Visual Word Recognition in Reading Kannada

[1]Jayashree C Shanbal & [2]K.S. Prema

Abstract

Reading is a complex cognitive process. It is a process that requires co-ordination of a series of sub-functions, which include visual functions, verbal functions and other cognitive functions like memory and attention. Impairment in any one or more of these functions can affect reading. Amongst a host of reading processes, visual word-recognition in children is widely investigated. There are many models proposed to explain visual-word recognition. The most widely discussed model is the 'Dual route cascaded (DRC) model (Coltheart, Rastle, Perry, Langdon & Ziegler, 2001). The purpose of the present study is to explore visual-word recognition in Kannada in children with normal reading abilities. Further, the study also investigated if lexical processing in reading Kannada is through serial or parallel processing. The subjects consisted of 10 children in the age range of 10-12 years with normal reading ability. Children witht a minimum of four years of exposure to Kannada reading were selected. Basic reading level in Kannada was established using the Kannada Reading Test developed by Purushothama (1992). The children were required to identify the word in a given word-nonword pair presented through DMDX software program. The reaction time of their responses to identify the word in a given word-nonword pair was measured and recorded with the help of the DMDX software. The results of the study are discussed in light of the existing literature on 'Dual route cascaded (DRC) model'.

Key words: Reading, visual-word recognition, dual route, lexical processing, non-word, reaction time

Reading is a complex cognitive process. It involves the co-ordination of a series of functions which include visual functions such as orthographic (word form) analyses and verbal or language functions such as phonological, semantic and syntactic coding in addition to other cognitive functions like memory, attention and motor skills. Reading can be disturbed by faulty mechanisms in any one or several of these above functions (Lachmann, 2001).

The recognition of words and its relation to reading is one of the core topics in reading research and has been studied extensively in the recent years (Besner, Waller & MacKinnon, 1985; Coltheart, 1987). The study of word recognition is important because identification of a word entails the activation of several types of associated information or codes, each of which contributes to the interpretation of the text material. Further, deficits at the level of word-recognition have been found to be characteristic of children who fail to acquire age-appropriate reading skills (Perfetti, 1985; Stanovich, 1986).

There are many documented empirical research reports on visual word recognition. Various reading models have been proposed in order to understand the mechanisms involved in visual word recognition. A number of other models also attempt to explain visual word recognition and its role in reading related tasks (Marshall & Newcombe, 1973; Meyer, Schvaneveldt, & Ruddy, 1974). These models try to explain the processing of words, irregular words and non-words- that irregular words and nonwords require separate mechanisms for their recognition: Irregular words require lexical lookup because they cannot be pronounced by rule, whereas nonwords require a system of rules because their pronunciations cannot be looked up. Forster's (1976, 1979, 1989) autonomous search model views word recognition system as one divided into several parts. It talks of a master lexicon which contains all linguistic information about a word (e.g., semantic, phonological, spelling, and grammatical class). The master lexicon is arranged into bins with most frequent entries on top. Entries are searched serially until an exact match is found. If the match is correct, the search is terminated. If the match is incorrect (as in reading non-words) it will be rejected unless they have properties similar to real words. The search will take longer for regular non-words than for irregular non-words. This makes the model more similar to activation models like the logogen model. While in logogen model (Morton, 1969, 1970; Morton, 1979; Morton & Patterson, 1980), the words are processed as composite units, each word operating with an optimum threshold of its own, but not relying on the search process as in the autonomous search model (Forster, 1976, 1979, 1989).

[1]Jayashree C Shanbal, Lecturer in Language Pathology, AIISH, Mysore 570 006, [2]Dr. K.S. Prema, Prof. of Language Pathology, Dept. of Speech Language Sciences, AIISH, Mysore

Word recognition which involves lexical decision as well as word naming is explained with the help of Seidenberg and McClelland's (1989) connectionist model. The orthographic characteristics of words form the basis for the model. . On the basis of this model, the regular and irregular words are learned through experience with spelling-sound correspondences. There is no mechanism that looks up words, no lexicon, and no set of phonological rules. Instead, words are activated by input from connecting sub-lexical nodes. The key feature is that there is a single procedure for computing phonological representations that works for regular words, exceptional words, and non-words. Yet another connectionist model of visual word recognition is the Interactive Activation model (IA) (McClelland and Rumelhart, 1981). Information is represented as a network of parallel distributed processes (PDP). It consists of a connected network of processing units or nodes that are used to perceive acoustic features, phonemes and words. These are connected at different levels. As excitatory and inhibitory activation is passed through the network of nodes, the pattern of activation is developed to represent the history of the input prior to activation.

Amongst a host of models existing, to date, Coltheart et al.'s Dual Route Cascaded Model (DRC) is considered to be the most successful one to explain the processing of both words and non-words.

The Dual Route Cascaded model

The Dual Route Cascaded model (DRC) (Coltheart, Rastle, Perry, Langdon & Ziegler, 2001) has two core assumptions- that the processing throughout the model is cascaded. That is, any activation in earlier units immediately starts flowing to later units. Second, there are two routes for translating print into sound - a lexical route, which utilize word-specific knowledge, and a non-lexical grapheme-to-phoneme conversion (GPC) route, which utilize a sub-lexical spelling-sound correspondence rule system. These routes are depicted in Figure 1.

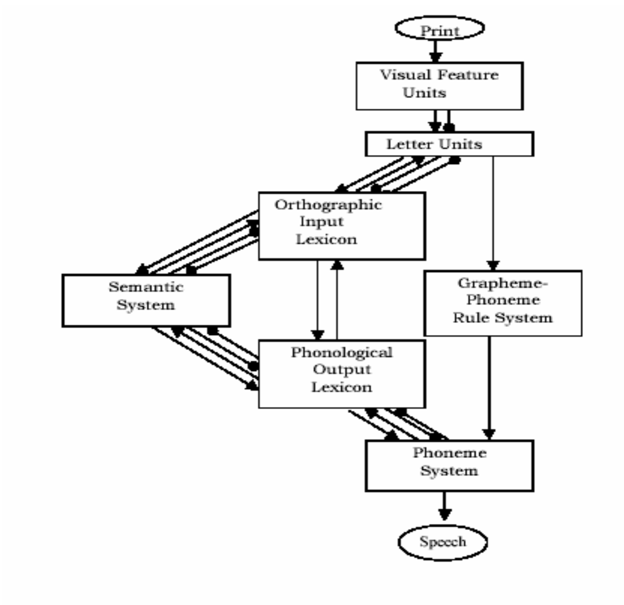

Figure1: The DRC model of visual word recognition

DRC is an extension of the IA model, in which the essentials of the feature and letter level processing modules (top part of Figure 1) are maintained. The assumption of cascaded processing is derived from McClelland and Rumelhart's (1981) work on the Interactive Activation model (IA) of context effect in letter perception. Another feature of the IA model and most of DRC is that processing is done in parallel. For example, all features across the stimulus array are extracted in parallel. Similarly, all the letters units are activated in parallel. Indeed, processing occurs in parallel within all modules except the GPC module, where processing is serial.

The Two Routes

A second major assumption of DRC is that there are two routes underlying the process of converting print to sound (Coltheart, 1978). One is the lexical route and the other is the non-lexical GPC route. The lexical route translates the recognition of a word based on word specific knowledge. The route consists of three components: the semantic system, the orthographic lexicon, and the phonological lexicon, as seen in the left part of Figure 1. The semantic system computes the meaning of a word, whereas the lexicons compute the words' *orthographic* and *phonological* form. Representations of a word in the orthographic lexicon and the phonological lexicon are linked so that activation in one leads to activation of the other. For instance, the letters "c," "a" and "t" will activate the orthographic representation of "cat," which will then activate its phonological representation of /kæt/. The non-lexical route generates the recognition of letter string via a set of *sub-lexical spelling-sound correspondence rules*. The set of rules is within the GPC module. The GPC module applies rules serially left to right to a letter. That is, letters activate phonemes in a serial, left to right fashion. Activation of the second phoneme does not start until a constant number of cycles after the start of activation of the first letter. For example, given a non-word like "bant", the corresponding translation would be: B -> /b/, A -> /æ/, N -> /n/, and T -> /t/.

The lexical route utilizes word-specific knowledge to determine the corresponding recognition, whereas the non-lexical route translates graphemes into phonemes via a set of sub-lexical spelling-sound correspondence rules. Thus, given a word that is known to the reader, the correct recognition is quickly generated by the lexical route. A non-word that cannot be found in the orthographic lexicon and hence cannot be read by the lexical route can be read by the non-lexical route. Together, an intact system of lexical and non-lexical routes is capable of recognizing both words and non-words.

The above cognitive models of reading mainly emerged from the studies of reading in a deep or alphabetic orthography like English (Coltheart, 1985; Frith, 1985; Seymour, 1986). Alphabetic orthographies differ in complexity of their grapheme-phoneme- correspondence rules (GPCRs). In shallow or transparent orthographies (i.e., Italian, German, Serbo-Croatian, Spanish and to a certain extent Portuguese) the GPCRs are highly consistent, whereas in deep or non-transparent orthographies they are quite consistent and unpredictable. The latter, feature many words whose spelling does not convey their pronunciation clearly and have numerous exceptions and many irregular words (English being the extreme case). Studies carried out in orthographies as different in their degree of transparency as Italian, German, English, French, Greek and Brazilian Portuguese have evidenced important differences in children's raeding strategies (Cossu, 1999; Frith, Wimmer & Landerl, 1998; Harris & Giannouli, 1999; Pinhiero, 1995; Porpodas, 1991; Sprenger-Charolles &Bonnet, 1996; Wimmer & Goswami; 1994; Wimmer & Hummer, 1990).

Wimmer & Hummer (1990) found that German beginning readers appear to rely mainly on an alphabetic strategy and display little evidence of the use of logographic strategies. Their errors in word reading are mostly pseudo words, which indicates that German beginning readers use the *sub-lexical route* and move into reading by assembling pronunciations through the use of GPRCs. Studies comparing German and English (Frith et al., 1998; Wimmer & Goswami, 1994) showed that German children read better, faster and with fewer errors than English children. Moreover, the performance of German children in pseudo word reading correlated highly with the reading of familiar words whereas the same correlation was not significant among English children of the same age. This means that although German children use the same procedure (a phonological, sub-lexical or indirect one) to read both words and pseudo words, English children use a visual, lexical or direct procedure to read words and phonological, indirect procedure to read pseudo words. A similar pattern of results was obtained when reading in English was compared to reading in other shallow orthographies such as German, Italian and Spanish (Cossu, Gugliotta & Marshall, 1995; Goswami, Gombert & Barrera, 1998; Thorstadt, 1991). These studies also showed that more complex orthographic systems are more difficult and they entail the use of different reading strategies.

Until a few years ago, it was assumed that the word recognition procedures occurred across all writing systems, regardless of their orthographic depth and consistency. However, a set of recent studies comparing reading in different alphabetic systems pointed out that, factors such as the level of orthographic transparency of the alphabetic rendition of the language and even the characteristics of the spoken language may influence the process of word recognition.

The present research makes an attempt to understand whether the existing cognitive models of reading, which emerged to explain word recognition in alphabetic languages like English, can explain the same in a non-alphabetic language like Kannada. Amongst a host of models existing, to date, Coltheart et al.'s (2001) Dual Route Cascaded Model (DRC) is considered to be the most successful one to explain visual word recognition while reading. DRC model has been adopted to explore visual word recognition in one of the non-alphabetic languages of India i.e., Kannada. Kannada is an example of a shallow orthographic system. Most of the graphemes in Kannada have a clear and precise phoneme translation. The GPCRs allow readers to determine the phoneme corresponding to each specific grapheme without ambiguity and thus reading is controlled by a set of consistent rules. For e.g., the grapheme 'Pï' is read as /k/ in any context within a word. When it is followed by a vowel like /i/, the written form gets modified to 'Q' (/ki/) where the vowel gets fused with the consonant. Thus the rule remains the same except for the irregularity of 'arka' (ð) in Kannada. While writing 'arka', the form is written after a consonant but read out before reading the consonant.

For e.g., 'PÀªÀÄð' (CVCV**C**) is read as /karma/ (CV**C**CV). The form 'ð' (arka) is read before /m/ in /karma/ whereas written after /m/ as in 'PÀªÀÄð'.

Need for the study

Writing system of a language plays a major role in the acquisition of word recognition skills in children. Constraints on the forms of written words impose significant impact on the process of word recognition. . In other words if a language is very regular in spelling as in syllabic language, children naturally practice the predictable phonology of the language much more easily as they learn to read than do children who learn an alphabetic language like English where the frequency of irregularities inhibits such practice.

Most of the experimental research conducted in English presents a l view that irregular words and non-words require separate mechanisms for their recognition. To explain further, irregular words require lexical lookup because they cannot be recognized by rule, whereas nonwords require a system of rules because their pronunciations cannot be looked up. An attempt has been made in the present study to explore the visual word recognition in Kannada which is an Indo-Dravidian language following the semi-syllabic orthographic system of language.

Aim of the Study

The aim of the present study is to explore the process of visual word recognition in reading Kannada script.

Method

Subjects

Ten children in the age range of 10-12 years with average intelligence, normal hearing and normal vision were selected. Children with a minimum of four years of exposure to Kannada reading were selected. Basic reading level in Kannada established using the Diagnostic reading test in Kannada developed by Purushothama (1992).

Test Material

The test material included tri-syllabic words in Kannada and corresponding nonwords (non-words were prepared by retaining the first syllable of the word and interchanging the second and the third syllables) were prepared. These words were non-geminate and non-cluster tri-syllabic words. The list consisted of 15 words and 15 nonwords as target words. The list consisted of 30 target stimuli presented randomly. The stimuli were typed on to software called 'Baraha Version 6.0'.

The stimuli were presented in black font on a white background on the middle of the computer screen. The stimuli were presented visually at random on a computer screen. The stimuli were presented through the DMDX software. The DMDX software is a Window-based program designed primarily for language processing experiments. It can be used for the presentation of text, audio, graphical and video material. It enables the measurement of reaction times to these displays with millisecond accuracy. The reaction time was measured and recorded with the help of the DMDX software.

Procedure

The study taken up was carried out in the following phases.

Phase: 1: A tri-syllabic word was presented to the subject for 500 ms visually on a computer screen through the DMDX software. Prior to the task, practice items were given with immediate feedback of whether the response was correct or incorrect.

Phase: 2: After the presentation of the target stimulus a gap of 500 ms was given after which a pair of word and non-word was presented for 4000 ms. The subjects were instructed to identify the target stimulus from the word-non-word pair by pressing the left or the right arrow key on the key board. The software was programmed in such a way that the left arrow key corresponded to the stimulus on the left side of the screen and the right arrow key corresponded to the right side of the screen. Immediate feedback was given on the screen after the subject presses the key whether the response was correct, wrong or there was a no response. For e.g., a word /karaDi/ is presented for 500 ms and then the word- non-word pair "/karaDi/ /kaDira/" is presented. This pair remains on the screen for 4000 ms. The subject was required to give a response as fast as possible by using the left and the right arrow keys on the key board

All the stimuli were presented one by one. A total number of thirty target stimuli were presented and the subjects were instructed to identify as fast and accurately as possible. Each experimental session lasted for approximately 20 minutes.

Scoring

The responses are analyzed for accuracy and for the time taken to give the accurate response i.e., the reaction time as recorded by 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 10.0 software.

The data was subjected to statistical analysis and the results are summarized in the following tables. The data was analyzed using paired sample t-test to see the performance of children on visual word recognition task. The reaction time for words and non-words for all the subjects were analyzed.

Results

The results of the study are summarized in the following tables,

Table-1: Mean Reaction Time (in ms) for words and non-words

Subject	Mean Reaction Time (in ms)		t-value	Sig. (2-tailed)
	Words	**Nonwords**		
1.	1380.6807	1737.0913	**-2.656**	**0.026***
2.	1187.4453	1161.8527		
3.	2185.6780	2823.5967		
4.	1572.0680	1707.0307		
5.	985.2047	1423.8667		
6.	883.6740	856.6200		
7.	1094.4407	1162.7820		
8.	1106.0267	1082.0747		
9.	997.7580	1098.0487		
10.	1015.0727	1760.2907		

*p<0.05

Table-1 shows the mean reaction time measures for words and non-words of all the subjects. From the table we can see that the reaction time for non-words is comparatively greater than for words in almost all the subjects. It also shows that there is a significant difference between the RTs for words and non-words (0.026 at p<0.05).

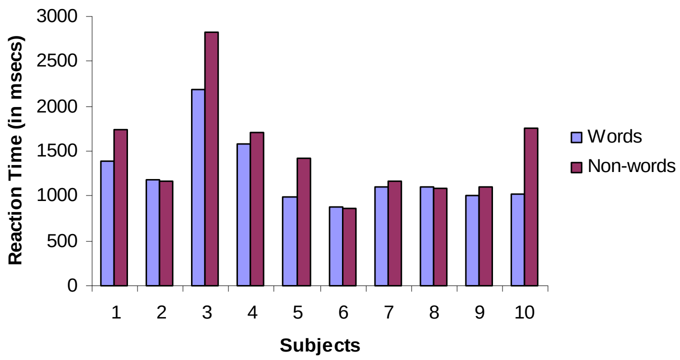

Figure 2: Mean Reaction Times (in ms) for words and non-words in all the subjects

Figure 2, shows the mean reaction times for words and non-words in all the subjects. From the figure it is evident that the reaction time for non-words is greater than that of words in almost all the subjects. This indicates that the subjects take longer time to identify non-words from a given pair of word and non-word compared to that of words.

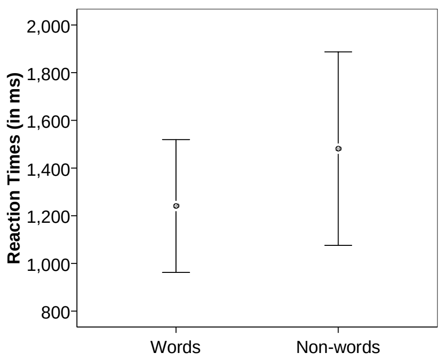

Figure 3: 95% Confidence Interval for the Mean RTs for words and non-words

Figure 3 shows the error bar at 95% confidence interval between words and non-words for all the subjects.

Discussion

The main aim of this study was to examine the process of visual word recognition in reading Kannada script that may be different compared to a deep orthography like English.

The results of the present study indicate that the children take longer time to recognize non-words when compared to words presented visually. The performance of children the on visual word recognition task can be interpreted using the 'Dual route cascaded (DRC) model' (Coltheart, Rastle, Perry, Langdon & Ziegler, 2001).According to this model, in reading, it is generally agreed that there are two routes for accessing information. One is a *lexical route* and the other is the *non-lexical GPC route*. The lexical route translates the recognition of a word based on word specific knowledge. The other route i.e., non-lexical route generates the recognition of letter string (be it a word or a non-word) via a set of sub-lexical spelling-sound correspondence rules (See Figure 1).

For example, the children will take longer time to recognize '**PÀ®ªÀÄ'** /kΛlΛmΛ/ (which is a non-word) when compared to '**PÀªÀÄ®'** /kΛmΛl/ which is a word and which means 'lotus'. This difference in processing /kΛlΛmΛ/ and /kΛmΛlΛ/ can be explained using the DRC model.

Initially the printed visual stimulus '**PÀªÀÄ®'** (/kΛmΛlΛ/) is loaded into the visual feature units (See fig. 1). The lexical route translates the recognition of /kΛmΛlΛ/ based on word specific knowledge. The route consists of three components: the semantic system, the orthographic lexicon, and the phonological lexicon, as seen in the left part of Figure 1. The semantic system computes the meaning of a word which means 'lotus' in Kannada, whereas the lexicons compute the words' *orthographic* and *phonological* form. Representations of /kΛmΛlΛ/ in the orthographic lexicon and the phonological lexicon are linked so that activation in one leads to activation of the other. For instance, the letters "**PÀ**" /kΛ/, "**ªÀÄ**" /mΛ/ and "**®**" /lΛ/ will activate the orthographic representation of "**PÀªÀÄ®**," which will then activate its phonological representation of /kΛmΛlΛ/. Whereas, the non-lexical route differs from the lexical route in both the knowledge base and the type of processing it employs.

While processing a non-word, initially the printed visual stimulus '**PÀ®ªÀÄ'** (/kΛlΛmΛ/) is loaded into the visual feature units (See Figure 1). The features are made up of each letter of the word i.e., **PÀ** /kΛ/, **®** /lΛ/ and **ªÀÄ** /mΛ/. Activation is passed from the feature units to the letter units in parallel across all features and letter positions. Because the processing at the letter level is parallel and cascaded, all letter positions are activated at the same time and activation cascades to the orthographic level and GPC module immediately. Unlike the orthographic level, where activation occurs in parallel, the GPC module is constrained by its serial processing. At this level the GPC module starts processing the first letter. The sub-lexical spelling-sound correspondence rule system is searched until a rule is matched to the first letter. The GPC module receives the same letter input until the first letter of the word reaches its threshold. Once the letter is recognized with maximal activation, the second letter is admitted to the GPC module. Once the second letter is recognized with maximal activation threshold, the first two letters are fed into the GPC module. The rule system is then searched until a rule matched the first two letters. If such a rule cannot be found, the rule system will find a rule matching the first letter, and another rule matching the second letter. That is, the rule system will always try to match the longest grapheme. The translation process continues with the GPC module receiving an additional letter every cycle, until all letters have been translated to phonemes.

In the whole process, the time taken to recognize non-word increases due to the serial processing that takes place at the GPC module before it is recognized. Whereas, the processing of words does not go through the GPC module and is processed as a whole unit, which is compared with the available knowledge of the word in the semantic system. Hence, it takes lesser time to process and recognize words than non-words presented visually (Coltheart, 1978; Marshall & Newcombe, 1973; Meyer, Schvaneveldt, & Ruddy, 1974).

Lexical errors generally reflect a failure in the use of the direct route to access the mental lexicon. A reader addresses word representations without accomplishing an analysis of the orthographic segments of the printed word. Because Kannada orthography is shallow, children may be making a predominant use of the phonological route in the first stages of reading acquisition. When they become skilled and familiar enough with many of the words, they turn to a predominant use of the lexical or direct route. In short, the present results suggest that subtle differences in the degree of predictability of GPCR in Kannada orthography may influence not only the timing of reading acquisition, but also the relative use that children make of the direct and the phonological routes in different phases of reading acquisition. Finally, consideration must be given to the generalization of the results of this research. It is widely accepted that the reading of pseudowords is a good indicator of knowledge of the alphabetic code. Researchers in the field consider this task to be proof of the comprehension of the basic reading mechanisms (Frith et al., 1998; Goswami et al., 1998; Wimmer & Goswami, 1994). However, we are aware that the tasks we used are mainly related to word recognition skills. We must therefore be careful to keep in mind that there are other processes of a higher level that also play a role in reading skills.

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