Lexical Processing in Bilingual Children: Evidence from Masked Phonological Priming

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Abstract

Earlier, the general idea was that bilinguals had two mental lexicons: one for the first language and one for the second. In addition, a language switch mechanism controlled which lexicon was active. In recent years, however, evidence has accumulated showing that the initial stages of visual word recognition are largely language independent and that the assumption of independent lexicons may not be true. The aim of the present study is to explore visual word recognition in bilinguals through a masked phonological priming experiment. The participants consisted of 30 Kannada-English bilingual children in the age range of 10-12 years. The test material consisted of a total of 40 words in Kannada and 40 words in English. These were studied in 4 different priming conditions which included 10 semantically related prime (SR), 10 semantically unrelated prime (SUW), 10 non-words (NW) and 10 orthographically related nonword prime (OR). The findings of the study are further discussed with evidence from language-selective access models of bilingual word processing and phonological models of lexical processing.

Literature strongly suggests that the pattern of acquisition of literacy in bilingual children is different from that of monolingual children. Bialystok, Luk and Kwan (2005) opined that bilinguals may be transferring the reading skills acquired in one language to learn to read in the other. Studies have been conducted at various levels to understand the processing of information in bilinguals at phonological, lexical and syntactic levels. Understanding of lexical level processing is important as this may explain processing at a conceptual level in understanding any language. Empirical research has been conduct to understand what the lexicon itself contains, in terms of lexical form and lexical semantics. Potter, So, Von Eckardt and Feldman (1984) have hypothesized that some lexical representations for both languages may be integrated, while other representations may be separated. They suggested that the lexical form may be distinct for two languages, but the lexical semantics for the two languages may be integrated. Other researchers claimed that the lexical forms may be integrated (Van Heuven, Dijkstra, & Grainger, 1998), in that the semantic representations still may mostly be integrated, although they may be affected by their usage and by the context in which they appear.

There have been many theories and models proposed in order to study lexical processing in different bilingual populations across the world. Researchers have attempted to understand how the lexical representations are accessed in the bilinguals. Particularly, researchers examined the mental lexical representations of the learners to see whether or not this condition would enable the representations for both languages to be accessed in the same way. A few who suggested that the lexicon was separated by the distinct languages in bilinguals did not support that the words could be accessed in the same way. This led to the creation of the models of selective and non-selective access. Selective access means that a bilingual can only access the lexicon from one language at a time. Non-selective access means that the

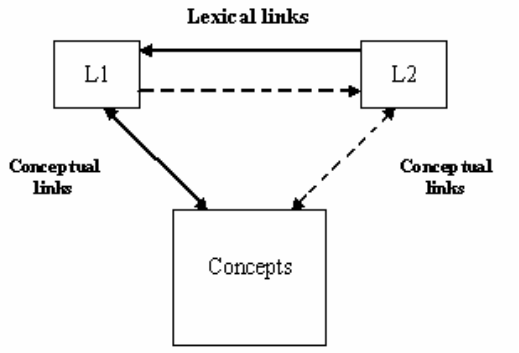

Figure 1: Revised hierarchical model
(Source: adapted from Kroll and Stewart, 1994)

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bilingual can access the lexicon from both languages at the same time (cited in Locke, 2008). Van Heuven et al. (1998) suggested of combining the model of integrated lexicon with non-selective access. Kroll and Sunderman (2003) have also suggested that it is possible for learners to have one integrated lexicon represented in the mind and a non-selective mode of access. The representation of the lexicon and the mode of accessing the lexicon have been found to be the two key components of better understanding the makings of the bilingual lexicon (Eileen, 2008).

A few of the widely accepted models have been delineated in the following sections. Some of these models include the Revised Hierarchical Model (Kroll & Stewart, 1994) and Bilingual Interactive Activation Model (Grainger, 1998). Kroll and Stewart (1994) suggested the revised hierarchical model, which purports the directional asymmetry of L1 and L2 lexical processing (see figure 1).

Figure : Revised hierarchical model

(Source: adapted from Kroll and Stewart, 1994)

It proposes that learners evolve in their lexical processing. They use word association at low proficiency, but then develop to utilize concept mediation as their proficiency rises. The model merges the word association and concept mediation alternatives into a single model in which the strength of the connections between words in L1 and L2 and concepts is proposed to take on different values. The initial dependence on L1 to mediate access to meaning for L2 words is assumed to create strong lexical level connections from L2 to L1. However, at a lexical level, the connections from L1 to L2 are not assumed to be particularly strong because there is little need for the learner to use L2 in this way. Likewise, the model assumes that connections between words and concepts are stronger for L1 than for L2. A number of empirical findings support the predictions of the revised hierarchical model. Learners are more likely to conceptually mediate when they have a higher level of proficiency because they do not have to rely on lexical inter-language connections (Talamas, Kroll and Dufour, 1999). The shift from word association to concept mediation is dependent upon fluency level. Although the processing between L1 and L2 languages becomes increasingly similar as the proficiency level of L2 rises, Talamas et al. (1999) claimed that the connection between L1 words and concepts will almost always be stronger than L2 words and concepts due to the strong initial connection for L1 words and concepts.

The Bilingual Interactive Activation model is a computational model that analyzes word recognition. This model was proposed by Dijkstra and Van Heuven (1989) and Grainger and Dijkstra (1992). It is based on the Interactive Activation model of McClelland and Rumelhart (1981). The Bilingual Interactive Activation model claims that the lexicon of the bilingual is not separated, but integrated. It also claims that lexical access is non-selective. This means that, according to this model, even in the initial stages of word recognition, the bilingual can theoretically activate a word from either language in their lexicon. However, something must account for the fact that bilinguals are able to select a word for a given language. Language selection occurs because of language nodes. These language nodes work to suppress the language that is not being targeted with a top-down influence. Although these nodes may not be activated in the first stages of word recognition, they are triggered later on so that a bilingual can appropriately select the language they wish to use.

Phonological information generated from the printed word does influence early, automatic processes in visual word recognition (Berent & Perfetti, 1995; Ferrand & Grainger, 1994; Lukatela & Turvey, 1994; Van Orden, Pennington, & Stone, 1990; Ziegler & Jacobs, 1995). These data have seriously compromised the hypothesis according to which only orthographic codes mediate contact with lexical representations in the recognition of printed words (e.g., Baron, 1973; Forster, 1976; Humphreys & Evett, 1985) and suggest on the contrary that phonology plays a central role in visual word recognition (e.g., Carello, Turvey, & Lukatela, 1992; Lukatela, Lukatela, & Turvey, 1993; Lukatela & Turvey, 1994; Van Orden et al., 1990; Ru benstein, Lewis, & Rubenstein, 1971). Recently, Lukatela, Van Orden, pointed out that although there is now abundant evidence for the role played by phonological codes in visual word recognition, there is no clear-cut positive evidence for the role played by orthographic codes (other than subserving phonological code activation).

Need for the Study

There is much debate over how the bilingual lexicon functions in the brain. Past studies have analyzed how bilinguals' access and store lexical information with the hope of better understanding how the bilingual lexicon operates. However, the debate still remains over whether or not the bilingual lexicon is composed of one conjoined unit or two distinct parts, one for each specific language. On a practical level, it is known that more proficient bilinguals do not seem to have a problem accessing words from a specific language

when needed. Yet, at the same time, bilinguals also have shown the ability to code-switch, where they are able to access both languages almost simultaneously. These concrete examples serve to further the debate over how it is that the bilingual lexicon is stored and operated. In order to explore processing in bilingual children, an experimental paradigm need to be designed which taps the route to process meaningful words as well as non-meaningful non-words in a primed condition in the two languages.

Aim of the Study

The aim of the present study was to investigate lexical processing in bilingual children with a semi-syllabic language background but learning to read and write an alphabetic language in school. This was done using a masked phonological priming task widely recommended in literature.

Method

Participants

The participants were 30 Kannada-English normal bilingual children in the age range 10-12 years of age. All the children spoke Kannada as their first language (L1) and English was the medium of instruction in school. Kannada was taught as first language (L1) subject in school and English was taught as second language (L2) subject in school. All the children were screened using the WHO disability checklist (Singhi, Kumar, Malhi, & Kumar, 2007) for any sensory, motor or cognitive impairments, delayed acquisition of motor and verbal skills, communication difficulties and presence of other related ailments.

Test Material / Instruments

The test material consisted of a total of 40 high frequent words in Kannada and 40 high frequent words in English. These words were selected from text books following Karnataka state syllabus. These were words were rated as high frequent words by three experienced speech-language pathologists. The study was conducted using these words in four different priming conditions,

1. *Condition 1:* 10 semantically related prime (SER). For e.g. (camel–desert)
2. *Condition 2:*10 semantically unrelated prime (SEUR). For e.g., (camel-apple)
3. *Condition 4:* 10 orthographically related non-word prime (ORNW). For e.g.,(camel-camef)
4. *Condition 3:* 10 non-words (NW) - Non-words were constructed by changing the final syllable of the word. For e.g., (camel-camef)

Totally 80 conditions were presented visually in black font on a white background on the middle of the computer screen. These words were presented on a computer screen using the DMDX software (Forster & Forster, 1999). It enables the measurement of reaction times to these displays with millisecond accuracy.

Procedure

Each participant was tested individually in a session lasting for about 20 minutes. At the beginning of the session, participants were seated in front of a computer. The lexical decision task was then explained to them. Practice sessions were carried out before the actual testing. Participants were instructed to ignore the first word and respond to the second word which appeared after 500 ms on the computer screen. The participants were instructed to press the keys '1' if the word was meaningful and '0' for non-meaningful word. They were instructed to respond as quickly as possible, but also told that it was acceptable to respond even after the word had disappeared from the screen.. Reaction times (RT) in milliseconds and accuracy measurements were recorded using the DMDX software.

Scoring

The responses for accuracy and reaction time (RT) in milliseconds were recorded using the DMDX software. The software automatically saves the reaction time values on a Microsoft-Excel Sheet. These reaction time measures are measured and recorded. The data was subjected to statistical analysis through the SPSS Version 16.0 software.

Results

The aim of the present study was to investigate lexical processing in bilingual children using a masked phonological priming task. Mixed ANOVA was performed to compute mean and standard deviation for the data and Duncan's post-hoc tests were done to look for statistical significance in the data. In mixed ANOVA grade was considered as independent factor. The other two factors were languages and the conditions. The results have been described as,

I. Group comparison for accuracy measurements across languages, grades and conditions

II. Group comparison for reaction time (RT) measurements across languages, grades and conditions

I. Group comparison for accuracy measurements across languages, grades and conditions

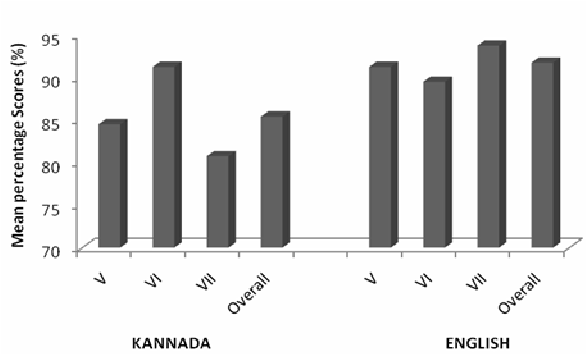


Figure 2: *Mean a*ccuracy scores (in %) across grades & between languages

Accuracy scores were calculated across the grades (grades 5, 6 and 7), between the languages (Kannada and English) and across conditions (SER, SEUR, NW, ORNW). Figure 1 shows reperesnetation of mean percentage scores for accuracy measurements of word recognition in children across grades and between languages. Figure 1 shows that the overall performance of childern is better in English compared to Kannada. This could be because of the regular usage and exposure of English in schools as media of instruction. This may be because the use of English (L2) more regularly for reading and writing when compared to that of kannada (L1). However, there was no significant difference found in the performance of children between the languages or across the grades.

Further, specific analysis of performance of children in terms of accuracy was done in language English and Kannada. Figures 2a and 2b show the mean accuracy scores (in %) across the condition in English and Kannada respectively.

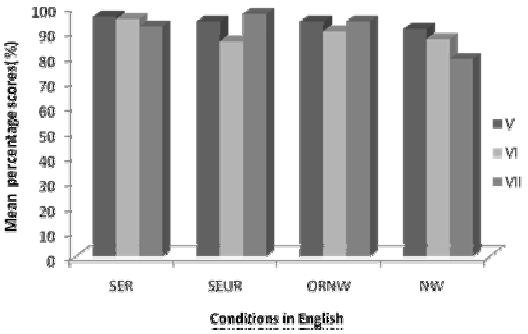


Figure 2a*:* Mean accuracy scores (in %) across the condition in English

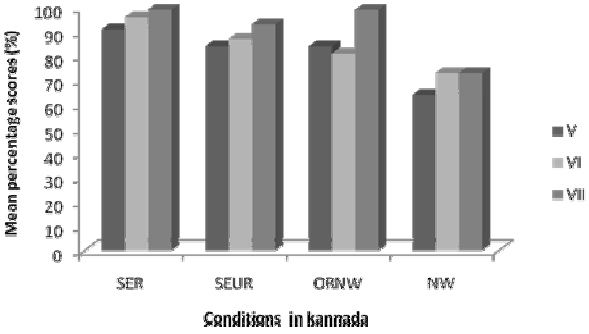


Figure 2b*:* Mean accuracy scores (in %) across the condition in Kannada

Figures 2a and 2b show that the performance of children is similar in English and Kannada across all grades in all the conditions, except in the nonword prime condition. The performance of children in the non-word prime condition was found to be poorer in Kannada than in English. The performance of children was found to be better on semantically realted prime condition (SER) compared to semantically unrelated prime condition (SEUR), orthographically related non-word prime cindition (ORNW) and non-word prime condition (NW) (See Figure 1 for comparison of performance of children in different cinditions).

II. Group comparison for reaction time (RT) measurements across languages, grades and conditions

Mixed ANOVA was done to compare the performance (reaction times in ms) of children across grades, between languages and across the conditions. Table 1 shows mean and standard deviation (SD) computed for reaction times of children in English and Kannada across grades and across the conditions.

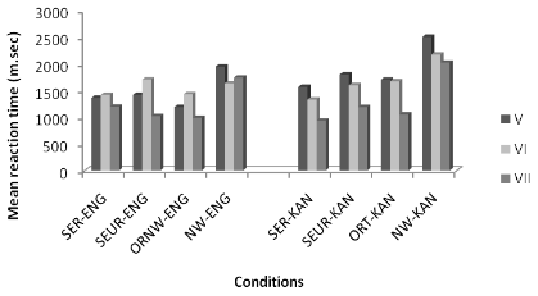
The results in Table 1 revealed that the overall mean reaction time was longer for children in grade V when compared to grade VI and grade VII in all the four conditions (SER, SEUR, ORNW and NW). A developmental trend was found in the performance of children for reaction time measurements. The statistical analysis showed an overall significant main effect in the mean reaction times across the languages i.e., $F(1, 27) = 10.68$, $p < 0.01$. The results reveled that children responded faster on tasks in English compared to Kannada (See Table 1 for mean scores across languages). The analysis also revealed a highly

Languages	Conditions	Grades					
		V		VI		VII	
		Mean	SD	Mean	SD	Mean	SD
English	SER	1370.12	258.68	1424.32	184.17	1200.71	256.02
	SEUR	1424.73	238.80	1713.65	308.98	1027.07	167.23
	ORNW	1193.26	230.68	1434.19	280.99	993.13	302.11
	NW	1955.79	1245.97	1641.17	276.46	1750.19	386.44
Kannada	SER	1573.53	230.25	1336.91	357.17	941.25	151.55
	SEUR	1807.30	364.10	1607.72	386.00	1194.57	225.42
	ORNW	1709.30	254.57	1681.93	245.19	1058.39	261.64
	NW	2511.57	633.95	2182.65	758.25	2032.09	719.50

Note: SER= Semantically related prime, SEUR= Semantically unrelated prime, ORNW= Orthographically related non-word prime, NW= Non-word prime

Table 1: Mean and SD scores of reaction times of children in English and Kannada across grades and across different conditions

significant main effect across conditions i.e., F (3, 27) =40.63, p <0.001. A significant interaction effect was found across languages and conditions, i.e., F (3, 27) = 3.43, p< 0.05. A significant main effect was also found across all the conditions at F (2, 27) = 19.70, p<0.001. Further, Post hoc duncan test revealed that there was no significant difference in the performance of children in grades V and VI. There was a significant difference in the perfomance of children in grades V and VII at 0.05 level. Figure 1 shows the mean reaction times of children across grades, across conditions and between the langauges.



Note: SER= Semantically related prime, SEUR= Semantically unrelated prime, ORNW= Orthographically related non-word prime, NW= Non-word prime, ENG= English, KAN = Kannada

Figure 3: Mean reaction time for all four condition across the grade and language.

Figure 1 shows that within conditions, children have taken longer time to repond in the NW prime condition in both English and Kannada. Children have taken the least time in the SER prime condition in both English and Kannada. It was also observed that, there was a developmental trend found on reaction times measures of children where the children in higher grades performed faster than the children in the lower grades. Pair sampled t-test was done to comparison was done to explore the overall difference across and within the conditions. The results revealed that, when, SER prime condition was compared with the other three conditions, there was a significant difference in reaction time measures for semantically unrelated condition and nonword prime condition at 0.05 level and 0.01 level respectively. The results revealed that in English, there was no significant difference in reaction times between SER and SEUR condition and ORNW. Whereas, there was significant difference in the performance of children between SER and NW condition. Children have taken longer time in NW prime condition compared to SER, SEUR and ORNW conditions. In Kannada, similar results were observed where children took longer time in NW condition compared to SER, SEUR and ORNW conditions.

Discussion

The aim of the present study was to investigate lexical processing in bilingual children using a masked phonological priming task. The data was analyzed for accurate responses and reaction time measurements.

The results revealed that overall Kannada-English bilingual children showed better performance in English (L2) than in Kannada (L1) (see Figures 2, 2a, 2b and 3). This was noted for both accuracy and reaction time measurements in Kannada and English. However, significant difference was found for reaction times in Kannada and English. Children took lesser time in L2 compared to L1. This could be explained using the revised hierarchical model (RHM) proposed by Kroll and Stewart (1994) (See figure 1). Kroll and Stuart (1994) reported that children took longer time in L2 naming than L1 naming. Contradicting to this study, the present study, revealed that children took longer time in L1 than L2. It can be explained hypothetically using the same model that in the present study, the participants were children in higher grades whose conceptual links may be established due to exposure to L2 reading more than L1 reading. Children in the present context study Kannada as only a subject whereas, English is studied as a subject and also a medium of instruction. Hence, the exposure is more to English reading than Kannada reading. The link between the L2 and the concepts might have become strong in these children because they are exposed to L2 language in their literacy skills much more than the L1 language. Due to this it is possible that older children need not always

process orthographic information to reading through L1 and then move to L2 and then establish a link with the concepts.

Further the results of the present study revealed that children took lesser time to respond when the target word was primed with a semantically related (SER) word than semantically unrelated (SEUR) prime, orthographically unrelated (ORNW) prime or nonwords (NW) as prime. This was found to be true for performance of children in both English and Kannada. This may be because of integrated lexical semantics and different lexical forms. Integrated lexical semantics indicates that as the target word and the prime word share the same lexical semantics, the processing is facilitated faster than when the prime is unrelated in SEUR condition. Also, RNW and NW prime words do not facilitate word recognition as they do not share the lexical semantics in terms of their relation to meaning. This finding supports Van Heuven, Dijkstra, and Grainger (1998) who reported that semantic representations may be integrated although they may be affected by their usage and the context in which they appear. Hence, despite the languages, semantic related conditions facilitate word recognition better for reading in children. These findings also support the non-selective processing in bilinguals. This means that processing in children may not be due to language specific features. These children process information in a similar way even in languages with two different orthographies. Here, children depend more on semantic information for word recognition in both English and Kannada and do not depend on the phonological information. These findings also support Kroll and Sunderman (2003) who have suggested that learners may have integrated lexical representation and a non-selective mode of access of information.

Conclusions

A better performance in L2 than L1 could be because the children under study are older children whose conceptual links may be established due to factors like exposure to L2 as it is also the medium of instruction when compared to L1 which is only learnt as a subject in school. Also a better performance for semantically related prime condition is indicative of the fact that despite the language difference, processing is more integrated for lexical semantics and access mode may be more non-selective in nature as explained by other models in literature.

Implications

- The present study helps understand that priming tasks can be used to study different levels of lexical and sub-lexical processing in bilingual children. How does this processing differ in adult bilinguals with better proficiency in L2 will be yet another interesting question that need to be addressed with future research.
- Such experiments can be used as tasks in themselves to assess processing in monolinguals, bilinguals and dyslexias associated with them. The findings would prove crucial while understanding the mechanism in the clinical population.
- Further, what would be more interesting to note is deciding on including the phonological related tasks and semantic related tasks as part of the intervention programs for the clinical population like the SLI, children with dyslexia, etc.

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