated by an inhibitory link to the output of L2 at the stage of phonological assembly, suppresses the activation of L2 words at the assembly stage’ (Wei, 2000).

It is proposed that the suppression of L2 is achieved externally in spontaneous use. This proposal predicts that dysfluencies in L1 will occur whenever there is an L2 expression of a concept which is more available than one in L1. For instance, L2 may possess a single word or idiom which expresses an idea that demands a novel phrase in L1. In order to produce the L1 phrase, the alternative in L2 must be suppressed.

If we speak about the case of code-switching, according to Wei (2000), “there need be no external suppression of L2 at all; at least in the simplest case, such as continuous word association, the output can be free to vary according to which words reach threshold first. Indeed in this circumstance, mixing languages is certainly no slower than producing associations in only one language (Taylor, 1971). In the case of normal speech a word cannot be produced unless it fits the syntax of the utterance. Accordingly, for example, an adverb will not be produced in a slot requiring a noun. Switches then will obey the syntactic properties of the two languages although no special device or grammar is required to achieve this goal. Code switches most often involve single words, especially nouns (Pfaff, 1979), though ones involving phrases or entire clauses also occur. In these latter cases, we suppose that structures from L2 reach threshold earlier. Since any words produced must meet the structural conditions, such a scheme predicts that code switches will preserve the word order in both languages” (Wei, 2000).

A more complex form of regulation is needed in the case of translation. Both language systems are required and when translating from L2 to L1 the output system for L2 must be suppressed. In principle, such suppression may be achieved internally or externally (as noted above). In practice, however, since translation into L1 requires that the speaker does not simply repeat the message in L2, it is proposed that suppression of the output from L2 is achieved internally in the same way as a monolingual speaker might avoid simply repeating a word or a phrase just heard. To recap, when speaking L1 spontaneously, L2 is externally suppressed, whereas when translating from L2 to L1 the output of L2 is internally suppressed.

Since distinct inhibitory means are used in spontaneous speech and in translating, it follows from the claim that resources are consumed in such activities that speaking may be affected by the nature of the previous activity. For example, in a paced task where the rate at which resources are used exceeds the rate at which they are replaced, there should be a “fatigue effect.” A bilingual will be slower to name pictures in L1 after a session of such naming compared to a session where L2 names had to be translated into L1. In the latter case no L1 inhibitory resources would have been used to regulate the L2 system and hence would be available for naming in L1 in the second session.

It is appropriate to mention here that “if other nonlinguistic systems also consume the resources provided by the generator then the use of such systems would affect the control of speech” (Wei, 2000). For example, as stress or anxiety increase, speech should be disrupted especially in a person’s weaker language. Empirical research supports this expectation (Dornic, 1978). A further factor which may exert a profound effect on the availability of resources is brain damage.

Fluent code-switching is likely to recruit other structures implicated in language control and so studying it is important. Green (2011) asserts that it is impossible to know the neural bases of code-switching but possible to know that “those who code-switch are adept at adapting words to the current syntactic context though of course there will be individual differences in the inventiveness of such code-switches” (Green, 2011). Neuropsychological data implicate cerebellar structures in the control of morphosyntax (Fabbro et al., 2000). For example, Silveri et al. (1994) found that damage to the right cerebellum led to morphological deficits including inappropriate substitutions of bound grammatical morphemes. The fundamental idea is that right cerebellum acts together with left frontal structures as part of a language control circuit (Fabbro et al., 2000). Critical support for this notion comes from data showing that damage to the right cerebellum suppresses activation in left frontal cortex and elicits aphasic symptoms.

Reperfusion of the cerebellum reduces such symptoms (Marien et al., 2001; as cited in Green, 2011).

Code-switching involves adapting morphosyntax. Given the neuropsychological data, we can predict that such adaptation will involve the right cerebellum. From a functional point of view, since code-switching involves the online adaptation of the morphosyntactic resources of each language, fluency in code-switching requires timing and synchronization – a role for which the cerebellum is also well suited. A plausible prediction from existing data is that code-switching is mediated by the co-activation of right cerebellar regions and left frontal cortex. Research on code-switching is therefore important for extending our understanding of language control in bilingual speakers and building on the model of Abutalebi and Green (2007, 2008).

Lexical Representations

In essence, being bilingual means having more than one lexical representation to express the same meaning. English–French bilinguals (bilinguals whose native language is English and whose second language is French) for instance can refer to the barking pet by the English word *dog* or by the French word *chien* [dog]. The most simple and intuitively appealing theory about these lexical representations would probably be that bilinguals have two separate lexicons (mental dictionaries): one lexicon that contains all the words of their native language (L1) and another lexicon that contains the words of their second language (L2). Surprisingly, a lot of evidence has been gathered against this hypothesis. Many studies have found that lexical representations from the first language are accessed during processing words from the second language and vice versa.

Language Processing in Bilinguals

As bilinguals must constantly negotiate between two potential lexical choices in order to retrieve meaning, the study of bilingualism is an effective way in which to assess the potential modularity or interactivity of language processing. (Heather, Th., 2011) Traxler (2012: 419) asserts that ‘the first rule of bilingualism is that the two languages compete’, and indeed research has shown that lexical information from both languages is automatically activated before the appropriate language term may be selected (Bailystok et al., 2004). For example, English and German-speaking bilinguals would automatically activate both words ‘dog’ and ‘Hund’ when presented with a ‘domesticated carnivorous animal’(OED, 2012), but have to ignore the undesirable word choice depending on the context. These interactions are present when a second language is acquired as well as during comprehension and production in capable bilinguals (Kroll & Schwartz, 2006).

There are two models submitted by Potter et al. (1984) to account for this interaction: the Word Association model (WA) and Concept Mediation model (CM), the suitability of which they investigated by having bilinguals of ranging proficiency name pictures and translate words. The WA model proposed that new second language (L2) words would be accessed indirectly after being translated into the existing first language (L1) system, thus for example the German ‘Hund’ would be immediately identified as the English-dominant ‘dog’ and bilinguals would perform better on the translation aspect of the study, whilst in the CM model meanings ‘dog’ and ‘Hund’ would be accessed directly. The experiments found that participants named pictures and translated words at approximately the same average speed, indicative of CM. Bialystok (2001: 102), also surmises that the growing body of research including, among other areas, research into Stroop interference, suggests that the two languages are presented independently.

If bilinguals indeed process language by quickly selecting and rejecting conflicting information, they should, in theory, perform better than monolinguals in incongruent examples in the Stroop task (1935), in which participants must verbally identify the colour of a word, whilst resisting the urge to read the word itself. Stroop Interference occurs when the automaticity of reading prolongs the time taken to focus on the colour and produce a reaction, whilst Stroop Facilitation features shorter reaction times (RTs) when the stimuli are presented congruently, for example the word 'RED' written in red ink, and do not feature this conflict (Van Heuven et al., 2011: 1). To overcome the disparity between ink colour and word written, conflict resolution processes and cognitive control is required, skills already utilised by bilinguals to make choices between languages (Van Heuven et al., 2011). As a result, bilinguals are more efficient in executive control tasks, such as Stroop, whilst monolinguals are not inhibited by these constant conflicting lexical choices and perform better in lexical retrieval tasks which bilinguals find more effortful (Bialystok et al., 2008). With their greater level of cognitive control and experience with handling rival information, bilinguals may read words on the Stroop task less automatically than monolinguals and thus be less susceptible to the Stroop effect (Bialystok et al., 2008). Moreover, bilinguals are faster in the Simon task, in which participants must ignore the spatial position of the word and press on a keyboard a button on the left or one on the right to indicate true or false (Bialystok et al., 2005).

However, although this research is highly supportive of CM, Zhang et al. found that Chinese-English bilinguals translated English words into Chinese in a morpheme lexical decision task (Zhang et al., 2011). When presented with English word pairs whose Chinese translations repeated the first morpheme, reaction times were faster than for words which did not translate into such straightforward morphologically repetitive words, suggesting that bilinguals automatically translate into their L1.

Chinese-English bilinguals exhibit right-hemisphere activation when reading both languages, whilst American students learning to read Chinese later as L2 only demonstrated right-hemisphere activation when reading Chinese characters (Perfetti et al., 2007). Whilst performing the Simon task, magneto encephalography (MEG) imaging revealed that fast responses in the conflict examples resulted in increased activation in Broca's area for bilinguals, but in the dorsolateral prefrontal cortex and other frontal areas of monolinguals (Bialystok et al., 2005). Bilingualism also results in denser grey matter in the left inferior parietal cortex and, as Perfetti et al. and Bialystok et al. demonstrate, affects how the brain is structurally organised to accommodate the two languages (Michelli et al., 2004). It is evident therefore that bilingualism and the necessity to suppress undesirable information has a profound effect on the brain and how language is processed.

Heather, T. (2011) to investigate this conflict bilinguals experience when retrieving a word performed a Stroop task on an equal number of bilinguals and monolinguals. He showed 5 monolinguals and 5 bilinguals the same pattern of 40 colour words on a laptop, recorded their vocal responses and analyzed the reaction time taken to respond to each incongruent word. The Stroop task replicated the process of interference and competition (in this case between the instinct to read the word and identify its colour) experienced by bilinguals, whose conflict occurred between two semantically equivalent words, and thus was an interesting method of testing a participant's ability to handle this conflict. By directly comparing the reaction times of the two groups of participants Heather Thomas (2011) was able to find either support for the WA or CM models of bilingual language processing.

The study was expected to support the previous studies and suggest that bilinguals performed better than monolinguals in the Stroop task (Bialystok, 2001; Bialystok et al., 2004; Okuniewska, 2007; Bialystok et al., 2008; Van Heuven et al., 2011), but the mean RTs were in fact faster for monolinguals, so the data did not support the CM model. The kind of bilinguals used or the ages of participants are factors which could account for this surprising result.

One proposed interpretation for why Heather's results did not corroborate with the expected prediction is due to the fact that the bilingual participants were mostly non-English dominant, the language utilized exclusively by the task, and thus might have been more likely to translate as Participant 1 did. Research had shown that balanced bilinguals responded faster than unbalanced bilinguals in the Stroop task (Zied et al., 2004). The two English-dominant bilinguals were more balanced bilinguals than the others used in the study, and although one of the two produced anomalous results, the other produced the fastest bilingual mean time (693ms), which corroborated with Zied et al.'s findings.

Age of acquisition was another important factor, as sequential bilinguals (Participants 1, 6 and 7) had a longer delay before being exposed to their L2 and thus the author would expect there to be greater input from their non-English language than the two balanced bilinguals of the study (Participants 4 and 5) (Harley, 2010: 84). Mägiste (1984) in her language proficiency hypothesis suggested that more balanced bilinguals would suffer less from the interference effect, and as Participant 5 does indeed have the fastest bilingual mean RT this would appear to corroborate. However, one example is not enough to base a definite conclusion on and more research would have to be done.

Another explanation for the data's inconsistency with existing research was due to the age range selected. Zied et al. (2004) found when studying old and young age groups of French Arabic bilinguals that there was a correlation between age and diminished performance in the Stroop task, and Bialystok et al. similarly produced faster reaction times from younger participants in their Stroop task (2008). Ludwig et al.'s Stroop task also revealed that older participants had longer RTs than younger ones, who were able to resist the dominant response to read the word more easily (2010). Because of this research Heather (2011) decided to select participants of a close age range so as not to receive a range of times which could be attributed to their age, but selecting a number of older participants in addition would have perhaps featured fewer capable monolinguals.

Okuniewska (2007) found the 20-29 age range to be optimal for efficiency in this area, and Bialystok et al. similarly found that bilinguals were faster in the Simon task in all age groups except for in the category of young adult (20-30 years, in which all but one of the participants fall), where monolinguals and bilinguals produced equal RTs. Furthermore, high intellectual level as well as age had been shown to contribute to better performance in the Stroop task (MacLeod et al., 1991). As mean age of Heather's (2011) participants was 20.7 years with a range of 17-23 years, and in full-time education, they were arguably in optimum condition for doing the Stroop task and thus both monolinguals and bilinguals would perform well regardless of the number of languages spoken. Researcher's faster monolingual times might therefore be explained by their young age and level of education, and to investigate this further more age groups would have to be involved in the study.

According to Heather (2011), although the study did not provide evidence for the CM model of language processing, this was probably due to the simplicity of the experiment and the narrow range of participants featured. Combining this with different age groups and different

intellectual levels would have been more illuminating. Moreover, Stroop Facilitation (1935) by way of congruent colour examples would also have been useful in order to determine the individual differences and provide a non-conflicting point of comparison (Heather, 2011).

CONCLUSION

The question of how bilingual individuals process languages has attracted significant attention for decades. Findings in Wu and Thierry's (2012) study bring new insights into bilingual lexical organization and the functional mechanisms underlying word comprehension. They demonstrate parallel access to translation equivalents in the native language when words in the second language are involuntarily processed in the context of low-level, nonverbal task. This suggests that lexical representations across languages are connected in the same network as those within a language, supporting the view of integrated lexical representations. However, evidence has also been found, in the same experiment, that implicit access to translations in the first language is rapidly inhibited before its activation level reaches consciousness and before it can affect behavioral performance (Wu and Thierry, 2012).

This suggests that previous findings of cross-language interaction/ interference that were yielded in explicit language processing context might be confounded by task-dependent variables and therefore, underestimates the efficiency of the inhibitory control mechanism at play in bilinguals. Future studies will be needed to test the generalizability of this conclusion by examining bilinguals at different levels of second language proficiency.

According to Kroll et al. (2012), the review of studies suggests a language system that is highly permeable across the bilingual's two languages, with information about words and grammatical structures activated concurrently even while a bilingual is reading text or listening to speech in one of his or her two languages alone. A very counterintuitive aspect of this body of research is that the activity of the unintended languages is not simply a matter of proficiency. Both languages appear to be active in even highly proficient bilinguals. Although much of this research is at a very early stage of development, it holds important implications for characterizing bilingual performance and for the way in which bilingualism provides a model more generally for investigating constraints and plasticity in language processing. The presence of two active and competing languages makes the bilingual an especially informative source for psycholinguists interested in how cognitive systems compete and in how the resulting competition is resolved.

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