EVIDENCE FOR THE INHIBITORY CONTROL-BASED LANGUAGE-NON-SPECIFIC LEXICAL SELECTION IN BILINGUALS

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Abstract

In the context of the ongoing and overwhelming debate on the 'language-specific' versus 'language non-specific' nature of bilingual lexical selection, the current study aimed at investigating this issue using a 'semantic relatedness judgment' paradigm. A group of proficient Malayalam-English bilinguals were required to judge the semantic relatedness (i.e., semantically related vs. unrelated) of word pairs in two language conditions (viz. monolingual – L2-L2 & cross-lingual – L2-L1). The semantically related monolingual and cross-lingual stimuli were judged faster compared to their semantically unrelated counterparts. Monolingual word pairs were judged faster compared to their cross-lingual counterparts both in the semantically related and unrelated conditions. Findings of the present study supported the 'language non-specific' nature of lexical selection in bilinguals. In addition to this, it also provided evidence for the role of inhibitory control of the non-target language in bilingual lexical selection.

Key Words: Bilingualism, Language-specific lexical selection, Language non-specific lexical selection, Semantic system

One of the most remarkable abilities of bilingual speakers is that of separating their two languages during the production of speech (Costa & Santesteban, 2004). Although the speech of highly proficient bilinguals in their second language (L2) often carries traces (e.g., accent, syntactic structures) of the first language (L1), it rarely exhibits lexical intrusions (Poulisse, 1999). That is, these bilinguals are competent enough at selecting and producing words from only one of their lexicons, either from L1 or L2 according to the communicative context. The contemporary investigations of the bilingual mental lexicon focus to uncover this intricate mechanism. In the following sections, we provide a brief overview of the mono- and bilingual language production system.

Lexical selection in monolingual speech production

A central stage in language production – the lexical selection – is the process of retrieving the words from the lexicon that match the speaker's communicative intention (Caramazza, 1997; Dell, 1986; Levelt, 1989; 2001). A selection mechanism is often believed to function as several lexical representations are activated due to spreading activation from the semantic system to the lexical level. That is, the activated conceptual node spreads a proportion of its activation to its corresponding lexical node. In this context, the semantic system activates not only the word that matches the intended meaning but also other semantically related items. For example, when naming the picture of a dog, not only the lexical node "dog" is activated, but also other related lexical nodes such as "cat" and "bark". It is assumed that the lexical selection mechanism is in charge of deciding which of the activated lexical nodes needs to be selected for further processing. Further, it is widely accepted that the level of activation of lexical nodes is the critical variable for deciding which node is to be selected. Thus, in general, the lexical selection mechanism would pick out the node with the highest level of activation which, in the normal case, corresponds to the intended meaning. However, some models of lexical access assume that this mechanism is also sensitive to the level of activation of non-target (yet activated) lexical nodes that act as competitors (e.g., Roelofs, 1992).

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Lexical selection in bilingual speech production

Applying the lexical selection mechanism in the case of bilinguals, two questions become relevant. First, does the semantic system activate the two lexicons of a bilingual? Second, do the lexical nodes of the non-response language act as Competitors? Previous research has shown a positive answer to the first question. That is, during the course of lexicalization in one language, the lexical nodes of both languages of a bilingual receive activation from the semantic system (Colome, 2001; Costa, Caramazza, & Sebastián-Gallés, 2000; Gollon & Kroll, 2001). However, with respect to the second question, some models of lexical access assume that the lexical selection mechanism is language-specific (Costa & Caramzza, 1999; Costa, Miozzo, & Caramazza, 1999; Roelofs, 1998). That is, the lexical selection mechanism considers the activation levels of the lexical nodes in the intended language. Therefore, according to these models, the lexical intrusions from the non-response language do not occur while speaking in a given language. In contrast to this, other models of bilingual lexical access assume that the lexical selection mechanism considers the lexical nodes from both languages – i.e., language non-specific lexical selection. That is, these models assume that, following the activation of a conceptual node, multiple lexical nodes are activated in both target and non-target languages. For example, when a Malayalam-English bilingual is asked to name the picture of a cat, the conceptual node [CAT] sends activation to its corresponding Malayalam (/pu:t?a/) and English (/cat/) as well as to several other semantically-related lexical nodes [for e.g., (/patti/ in Malayalam and its translation equivalent in English / dog/]. Consequently, this mechanism requires a means by which the target item (not its semantically related items) can be selected in the target language (not in the non-target language) by creating a differential level of activation in the two lexicons of a bilingual. Here, the pertinent question is: How does the system produce an imbalance of activation between the two lexicons? Two solutions have been postulated to explain this. The first postulation assumes that both target and non-target lexical nodes are activated roughly equally – thereby arising the 'hard problem' (Finkbeiner, Almeida, Janssen, & Caramazza, 2006) – and this is overcome by an inhibitory mechanism (see below) that suppresses the activation of the lexical nodes of the non-response language (de Bot, 1992; Green, 1986, 1998; Poulisse & Bongaerts, 1994). In contrast, the second postulation assumes that there exists a differential activation of the lexical nodes in the two languages (essentially, the lexical node in the target language being activated more than those from the non-target language) (La Heij, 2005; Poulisse & Bongaerts, 1994). Therefore, according to the second assumption, the issue of 'hard problem' does not arise in bilingual lexical selection.

Green's (1986; 1998) Inhibitory Control Model (ICM) has been employed to explain the bilingual selection mechanism. According to ICM, the control of lexical representation is achieved through the language task schemas. That is, each lexical node is associated with a language tag or schema (such as L1 or L2). These task schemas are claimed to exert control over the bilingual lexicon by inhibiting or activating the lexical nodes based on the language tags they possess. Task schemas also exert control through the suppression of competing task schemas of the non-target language. An important feature of the ICM is that inhibition is proposed to be reactive in nature. That is, the more non-target lexical representations become activated initially, the stronger those representations are then inhibited.

Experimental evidences for language non-specific lexical selection

Among the proponents of the language non-specific bilingual lexical selection, Meuter and Allport (1999) provided the most crucial evidences for the language suppression hypothesis. In their study, there were two independent variables: language switching (switch vs. nonswitch) and naming (in L1 vs. L2). The results of their study revealed two significant findings. First, a main effect of switching – that is, increased latency for switch trials. Second, an asymmetry of switching cost – that is, greater switching cost for L1 responses compared to L2. These two findings have been considered as the firm evidences of language suppression in bilingual subjects.

This asymmetrical switching cost in bilinguals has been regarded as the signature finding of language suppression in bilinguals (Finkbeiner et al., 2006). The L2-L1 switching cost has always been found to be longer across the studies following the seminal study of Meuter and Allport (1999). For instance, Costa and Santesteban (2004) replicated the increased switching cost from L2 to L1, although these authors claimed that this asymmetry arose from the language proficiency. Finkbeiner et al. (2006) replicated the findings of Meuter and Allport (1999) and claimed that the switching cost arises from the stimulus qualities (i.e., univalent versus bivalent). That is, these authors disentangled the switching cost by keeping the experimental condition constant (L2 to L1) and varied the stimulus trial. In the univalent condition, the participants were required to name the pictures only in L1 whereas in the bivalent condition, they were required to name the digits both in L1 and L2. The results of this study showed a strong asymmetric switching cost in the bivalent condition (digit naming) with no evidences of switch cost on the picture naming (univalent) task. Finkbeiner et al. (2006) claimed that the nontarget language is not completely suppressed as a whole when selecting the lexical representations in the target language.

Experimental evidences for language-specific lexical selection

In contrast to the language non-specific nature of lexical selection, the language-specific view assumes that the lexical selection mechanism considers only the activation of the lexical nodes of target language (Costa, Miozzo, & Caramazza, 1999; Roelofs, 1998). According to these models, the lexical selection in bilinguals proceeds the same way as in monolinguals as the nontarget language is never considered during the lexical selection process. Evidences for this proposal come from the semantic interference effect (SIE) using picture word interference paradigms.

Semantic interference effect reflects the competition of different lexical nodes at the lexical level and this has been widely employed in bilingual research (Roelofs, 1992; Schriefers, Meyer, & Levelt, 1990). Although the semantic interference effect, at first instant seems to show the language non-specific nature of lexical access, a careful interpretation questions this argument (see, Costa, Colome, & Caramazza, 2000, for a discussion). In addition, it has been repeatedly reported in different languages that the identity effect – a paradigm employed to study the semantic interference effect by presenting the distracter word either in the same language or different language – leads to faster naming latencies when the distracter word corresponds to the target word's translation equivalent than when it was unrelated. The mechanism behind this facilitation of the target language by the non-target language distracter is that the presentation of the distracter word activates its concept which in turn activates the lexical nodes in both languages. The faster naming latency in the target language can be explained only by the language-specific view of lexical access, as the language non-specific nature should result in slower naming latency resulting from the competition between the lexical nodes in both target and non-target languages. Therefore, these evidences strongly propose the language-specific nature of lexical access in bilinguals.

Aim of the study

From the brief review above, it is apparent that a consensus on the nature of lexical selection mechanism is yet to emerge. In the context of such ambiguous theoretical proposals, investigations employing novel paradigms seem pertinent. The present study, therefore, aimed to determine the nature of lexical selection (i.e., language-specific vs. language non-specific) in a group of bilingual subjects using a semantic relatedness judgment task. This task requires the participants to judge the semantic relatedness of a critical stimulus (second word of the word-pair) subsequent to the presentation of the first word.

Objective of the study

The objective of the study was to compare the judgment time between two variables: semantics (related & unrelated) and language (monolingual & cross-lingual).

Working hypotheses

In the present study, we hypothesized that:

a. A faster judgment time in the case of semantically related word pairs compared to their semantically unrelated counterparts may indicate the language non-specific nature of bilingual lexical selection. This is especially relevant in the case of the cross lingual word pairs (e.g., cat – patti vs. cat – thoppi).

b. Within the semantically related word pairs, if the monolingual items (e.g., cat – dog) are judged faster compared to the cross lingual items (e.g., cat – patti), it is suggestive of a differential activation of lexical items from the two languages, with an advantage of the monolingual lexical items.

c. Finally, in the semantically unrelated condition, if the monolingual items (e.g., cat – hat) are judged faster compared to their cross lingual counterparts (e.g., cat – thoppi), it would be indicative of a non-semantic-based lexical selection mechanism among the two lexicons that are activated in parallel.

Method

Participants

A group of 25 right-handed university students (Mean age – 21; SD – 2 years) volunteered to participate in the study. All participants were born and brought up in Kerala – the southwest state of India, where the dominant language is Malayalam (a Dravidian language). All had their education in English medium, starting from the kindergarten level (early sequential bilinguals) and all judged themselves to have relatively good proficiency in their second language (English) (M = 5.5 on a 7-point scale).

Stimuli

The stimuli were prepared by pooling a list of semantically related and unrelated nouns by a group of five Malayalam-English bilingual subjects. From this list, the semantic relatedness was determined by a different group of 10 subjects who wrote down the features shared by each word pair. For the semantically related stimuli, pairs that had a minimum of three or more features were selected. For the semantically unrelated item, word pairs that did not have any features in common were selected. After this procedure, to further validate the list, the entire group of related and unrelated word pairs was rated by another group of another five subjects on a 5-point rating scale on their semantic relatedness. The extreme points of the scale were 'semantically highly related' and 'semantically highly unrelated'. These subjects rated all the items at either extreme. Following this, the translation equivalents of these words were developed. Care was taken to eliminate those words that had phonological similarity between the translated pairs.

The final stimuli consisted of 60 word pairs grouped under four experimental conditions. Of these 60 word pairs, 30 were semantically related and remaining items were semantically unrelated. Under these two semantic conditions, equal number of items was further grouped into monolingual and cross lingual conditions. Thus, the final set consisted of 15 stimuli each under English-English Semantically Related (EESR) (e.g., cat – dog), English-English Semantically Unrelated (EESU) (e.g., cat – hat), English-Malayalam Semantically Related (EMSR) (e.g., cat – patti) and English-Malayalam Semantically Unrelated (EMSU) (e.g., cat – thoppi) conditions (See Appendix for the stimuli).

Procedure

The experiment was carried in a quiet and dimly lit room. The stimuli were presented through DMDX reaction time software (Forster & Forster, 2003) in a Pentium IV desktop computer. The subjects were seated in a comfortable chair and were instructed to press 'm' or 'n' button of the keyboard following the judgment of semantically related and unrelated word pairs, respectively. In addition, the subjects were instructed to rest their index and middle fingers on 'n' and 'm', respectively, to eliminate the time lag to reach the button after every trial. Before the commencement of the experiment, a set of five trial items were provided for familiarizing with the task demands. A '+' symbol was presented at the center of the screen for 500 ms followed by an equal duration of blank screen. This was followed by the prime word, which remained on the screen for 750ms. This was replaced by a blank screen for 500 ms following which the target was presented for 2000ms. The inter-trial interval (ISI) was two seconds. Each subject was tested separately and the testing time did not exceed more than 10 minutes for each subject.

The participants were required to make judgment on the semantic relatedness (i.e., whether the second word of the stimulus pair was semantically related or unrelated to the first word). The stimuli were presented in two blocks, one for each language (i.e., mono- & cross-lingual) condition. The order of presentation of the stimuli was distributed such that half of the participants performed English-English task initially whereas the remaining half performed English-Malayalam task initially. Descriptive and statistical test of significance were performed for the judgment time of correct responses using SPSS 11 for Windows.

Results

The mean judgment time of English-English Semantically Related (EESR) word pairs was 875.06 ms (SD = 85.14; % error = 5.9) and that of the English-Malayalam Semantically Related (EMSR) word pairs was 980.35 ms (SD = 54.68; % error = 12.09). Similarly, the mean judgment time of English-English

Semantically Unrelated (EESU) word pairs was 1000.79 ms (SD = 54.48; % error = 7.9) and that of English-Malayalam Semantically Unrelated (EMSU) word pairs was 1068.52 ms (SD = 40.92; % error = 6.67). Figure 1 shows the mean reaction times of these four conditions.

To test our first hypothesis, we compared the judgment times of monolingual semantically related items (EESA) to that of their semantically unrelated counterparts (EESU). The comparison showed a significant difference between the two conditions. As part of the first hypothesis again, we compared the cross-lingual semantically related word pairs (EMSA) with their semantically unrelated counterparts (EMSU) and, more importantly, this too showed a significance difference in their judgment times. Further we compared the monolingual and cross-lingual semantically associated word pairs (i.e., EESA – EMSA) to test the second hypothesis. The difference in judgment times between these two conditions was significant with monolingual word pairs revealing mean judgment time faster by 105.2 ms. Finally, we performed pair-wise comparison of the semantically unrelated mono- and cross-lingual word pairs (i.e., EESU – EMSU) to test our third hypothesis. This comparison showed that the monolingual word pairs were judged faster by 67.7 ms compared to their cross-lingual counterparts. Table 1 provides the results of the comparisons of the mean difference in judgment time, confidence intervals, t-values, and the significance levels (p) of each of the comparison.

Table 1: *Paired comparisons of semantically related and unrelated mono- and cross-lingual conditions.*

Condition s*	Mean Difference	Confidence interval		*t*-value	df	*p*
		Lower	Upper			
EESA – EESU	-125.7	-181.04	-70.42	-4.88	24	< 0.001
EMSA – EMSU	-88.16	-130.93	-45.40	-4.42	24	< 0.05
EESA – EMSA	-105.2	-147.6	-62.99	-5.34	24	< 0.001
EESU – EMSU	-67.7	-94.68	-40.77	-5.39	24	< 0.001

** See text for expansion.*

To investigate the effects of language (i.e., monolingual vs. crosslingual) on the semantic relatedness (i.e., semantically related vs. unrelated), the judgment time data was submitted to repeated measures ANOVA. The results (Figure 1) revealed a significant main effect for language ($F(1, 96) = 75.91$, $p < 0.001$). English-English word pairs had significantly shorter reaction times (M = 937.92 ms; SD = 95.00) than the English-Malayalam word pairs (M = 1024 ms; SD = 65.28) and this difference was large ($\eta^2 = 0.844$). A significant main effect was also obtained for the semantic condition ($F(1, 96) = 32.08$, $p < 0.001$) indicating that the semantically related word pairs were judged faster (M = 927.60; SD = 88.37) compared to semantically unrelated word pairs (M = 1035 ms; SD = 58.59). This difference between the two conditions was large as indicated by the partial eta squared value ($\eta^2 = 0.69$). However, the results did not reveal any significant interaction between language and semantic relatedness ($F(1, 96) = 1.413$, $p < 0.24$).

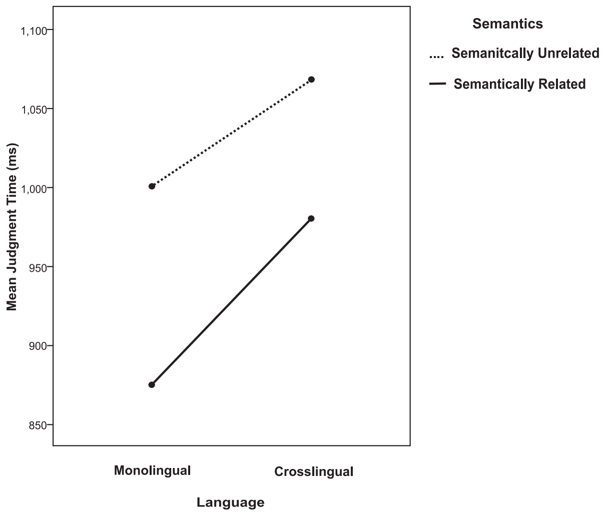

Figure 1: Mean judgment time of the semantically related and unrelated word pairs as a function of language conditions.

Discussion

The present study investigated lexical selection mechanism in a group of Malayalam-English bilinguals through a semantic-relatedness judgment paradigm. Before proceeding to the discussion of the results, a note on the task employed in the current study seems appropriate.

Nature of the task employed in the current study

Researchers often employ a variety of experimental tasks to investigate the underlying architectural and processing principles of the bilingual mental lexicon. The seemingly contradictory findings in bilingual research may, to a large extent, be attributed to the way the results from various experimental tasks are interpreted. As rightly opined by Marian (2008) "challenges arise not because different tasks are used, but because the different tasks often probe different phenomena, and that is not always taken into account when interpreting the findings", One should understand the task employed and the target processing under study in order to interpret the findings in the right direction. The current study employed a 'semantic relatedness judgment' task. Although we used words as stimuli and the visual word recognition is an essential processing component in such tasks, the emphasis in the present study was on the post-visual recognition stages of lexical processing – that is, the semantic processing. The participants of the study were provided with a word in their L2 for about 750 ms duration which was followed by a blank screen of 500 ms duration. The critical stimulus (i.e., the second word) of the word-pair was presented at the end of the 500 ms blank screen and it remained for 2000 ms. Therefore, the duration between the onset of the initial word to that of the critical word (either in L2 or L1), was 1250 ms. It is evident that the initial word recognition requires much less duration than this. In addition, the semantic knowledge of the first word is usually accessed within this time frame (Meyer & Schvaneveldt, 1971). Therefore, although the visual word recognition was involved in the early stages of the processing of the initial word of the stimulus pair, it is apparent that the participants have accessed the semantic representation of the same by the time the second word was presented. In this context, we interpret our results with respect to semantic processing rather than visual word recognition.

Returning to the findings of our study, the participants showed shorter judgment time for semantically related word pairs compared to the unrelated word pairs both in the monolingual as well as in the cross-lingual conditions (Table 1). In the monolingual literature, this finding is attributed to 'semantic priming' (Meyer & Schvaneveldt, 1971). That is, the presentation of the initial word (e.g., cat) could partially activate the semantic concept of the second word of the stimulus pair (e.g., dog), thus making the semantic relatedness judgment faster (See Krishnan & Tiwari, 2008, for a discussion). Further, the faster judgment time in the semantically related cross-lingual word pairs (e.g., cat – patti) compared to their unrelated counterparts (e.g., cat – thoppi) indicates that even L1 (e.g., patti) lexical items were activated by the initially presented L2 words (e.g., cat). That is, priming (by cat) of a semantically related monolingual (dog) as well as its translation-equivalent (i.e., cross-lingual) (patti) items indicated the possible spread of activation from the concept [CAT] to both L1 (patti) and L2 (dog) semantically related items. These findings, therefore, strongly indicate the language non-specific nature of lexical selection (La Heij, 2005; Meuter & Allport, 1999; Poulisse & Bongaerts, 1994).

A significant difference in judgment time between the semantically related mono- (e.g., cat- dog) and cross-lingual (e.g. cat-patti) further showed that within the two activated lexicons, the monolingual lexical items revealed shorter judgment time, supporting our second hypothesis that there was a differential activation of L1 and L2 lexical items following the semantic activation by an L2 word. In this context of such parallel and differential activation of L1 and L2 lexicons, additional interpretation is required to explain this intricate lexical selection mechanism. As mentioned in the introduction, there are two possible explanations (i.e., differential activation of L1 and L2 lexical items & inhibitory control of the non-target language) for the advantage of monolingual over the cross-lingual word pairs. In the following section, we argue that the mechanism behind lexical selection in bilinguals is the inhibitory control of the non-target language rather than the differential activation of L1 and L2 lexical items. To support our argument, we discuss the findings from the semantically unrelated mono- and cross-lingual conditions.

In the semantically unrelated monolingual (e.g., cat-hat) and cross-lingual (e.g., cat-thoppi) conditions, the participants exhibited a faster decision time in the former condition. Considering the fact that both conditions were not semantically mediated, the facilitation of the monolingual word pairs requires an additional mechanism (i.e., other than semantic mediation) is required. Considering the two explanatory hypotheses (i.e., Inhibitory control and differential activation), the latter (i.e., differential activation) fail to account for the observations from the semantically unrelated conditions. That is, according to the differential activation account, both L2 and L1 are activated to different levels. However, according to the activation level-based models of bilingual lexical selection, both L1 and L2 are activated only when they are semantically related to the conceptual node. Put it in a simple way, an activated conceptual node does not send its proportional activations to the semantically unrelated L1 or L2 lexical items. It is, therefore, apparent that the only explanation that could account for the facilitation of the monolingual semantically unrelated over the crosslingual semantically unrelated word pair is the inhibitory control mechanism (Green, 1986; 1998).

The inhibitory control mechanism (ICM) hypothesizes that when a bilingual speaks in one language, inhibitory control mechanisms are called up on to suppress the non-target language. According to the tenets of ICM, in the regulation of the bilingual lexico-semantic system, a conceptualizer builds conceptual representations, which are driven by the communicative goal. These both are mediated by a supervisory attentional system (SAS) together with components of the language system (i.e., language task schemas). The language task schemas, in turn, control the output leading to the accurate selection of words in the target language. Once the target language is established, the bilingual mind will turn to language tags to help determine which non-target words will need to be inhibited. According to Green (1998), words of the non-target language are suppressed to a degree that is proportionate to the level of activation based on language tags. Applying Green's model to the present study, it may be assumed that with the presentation of the initial L2 word, the language task schemas and tags of L2 suppress the L1 lexical items. Since the inhibitory control exerted on L1 is not semantic-based, even semantically unrelated L1 lexical items are suppressed. The results of the present study provided strong support in this regard by revealing slower judgment time in the case of semantically unrelated cross-lingual word pairs compared to their monolingual pairs. In this context, it is apparent form the current study that the bilingual lexicon employs an inhibitory control over the non-target language.

Summarizing the findings of the present study, it is apparent from the current observations that the bilingual subjects activated both L1 and L2 lexicon while processing supporting the language non-specific nature of lexical processing. Further, the study provided strong empirical evidence for the inhibitory control-based suppression of the non-target lexical items that are activated in parallel with the target lexical items.

Limitations of the study

The present study, however, had certain limitations. First, it did not incorporate the L1 monolingual condition (Malayalam-Malayalam). Second, the semantic relatedness was judged always from L2- L1 and the reverse direction was not investigated. We therefore, advocate that the future studies employing semantic relatedness judgment paradigm may consider these shortcomings.

Conclusion

In summary, the present study provided empirical evidences for the language non-specific lexical selection in bilingual lexico-semantic system using the semantic relatedness judgment paradigm for the first time. More importantly, it provided strong evidence for the role of inhibitory control mechanism (ICM) in bilingual lexical processing.

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