Processing Levels in an Alphasyllabic Script: Experimental Evidence from Malayalam

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by

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CERTIFICATE

This is to certify that the thesis entitled "**Processing Levels in an Alphasyllabic Script: Experimental Evidence from Malayalam**" submitted by **Sreerakuvandana** bearing Reg. No **15CCHL07** in partial fulfillment of the requirements for the award of Doctor of Philosophy in Cognitive Science is a bonafide work carried out by her under my supervision and guidance.

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DECLARATION

I, **Sreerakuvandana**, hereby declare that this thesis entitled "**Processing Levels in an Alphasyllabic Script: Experimental Evidence from Malayalam**" submitted by me under the guidance and supervision of Professor **Ramesh Kumar Mishra** is a bonafide research work. I also declare that it has not been submitted previously in part or in full to this University or any or any other University or Institution for the award of any degree or diploma.

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Dedicated to,

My mother who taught me to write,

My father who taught me to read

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Abstract

Everyday scenes, objects are usually conceptualized as ones that contains two levels; the global and local level (for scenes, see Cesarei & Loftus, 2011; for objects, see Ericson, Beck & Lamsweerde, 2015). The global information relates to the overall form of an object or scene, while the local information relates to the finer grain details that make this overall form (global element). What deserves attention is how information across these levels contribute in understanding these everyday objects, faces and scenes and what of the global and local level is perceived in order to arrive at meaning. Much like the scenes, objects and faces, human readers have an immense exposure to reading. They encounter millions of letters during their formative years of learning especially. The immense exposure to letters over one's lifetime means the reader also can (probably) alter their reading strategy according to the nature of the script. What impact can such an exposure have on reading? The thesis explores if such an exposure alters the way in which the reading strategy functions. As a reader of a particular language family gains experience reading in language A, should similarly process language B, that belongs to the same family; because with an increase in experience in reading, the influence of the number of features a letter has is supplanted by the number of shared features between letters (Wiley & Rapp, 2018). Contrasting characteristics of native scripts can also trigger a change in the nature of processing (Winskel et al., 2018) And if experience can put humans in a better position to identify letters, will this experience benefit the perceiver even when some features are not available for percept are some key areas the thesis ventures into.

Much like faces and objects, letter also has a global level, the overall shape and form; and a local level; the features (like the lines and curves etc.) that make up the global form. Therefore, an important question here concerns the nature of processing in letters, in alphasyllabic scripts and if the featural level factors affect the perception of the global form. Precisely, the thesis aims to address the kind of impact a complex script like that of an alphasyllabic script have on letter processing. Alphasyllabic scripts are characterized as having two levels for their representation of sounds and as such what processing level (the phoneme or syllable) is chosen by the system when reading alphasyllabic scripts, is explored in the thesis. Together with this, the thesis also aims to explore the crucial area of a letter for its recognition. That is, what part of a letter is needed for an accurate identification of the letter.

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Abbreviations

GPE	Global Precedence Effect
L1	Native Language
L2	Second Language
M	Mean
RT	Reaction Time
SD	Standard Deviation

Chapter 1: Introduction

Overview

This chapter provides an overview of the critical concepts the thesis deals and discusses about. Some of the key concepts are global and local processing, alphasyllabic scripts and its properties, highlights some studies in the context and its limitations, and concludes with a discussion of how the experiments conducted as a part of the study circumvent the limitations of earlier work. Chapter 1 begins with some relevant and relatable examples illustrating the important concepts.

1.2 The Brahmi scripts: A brief history

One of the oldest writing system by virtue of age is the Brahmi script, used in Ancient India and the present South and Central Asia. There is however no answer to the question if this system was influenced by another script, or if it was simply an indigenous invention. It is popularly accepted that Brahmi is derived from the Semitic scripts and later adapted to suit the needs of Prakrit and Sanskrit. Aramaic was the language of administration in the Indus valley, the present-day Afghanistan, Pakistan and northwest India. Even the official records were written using the Semitic script. The other sister writing system of Brahmi is the Kharosthi script that developed around the same time in the same region. However, Kharosthi was limited only to the Indus Valley region, while the Brahmi was throughout India. There is however no agreement on the connection between Semitic and Brahmi. Some scholars like Professor K. Rajan opine that the symbols found on graffiti on several sites in Tamil Nadu have Brahmi symbols depicted on them. The inscriptions are a testimony to the fact that this was the precursor of the script. Evidences from South India, has a strategic three-layer stratum of writing. The lower level has only graffiti inscriptions, followed by the middle layer that has a mix of Brahmi and graffiti inscriptions. The upper most or the latest layer shows only Brahmi inscriptions. Mangudi, a place in South India has also revealed inscriptions that have graffiti inscriptions initially, followed by Brahmi inscriptions on the top most layer. Archaeological sites, this way, are abundant sources of essential information that help in deciphering the unknown. Epigraphic material contributes to the knowledge of history of India.

The third claim stems from scholars who propose that Brahmi was derived from the Indus script, the popular script used in the Indus Valley civilisation. With the end of the Indus civilization, the script was no longer used. However, it is hard to verify. The early history of writing in India is clouded in mystery. Seals had scripts on them that were undeciphered. Many other such relics in the Indus Valley had inscriptions on them. However, it not till the Ashokan inscriptions that appeared that the writing system became prevalent. It is practically void after the fall of the Indus Valley civilization. Much of the written records and their development started from here. The Indian scripts that we are aware of today were derived from here to the present-day variants.

Kharosthi on the other hand, was another contemporary script that originated in the Northern Pakistan, recorded in the Asokan edicts. While Brahmi flourished far and wide, to many parts of India, Kharosthi was confined to specific locations. It died a slow death and the areas where Kharosthi was used, was replaced by other writing systems. However, there has been no Kharosthi derived scripts found till date. Although Kharosti and Brahmi were contemporaries of their time, the former died without any descendants and the latter is the parent of the major scripts of India, which have been locally known by different names and characterized by its own unique interesting features. However, Brahmi is used as a matter of convenience to refer to the Asokan script and the many varieties of it. This includes even the earlier derivatives until the end of Gupta period in the 6th century (Salomon, 1998). Figure (1) gives a quick picture of the Brahmi script derivatives.

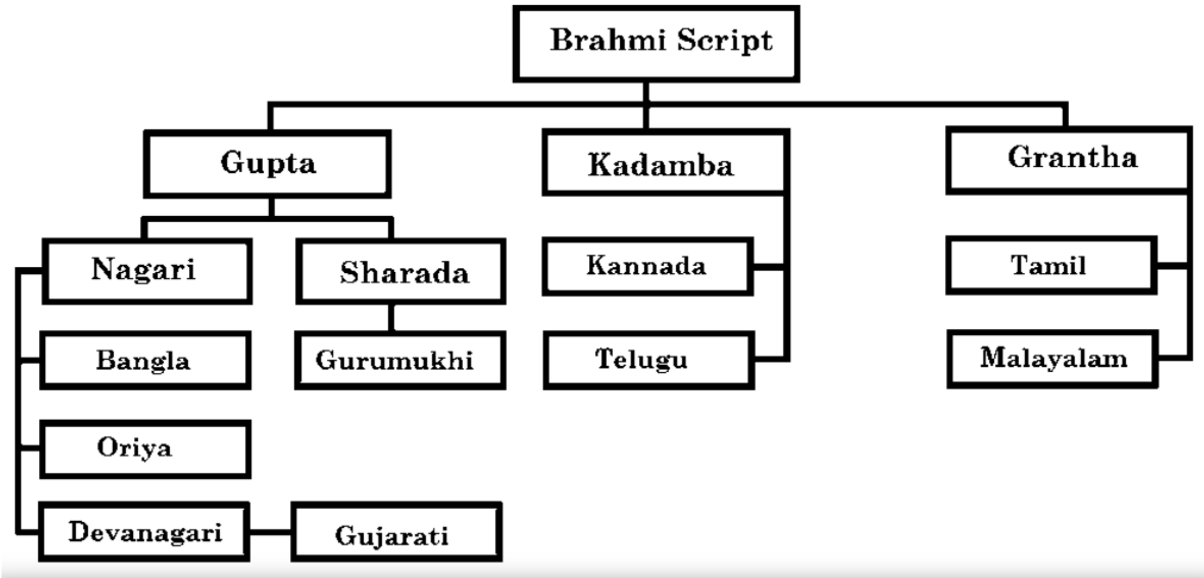


Figure 1. Evolution of the many Indian scripts from the parent Brahmi (Pal, Jayadevan, Sharma, 2012)

1.3 Writing systems of the world

'Writing system', 'script', 'writing' is used rather loosely. Writing system from now will mean to be used to differentiate systems that make use of linguistic units at the different structural level. These linguistic units are the phonemes, syllables etc. Therefore, an 'English writing system' means a writing system that will make use of an alphabetic system at its structural level, one that make use of the Roman script. Script then becomes an instantiation of writing system. Thus, the Greek alphabet, or the Roman alphabet are all alphabetic writing system instantiated by different scripts.

Orthographies on the other hand, are language specific. Orthography makes way for writing a particular language in a standardized and uniform way. It is more about the specific selection from the range of possibilities of script.

Making verbal communication visual, through a set of signs and symbols, is what writing system is all about. But, how it succeeds in doing this is another bigger question. Writing systems employ both phonetic and semantic symbols in their characters. This is encapsulated in four different writing systems of the world, which are,

1.3.1 Alphabetic. Alphabetic system represents the sounds or the phonemes in the form of letters. Words are formed in combination with other letters to produce meaningful utterances or texts. The vowels and symbols have separate letters to denote them. The common example is the English alphabetic system.

1.3.2 Syllabic. Japanese is an ideal example of a writing system that follows the syllabic style. A single syllable will contain a consonant and a vowel which is most often inherent.

1.3.3 Logographic. Logographs represent concepts. They convey more meaning, but do not have one to one correspondence between sounds and grapheme. Mandarin Chinese is a classic example of a logographic writing system.

1.3.4 Alphasyllabic. The scripts that represents sounds at the level of both phoneme and syllable. Almost all of the Indic scripts such as Tamil, Gujarati, Bengali etc. fall in this category of script.

The development from pictograph to alphabet is a process of increasing abstractness. Pictures are concrete and correspond exactly to what they are referring to. Alphabets on the other hand is abstract and requires an intermediate level of a sound or image. Gelb on the other hand has proposed the concept of ‘principle of unidirectional development’ and many scholars have accepted this view. The principle states that syllabaries are usually developed from logographies, and alphabets are developed from syllabaries, and also that these steps cannot be missed or reversed.

Thus, the different writing system mentioned above is a result of the different underlying forms. This also shows what is represented and what is not and in what relationship are they graphically marked. They are also a result of the typological differences. For example, syllables are more abstract when compared to words and thus, in the evolution of writing, syllabic writing appeared after the alphabetic system.

1.4 Brahmi derived scripts

Many languages of the that are spoken in the Indian subcontinent is derived from Brahmi. The origin of the many writing systems in Asia today can be traced back to Brahmi. The core unit of representation of these Brahmi derived writing systems is known as the aksara. Many of the languages of the Indian continent and also of the South East Asia, Central Asia use the Brahmi script as their writing system. Records from history show that gospels of religion, particularly Buddhism and traders propelled the need for adopting a script in the regions of South East Asia and Central Asia. This brought out a ripple effect, with such far-reaching changes into the linguistic, social and cultural spheres of everyday life. Some of the examples of languages who follow the Brahmi writing system are Assamese, Bengali, Gujarati, Kannada, Hindi, Punkabi, Tamil, Telugu, Malayalam in India and Sinhala of Sri Lanka, Thai, Burmese, Khmer, Javanese of South East Asia and Tibetan in Central India. All of these writing systems can be traced back to the Brahmi writing system. These, along with some other languages adopted the Brahmi and converted them into visually different symbols. See table (1). Although the aksaras differ aesthetically, all of them share the core psycholinguistic properties. Each of these aksaras vary in their form and shape. However, when we analyse them individually, we can expect to find a similar shared core psycholinguistic properties for each of the aksara across languages.

The Indian script is alphasyllabic in nature. Writing systems typically differ in the way in which the phonological unit of the language is represented. The degree of difference lies only in the physical representation and is very diverse. Each of the aksara looks visibly different from one another and are yet connected at their psychological level.

Table 1 *Selection of symbols across languages to represent the sound units in alphasyllabic script*

Symbol	Language
ക ഹ ഗ ര	Malayalam
क ह ग र	Hindi
க ஹ த ர	Tamil

Given this degree of difference in representation, it is likely that when children learn to read and write in these languages, it will also shape the orthographic domain; by the writing system that the child is learning to use (Ziegler & Goswami, 2005). The orthographic domain is all the aspect that contributes to the learning of the structure and mechanics of writing system (Nag, 2011) and writing systems in general is referred to as orthographies. For example, in a syllabary like Japanese, the sound unit /ka/ is a syllable か, that has both /k/ and /a/ in one block. These both units, that is, the sounds /k/ and /a/ cannot be separated from this one block of か. Thus, the language allows representation only at the syllable level with a default structure of CV (consonant+ vowel). In the case of alphabetic languages, the same sound is represented using two units ka which is k+a. Here, the sound units are represented at the phonemic level. Thus, the syllable ka is represented using two letter symbols of English, k and a. On the other hand, we have the aksara writing systems, that represent sounds both at the level of phoneme and syllable. For example, /ka/ is Devanagari is written as क and represents an inherent /a/ (vowel) sound. This is the inherent schwa and is a classic hallmark of aksara languages. However, a deliberate attempt can be made to silence the /a/ maatra (also known as a diacritic) by means of a *halant* thus making it कं. Here, the aksara represents sounds at both the level of phoneme and syllable simultaneously and hence is popularly referred to as abugidas (Bright, 1996; Daniels, 1996) or alphasyllabic scripts. They are partly alphabetic and partly syllabic. The initial stages of learning a language usually relies on trying to establish a connection between the spoken sound units and the written symbols. If this fundamental stage has to be cemented well, a considerable amount of time will be spent by children in trying to mater this connection as a pre-requisite for efficient reading. Typically, for alphasyllabic languages, the focus of attention has to be directed to two levels; the phonemes and syllables. Thus, the implications of teaching the aksara will also have an impact in shaping the literacy process. This will be discussed later in the chapter.

The alphasyllabic scripts also have more or less a similar kind of visuo-spatial characteristics. That is, aksara languages typically reflect a difference in the arrangement of phoneme markers around its consonant. The arrangement is not linear and is most often surrounding the consonant, on any side and therefore is regarded as a non-linear arrangement. With the primary consonant intact, all the sound (phonemic makers) will be ligatured around this consonant. Depending on the language, the vowel markers can appear on the left, right, top, bottom or surrounding (circumvowel) of the consonant. Figure (3) is illustrative of this. Notice in Figure (3) how the vowel markers are variously arranged around the consonantal base. The representative example is randomly chosen from three languages of India; Malayalam, Hindi and Tamil. Across these languages, the rule of ligaturing tends to be the same, where vowels as markers or maatras can appear anywhere surrounding the consonant. But in the process, the identity of the consonant stays intact and the shape is not altered.

These are the basic forms that the child or any learner of these languages are exposed to. As such, they tend to master these aksaras fairly faster.

Table 2 *Vowel markers arranged around the consonant in three languages of Indian subcontinent, Malayalam, Hindi and Tamil*.

Vowel markers	Language
കി ഹൂ ഗാ	Malayalam
की कि के कु	Hindi
போ மி மூ மா	Tamil

Note that the base form of the aksara does not undergo a change in shape or form. In Malayalam, the left most is കി /ki/, where ക is the base or consonantal form which takes a diacritic marker to the right of it. However, if the diacritic marker is added to left, it changes what the aksara stands for. Thus, there are very strict rules with respect to this.

A representation of the phonemic units in a language is made possible because of the aksara unit. That is, since each phoneme unit has a primary and a secondary form, these phonemic markers are placed before, after, surrounding, below or top of the consonant. As such there are also clear rules where a primary form and where a secondary form of a phoneme can be used.

1.5 Aksara writing system and the shared psycholinguistic features

The aksara writing system is placed between the contained and extensive orthography (Nag, 2011). Sonali Nag classifies languages on a continuum. In this continuum, the left side of the scale represents languages that have less number of syllables such as English and Khasi. English has only 26 alphabets and therefore is placed under the contained orthography set. On the other hand, in the extreme right end of the continuum are languages that have a large symbol set to represent the language. Chinese falls in this set. Therefore, depending on where the language falls, learning experience also differ. As of alphasyllabic languages, it becomes clear that the language demands create a learning situation that is different from learning an alphabet language (Nag, 2011).

The aksara writing systems have several characteristics with that of a syllabary and of alphabetic system. Each aksara can be used to represent one syllable unit; as in when learning की /ki/, children are taught to recite the unit as a whole. Note that in की, the syllable also has an underlying sound structure which is the ी unit that represents the reduced form of the vowel इ /i/. To enumerate better, the following are the properties of alphasyllabic scripts.

They have two representations for a basic vowel. The primary form of the vowel is written in its full form and almost always appear at the beginning of a word. On the other hand, the reduced form of the vowel appears elsewhere; the word medial position and at the final position of the word, as in the example illustrated above in की (क+ ी). However, in the word initial position, ी appear as इ. Ligatures such as ी are commonly referred to as *maatra*, which is equivalent to ‘diacritic’ in English.

One of the most important feature of an alphasyllabic script is its inherent schwa. The schwa is described as the silent vowel that lies in क /k/. When articulating क, the silent vowel is always pronounced. In order to silence this vowel, an explicit halant or a dot is used. Hence, by default, the aksara always has an inherent vowel.

The dependent vowel markers that appear in transcriptions of CV sequences, often in linear sequences that do not correspond to the temporal sequence of utterance. Two distinct varieties of this phenomenon are attested and discussed in the literature. One of these is exemplified in the item under (a) and the other, in the item under item (b):

a. कि /ki/

b. मस्जिद /mas.jid/

In the former, the vowel is written before (to the left of) the consonant, but articulated temporally after the consonant. In the latter, there is a mismatch between the organization of segments into syllables and the organization of the graphemes denoting the segments into aksaras. Notably, phonemic material belonging to the initial syllable is embedded in the middle of the second aksara. Vaid & Gupta (2002) and Kandhadai & Sproat (2011) arrive at contradictory conclusions with respect to (a). According to Vaid, the phenomena exemplified in (a) will incur an additional processing cost, whereas according to Sproat, they will not. Sproat, however, finds that an item like the one listed under (b) does incur additional processing cost, if the words are segmented at syllabic boundaries. This issue however can be settled depending on the task in question. Besides, there is evidence (Nag, 2010) from Grade 2 and 3 school children who showed that such mis-sequenced orthography-phonology mapping in the aksara language can indeed slow down the recognition process altogether. Nag found from an error analysis that such errors on such misaligned sequence (ी + क) was more common than when the vowel succeeded the consonant as in the case of /i:/ (क + ी). There is perhaps a good chance of confusion in phonological processing and phonology-orthography mapping. Despite the fact that these misalignment is clear in the writing, a clear visual form, there is still a confusion or an error when trying to recognize. This trend was seen even in older children, who despite the mastery in the basics of aksara, continued to make an error when spelling it (Nag, 2011).

c. के /ke/

Proceeding from top to bottom in (c), we encounter the vowel before (on the top of) the consonant, which is in reality articulated temporally after it. In (d) however, the graphemes representing the segments are encountered in the same sequence in which they are articulated.

d. कु /ku/

The phoneme marker is another hallmark of alphasyllabary. While there might be a lot of similarities across alphabet and syllabary writing system, note that the syllables represent sound at only one level. They also do not have distinct vowel markers like aksara languages. To go back to the Japanese example, か is one syllable which always comes as a block and the block cannot be further decomposed into subsequent phonemes. Syllables do not give scope for a further deconstruction. On the other hand, the Hindi aksara का can be further deconstructed to क and ा, which are the phonemes (/k/ and /a/). की /ki/ and का /ka/ are two aksaras of Hindi. Note that in both, the aksara base is the same. The only addition is the diacritic marker, where the former has an /i/ marker and the letter has an /a/ marker. Hence, the vowels appear in two forms, the primary form which is इ and अ respectively. Likewise, all the vowel markers have a secondary truncated form of the primary vowel. However, there may or may not be a similarity in the primary and secondary form. It is this secondary form that usually appears in the middle position of the word and at the final position of the word. In the beginning of the word, the vowel is always used in the primary form.

The number of consonants differs across languages. In general, most aksara language has aspirated sounds, voiced and voiceless sounds, except in case of Tamil which does not have either voiced or aspirated sounds. Even when the vowels attach to the consonant, the consonantal base does not change. Typically, both vowels and consonants are taught in schools, with a set phase of teaching. The aksara systems have three types of symbols. The first is the consonant that comes with the inherent vowel (/Ca/). The second kind is CV structure which is the consonant with an explicit vowel marker and the third is the CCV structure which is typically two consonants with one vowel. CCV structure is not fixed. Sometimes, there is also a CVV structure. This kind is known as the consonant cluster, where the consonants and vowels are stacked together. The corresponding vowels appear as diacritics and usually the consonantal base does not change. The diacritics are ligatured to the base of the consonant. The extent to which this stacking might allow a transparency of the individual aksara will differ depending on the language. In Malayalam for example, some aksaras that are vowel forms are truncated and attached to the consonant, thus eliminating any scope for identification, as in, ക്രോ /kro/ where the consonant ക /k/ is visible and the vowel markers surrounds ക, which is േ◌ാ. The other diacritic marker is the consonantal sound ര /r/, that appears in its reduced form (this is particular only to ര in Malayalam). A CCV structure is fairly common in almost all the aksara languages.

Given that these are some of the features across all the aksara languages, we can expect a similar teaching trajectory. As a learner of these languages, he/she is introduced to the primary vowels and the consonants with inherent vowels. Approximately a year later, consonants with explicit vowels are taught and then the CCV or consonant clusters are taught. Ideally, each phase of aksara has to be taught after the mastery of one form. However, in school textbooks often bring to attention, words like amma 'mother' or akka 'elder sister' which use consonant clusters to indicate mm of amma and kk of akka. Learners are not specifically taught this pattern in the beginning, but the words are used only to teach the learner what each sound, in this case, a stands for. Therefore, high frequency of CV and CCV sequence happens because of repeated exposure when trying to learn the sound units first. This kind of an aksara learning is said to have serious implications for the nature of literacy attainment (Nag, 2011). Apart from how they are taught in class, other factors also affect that may affect the processing of aksara. Schools generally differ in the way they teach the aksara. Nag 2007, report a study conducted in some schools in Karnataka, a Southern Indian city, where children are taught aksaras as a whole unit. They are asked to recite the syllables as a whole and no measure is taken to draw the attention of the children to the subsequent phonemic units of the syllable. In contrast to this, in another study conducted by Nag & Sircar, 2008, report that select schools in

Kolkata, an Eastern Indian state, the aksara is taught by deconstructing the form into its subsequent phonemic units. This way, the child is exposed to the local detail of the aksara. Such differences in teaching, specifically, the way in which schools direct the attention of the learner to the phonemic markers that is contained in the syllable block, will cast a shadow in the processing or perceiving as such. That is to say, while some children will view the aksara as one global whole, the other set of children will be able to abstract the phonemic units out of this global whole; their approach will be more analytical in nature.

1.6 Understanding Holistic and Analytical processing

In the discussion above, a special mention was attributed to the holistic and analytic processing of aksaras. This is an important concept that the current thesis aims to explore. The long standing discussion on what constitutes the unit of perception has been mired in disagreements. In a language that adopts the alphasyllabic script, it becomes even more interesting because even though the unit of representation is an aksara, the aksara unit in itself contains a phoneme (either explicitly or implicitly), but is represented as one single block. Therefore, what the unit of perception in alphasyllabic scripts, forms a larger part of the thesis. Apart from the fact that school children are taught differently when it comes to drawing their attention to the phonemic units of an aksara, there must be an effect of such ordering of aksara in the processing strategies adopted by a speaker who is highly proficient and one who is low proficient. This difference is an expected off-shoot because a proficient speaker's mastery or command over reading can enable him/her to surpass the underlying finer grain details of a script. Research in the areas of proficiency and reading suggest that there are multiple factors that can affect perception of a letter and that the visual system can adjusts its weighting of visual features when expert readers begin to efficiently and effectively discriminate the letters of the specific alphabet they are viewing (Wiley, Wilson & Rapp, 2016). This means, the nature of perception is likely to change with reading expertise. But what is not clear is where the focus of attention is when a letter is processed. Cognitive control processes are used exactly in such situations, where the task is uncertain. That is, when no cue is present in a particular situation, there can be a confusion when it comes to selecting which task or the action that has to be performed. Situations like these are very common in many of the visual scenes we encounter every day (Monsell, 2003). This confusion in the behaviour is because, our everyday visual world contains a lot of information that can probably be processed in just one look. This has to be appreciated, especially taking into consideration the fact that humans make about 3-4 eye movements every second (Henderson, 2003). Despite this marvellous rate of orientation of human eye, the real word objects are too complex to be processed, all of them. Humans thus have to grapple with a huge amount of perceptual data that at one glace, might be too much for perception. Humans are also continually exposed to situations that may or may not demand action. For example, when standing in front of a mirror, there could be a lot of things that a person could do; starting from adjusting the hair, applying a make-up, intently looking at self, among a range of other possible actions, and as such, depending on the goal of the observer, there could be a number of alternatives of action to that stimuli. Such sort of a stimuli will warrant multiple actions and is almost always constrained by the learned association or goal of the observer. In addition, the observer cannot perform all the actions at the same time and hence there must be some mechanism that will effectively reduce the possible number of actions. In order to effectively amend to the current goal of the observer and to overcome the many limitations imposed by the environment, the observer has to selectively attend to the limited resources, by way of directing attention to only a subset of items that may be relevant for the stimuli. This means, an effective goal directed behaviour will depend on a combination of process that will help in supressing irrelevant responses. These irrelevant responses are the ones that may interfere with the goals of the observer. The goal directed behaviour, while supressing the irrelevant responses, initiate responses that are relevant to the completion of the goal. This is collectively understood as the executive control process. But the important question is, how is the efficiency of selection achieved? And importantly, what gets selected, is it the whole unit or only the parts? The current thesis aims to understand xwhat are the factors that affect this selection style when it comes to perceiving a letter. In a letter from the alphasyllabic script, the reader has both phonemes and syllable as his/her unit of perception. Does the reading strategy change with respect the unit of representation? This is the central aim of the thesis.

1.7 Letter perception

Letter perception is an important, but most of all, an overlooked stage in the reading process. Letter perception clearly provides a critical front for reading as they are the functional units and are the independent pieces of a word code (e.g., McClelland, 1976; Oden, 1984; Pelli, Farell & Moore, 2003). A common debate that divides scholars and researchers when it comes to letter perception is how letters are perceived. The two argued theories are; the feature detection model (Pelli, Burns, Farell & Moore, 2006) and the whole letter template approach (Palmer, 1999). The feature detection model states that letters are identified by breaking or deconstructing the whole unit into the features that make-up the letter. This is also popularly known as the analytical approach. On the other hand, the whole letter template approach is where the unit is perceived as a whole. This is popularly known as the holistic approach. However, it is possible that when fluent readers encounter a letter, they are likely to know which of the features are exactly needed for accurate identification of a letter (Wiley & Rapp, 2018). For example, in identifying the letter ‘I’ and ‘P’, it is likely that only certain features of ‘I’ and ‘P’ are used for identification. One way to understand is to assume that the readers see ‘I’ as one feature minus what is present in ‘P’ (the extra arch to the right side of the letter ‘P’ that makes all the difference). This one arch is what is known as the distinctive feature. Readers could use this as a benefit when it comes to identifying a letter. In the case of alphasyllabic scripts, one advantage is that diacritic markers may be used to identification, like how Arabic speakers could use the diacritic markers, which are essential visual features for letter or word identification (Perea, Mallouh, Mohammed, Khalifa & Carreiras, 2016). But does this mean a complexity benefit exist only when reading Arabic or other alphasyllabic scripts? Contemporary theories of feature based letter perception have revealed newer perspectives into the theories. Pelli et. al., 2006 through the feature detection and letter identification, measured letter identification efficiency. They found that while the letter identification was not affected by stimulus duration, eccentricity and size, the letters did vary across alphabets and the fonts. Contrary to the template-matching approach, (letters are matched on to other letters based on their shape/form similarity) letters were expected to be identified optimally, as if they were all one single feature. This means, the identification of the whole was affected by the identification of each of the component features of the letter. The essential question is what is that causes these changes despite being able to understand the letter or perceive it? Pelli et.al observed that it was the square of the inside length and outside of the perimeter divided by the ink area which is known is perimetric complexity that made the difference. Perimetric complexity provides a measure of the visual complexity.

Letter complexity can also simply refer to the complexity that a reader or a learner in his/her formative years face, i.e.; when having to learn letters that look similar in form. In the languages family of abugidas, like Tamil, a south Indian language belonging to the Brahmi family, two aksaras /k/ and /ch/ look visually similar in form. The only difference is the left side stroke that is an extra in the former. Or, we could simply think of this as /k/ minus the extra stroke. We do not know how this is represented in the mental state. What is clear is that, complexity can also facilitate the perception of letter identity and this in line with Gestalt's idea of perception. The idea of perception is understood to be based on the broader understanding of 'similarity'. Regardless of the proximity of the object to each other, it is a basic human nature to group objects that are similar in nature, either in form, shape or colour. These objects or elements need not necessarily be next to each other. For example, the alphabets B and P of the Roman script, despite their distance in the alphabetical sequence, resemble each other in shape. Therefore, one way to understand this is, the human mind or the processing system identifies B and P as being visually similar, but only differing in an additional stroke and thus, the processing of both of them can be easier and faster. This means, the visual system singles out the common features and only focuses on what may be important for perception. This extra 'bulge' or stroke in B could also be a distinctive feature of B that will facilitate a quicker reaction time. On the other hand, the visual similarity of B and P can cause a potential delay in reaction time. If the visual system focuses on the independent strokes that make an alphabet, then it is highly possible that processing B and P can evoke a delay. However, if they are not identified with respect to their strokes then what might be interesting is to see which area of a letter is crucial for its recognition. Experiment 3 of the thesis focuses exclusively on this.

Complexity is defined as the number of features that make up a letter. It becomes important then to discuss the core idea of holistic and analytic processing. Does the processing strategy change with respect to the script in question? The other question the thesis eventually explores is how in a language that has both phonemic and syllabic units, processing happens and if this is affected by the visual complexity as such. Given that an aksara contains the phonemic markers and along with the consonant, does an analytical or holistic selection happen is also an area that the thesis ventures into. One way to however understand this selection problem is to the filtering process, which will minimize the use of the resources and also the processing, because they are limited. Another approach is to categorize and group the parsing process such that much of the effort can be offloaded with some automated routines such as grouping. The current thesis will also focus on what is it in an aksara that the reader selects in order to acutely identify the aksara. In other words, which area of a letter is crucial for recognition.

1.8 Hierarchical structure

The real world is highly structured. There is a certain hierarchy to this structuring. For example, the human body is one bug entity that is made of many other parts. These parts cannot exist independently. Visual scenes are similarly structured, one that is conceptualized as having global and a local information. Global information refers to the overall form of the object and the local information refers to the finer details of the whole object (Neisser, 1967). Within the human body for example, the body is highly organized, the fingers are contained in the hands, the hands within the arms and the arms within the human body. This sort of a nesting exists in all real-world objects that we see. Ordering of the global (the body) to local (the fingers) is the hierarchical structuring of levels. Also, the global level can encompass local constituents. However, this sort of a structuring can be challenging to the visual system, because usually the identity of one item in a certain hierarchical structure can prove to mislead the visual system. That is, the interpretation depends typically on the dominance of a particular level (whether global or local). Whichever appears more dominant, the visual system is susceptible to perceive it. Consider the example of squares arranged in the form a triangle (shape). Given the strict interpretation of the global level, one is likely to perceive it as a triangle. Similarly, given the strict interpretation of the local level, one is likely to perceive it as squares. Here, the global level is the triangle, which is the overall shape of the objects and the local level is the squares, one that makes up the triangle (the global object). Given this sort of an ambiguity, it is clear that the visual system definitely needs a co-ordinated processing of the objects that lie on both the global and local level. In the process of global processing, the local units are grouped into whole objects that enable perception (Koffka, 1935; Kohler, 1947; Wertheimer, 1955). On the other hand, during local processing, the entire picture is analysed to understand the individual objects (Han, Weaver, Murray, Kang, Yund, & Woods, 2002).

Navon, 1977, stated that the visual processing happens in a typical global-to-local fashion. One of the most common metaphor used in this context is forest before trees, the metaphor is used to describe the typical course of action that happens in processing. For example, one look at an unfamiliar object is enough to classify or identify the object. A glance will tell you that it is a ‘table’ that is lying in your living room. However, in order to accurately identify something as a ‘study table’, or ‘coffee table’ or ‘kitchen table’, requires an additional level of finer processing. This additional processing will elicit time (Potter, 1975, 1976). This means, there is a certain kind of temporal order that exists to processing the world every day and that the overall structure is perceived faster and efficiently than the finer grain details that make up this whole object. What is not clear is if these sort of a preferential global processing can have any consequence for behavioural activity. This question is still under investigation (see Hegde, 2008, Kimchi, 1992, 2003a,b, 2012, 2014; Navon, 2003; Morrison & Schyns, 2001; for reviews). We are also not certain if this global information can be used as a precursor to classifying the objects and scenes and control our act on the scenes, or if the information obtained from processing helps in controlling the processing of local level.

One another way a letter processing is understood is through the feature accumulation model, apart from the global-to-local model. The feature accumulation model is used to address the nature of information (perceptual) build up during the process of perception (Lupker, 1979). Precisely, what happens when only a partial information is available for perception, what would be the nature of that information? One way to see this is through the feature accumulation model. This means, in the initial stage, the observer will have no information about the nature of the image or visual cue presented to them. However, with time, all the features of the letters that are individual, will become available from the representation at the preperceptual visual storage or PVS. The features will continue to accumulate until the list gets complete enough to identify the letter that has been presented. This will enable the decision system to produce what the right answer is. Another simplest version of a feature accumulation model was proposed by Rumelhart and Siple (1974), who in their theory stated that the features usually correspond to the many line segments of a letter. This means, the feature set that is necessary for describing a letter is usually its lines that are diagonal, horizontal etc. and therefore, features such as these also tend to become a part of the symmetry list.

1.9 Perceptual information during letter processing

With respect to letter perception, as discussed above, the debate is between the models of perception; the whole letter template perception and the feature detection model. It is an acknowledged fact that a sentence contains words, which in turn contains letters; each of these letters further contains features that make up the letter. The functional utility of these subunits in the perceptual processing is what is often hotly debated and discussed.

When a letter is presented to an observer, or to a participant doing the experiment, what happens is that the perceiver tends to initially perceive a very large array of the perceptual data. Only with time is a focussed and clearer picture of stimulus comes. The perceptual system ideally brings to the notice of the observer, the stimulus, only after sometime. Therefore, a global idea of the letter is obtained very early in the process of processing and a clearer and focused image of the local elements or aspects become available only after a prolonged perceptual processing (Lupker, 1979). Lupker, 1979, through his study found that line features of a letter were first available for percept, followed by the relational information. The relational information is the one that puts the line features together and correctly. It was also found that the existence of one particular feature did not in any way, inhibit or facilitate the processing any other feature that was put out for display. Thus, it would seem at best to describe the course of letter processing as beginning from a global state and then moving on to a finer analysis.

But, what has to be addressed is if a global-to-local fashion is the uniform way of processing a letter or if the processing is subject to type of the script in question. A large body of studies have been conducted in alphabetic writing system, Hangul etc., with few to no work carried out in this aspect in alphasyllabic scripts. Chapter 2 of the thesis will focus on this; the nature of processing in alphasyllabic script.

1.10 Motivation of current work

Inconsiderate towards the other complex script such as alphasyllabic script. Need to take into account processing strategy adopted when unit of representation is two; syllable and phoneme. Winskel et.al, 2018 specifically studied Korean under the pretext that Hangul Korean is visually and intuitively complex. Through this, he assessed if the processing strategy of one script is carried on when trying to read another script. The answer is yes. Together with this, Koreans also processed familiar letters of a language in an analytical fashion than how English speakers did. Lachmann also conducted his studies among Roman script readers and found the GPE to disappear with letters. Liu et.al, 2010, studied children in order to understand what processing strategy happens are character level and word level. While at the word level there is a preference for holistic processing, at the character (unit of representation in Chinese), there is a preference for analytical processing. Both, in the case of Chinese and Korean, a differential processing strategy from that of English exists because of the script properties. While the German speakers who read English in Lachmann's study (2014) showed a classic GPE for non-letters and this effect disappeared for letters. With this, they concluded that letters are typically processed analytically. A follow up study was conducted by Schmitt, Van Leeuwen and Lachmann (2017) used the same stimuli as of Lachmann's earlier study (2014) with a larger number of participants. They used a training paradigm where there was use of either phonological or non-phonological associations to the non-letter symbols. Phonological association was used to generate the "letter knowledge" for the non-letters and thus eliminate the associated GPE. The results from the study showed that GPE remained regardless of the phonological or non-phonological association, one that was learned by the participant in the training phase. For letters in particular, a relatively small GPE was found along with a symmetric congruence effect (global-to-local interference and a local-to-global interference) for both local (13 ms) and global (18 ms). It is possible that the meaningfulness of the stimuli have affected GPE. Poirel et al. (2008), through his study, presented to his participants, a global-local detection task with compound letters, objects and non-objects. The results from the study show that the global level was robust and was processed faster than the local level. This happened regardless of the kind of stimuli in question. Also, a global interference effect was observed only with meaningful stimuli (letters and objects) but not with non-object stimuli. While all of the above studies are conducted in non-Brahmi derived. There is an extreme paucity in the alphasyllabic scripts. Little to no attempt has been made to understand the processing strategy in scripts that have two units of representation. Also, as discussed above, the Korean speakers who read English, processed English much like Korean; and the German speakers who read English, processed English much like German, signals that first language reading experience can indeed shape the processing of second language. Going by this conjecture, a reader of alphasyllabic should also process English or any other script, like how he/she would process his/her L1. This question is explored in the thesis. Wiley et.al, studies English and Arabic language in order to understand the carry over effects from Arabic to English. Arabic belongs to a different language family from English and as such the effects of a reader who has a lifetime of experience in encountering Arabic script, will be more pronounced. Arabic has diacritic markers and often serves as an important means to facilitate the identification of the letters itself. This case may be more important in alphasyllabic scripts because much like Arabic, alphasyllabic languages also have a lot of diacritic markers arranged variously around the consonant. Besides, there are also cases which has misaligned written and articulation sequence. As such, exploring processing strategy in languages can provide an insight into the nature of representation in the mental lexicon. Also, there is no study conducted so far (except in Chinese) that tries to understand which area of a letter is crucial for identification. A study of this sort is necessary to understand whether letters are processed holistically or analytically. When a language represents its sound at a phonemic and syllabic level, the implication for such a representation needs to be studied with respect to the processing strategy adopted. While this may not say if one is processed faster or better than the other, it will certainly tell us how task demands modulate our processing strategy, thus indicating that both holistic and analytic processing exist side by side.

Studies that have however worked on alphasyllabic scripts have shown that syllabic awareness is crucial in decoding aksara languages, other studies have shown that phonemic awareness increases only with increasing grades (in school); Nakamura, Joshi & Ji, 2018, have shown that both phonemic and syllabic awareness is a pre-requisite for aksara decoding through the grades. Also, as the ability to decode an aksara increases, the acuity of syllabic level representation of the phonology also increases, thus incorporating the phonemic-level representation too (Nakamura et.al, 2018). In light of this, the thesis was developed to understand problems of representation and how these representation can influence the reading strategy too. Typically, whether readers decode an aksara at the phonemic or syllabic level, will depend on the task. For example, in a typical compound stimuli, if the reader is asked to do an identification task, where he/she has to identify if the small and big letter are the same, then attention is more focussed and needs a finer analysis. Then the possibility of noticing the phonemic markers is more pronounced. Similarly, if the reader is asked to grade the similarity of two letters, we can expect a finer analysis. On the other hand, if the task is to simply report what they saw, the analysis need not be fine tuned and only a global processing may be required. Thus, the motivation of the current study is two fold; one to understand the reading strategy in a script that allows a phonemic and syllabic representation and two, to see how task requirements alter the reading strategy, thereby arriving at the point that both phonemic and syllabic awareness is available for percept and either one gains priority depending on the task in question. Also, that both holistic and analytical processing exists side by side during reading.

1.11 Objectives

There are three primary objectives. Three of these objectives have different sets of experiments with a specific aim. Experiment 1 follows the first objective and experiment 2 has a different objective. The last experiment, experiment 3 follows the third objective.

Objective 1: To examine the perception of aksara by a native and naïve speaker of a language, who belong to reading in the same language family. One experiment is used to investigate the perception of aksara (similarity of form was used as a measure), in a situation that requires the observer to simple form based judgements; in deciding if the aksaras look similar or dissimilar. An RT or Reaction Time experiment was carried out.

Objective 2: To examine if the reading or perception strategy changes with respect to what the unit of representation is. That is, to understand holistic and analytic processing is modulated when an aksara is crowded (with diacritic markers). Two experiments are conducted to understand the second objective. Experiment 2 has phonemes of Malayalam and experiment 3 has syllables of Malayalam. Compound stimuli was used here. Navon's (1977) global precedence hypothesis states that a global advantage can be observed along with an interference in the initiation of the percept; thus claiming that global properties of an object may have an edge, such as temporal precedence during the microgenesis of percept. This edge is attained could be due to early registration or speeded processing. An RT experiment was used to understand this.

Objective 3: To examine which area of a letter is crucial for recognition. Malayalam letters are blurred partially (from top-to-centre, bottom-to-centre, left-to-centre and right-to-centre) and participants are asked to identify the letter by means of typing it. High proficient and low proficient participants were recruited for the study. The resultant findings could be suggestive of the holistic or analytic processing that can happen. Also, to understand if any part of an aksara may have more facilitatory effect than the other that can help in efficient identification.

1.12 Thesis Outline

The thesis has a total of five chapters. Chapter 1 (Introduction) focuses on some of the fundamental concepts the thesis relates to; a brief history of the Brahmi-derived writing systems, core properties of alphasyllabic scripts and the complexity involved, and a nutshell of the widely discussed concept; Global and Local processing. Chapter 2 (Experiment 1) explores how natives and naïve speakers who speak a language from the same language family, perceive aksaras. Here, similarity of the form of aksara was used to explore this. Chapter 3 (Experiment 2) focuses on global and local processing in phonemes and syllables and tries to differentiate the differential processing strategies adopted with respect to phonemes and syllables. There are two different experiments conducted to understand this. Chapter 4 (Experiment 3) is the final empirical study that explores the question 'which area of a letter is crucial for identification?' The chapter has one experiment. Chapter 5 (Conclusion) is the final chapter of the thesis which provides a summary along with a discussion of the experiments that were presented in the earlier chapters. Together, it also identifies some impact of these findings at an application level.

Chapter 2: Are aksaras similarly perceived by all the speakers of alphasyllabic language?

Overview

Characteristics of the symbols used to notate a language needs to be studied given the immense exposure we as adults have towards reading. Letters of a language tend to be similar to one another and this can both facilitate learning, or at the same time impose a cognitive demand to learn two similar looking aksaras that have a different phonetic expression. Much like face perception, letter perception is understood to be a special class of visual object, which only the literate section of the population have exposure to. Therefore, narrowing of this perception is likely to happen with reading expertise.

An extensive exposure to individual letters can have an impact on readers, specifically, readers of any language. Both perception and identification of letters require the processing of the visual features that make up a letter. However, what is still under debate is, if letters are perceived as a whole or if they are decoded via their component features. The core properties of a human visual system have a role in determining how and which visual features are made use of for letter identification. Together with this, there is also evidence to support that the extent of experience with letters along with the type of one's experience, may have the potential to influence how the visual system processes the letters (Wiley, Rapp, 2018). Wiley, Wilson, and Rapp (2016) observed the effect of alphabet and Arabic on letter perception, among bi-scriptal Arabic-English readers and among naïve mono-scriptal English readers. The results showed that letter complexity was associated with less accurate responses for naïve observers while there was a faster accurate responses among the expert readers. Letter complexity is defined as the number of visual features that make up a letter. On the other hand, naïve observers were seen to be slower on more complex letters. This is not surprising, given their limited to no exposure to the language. This means, letters that have more visual features need time to process. In contrast to this, expert readers exhibited a benefit of this letter complexity. The current study however found that such a complexity benefit would arise only when the speakers belong to two language families that are different, both in orientation and shape of the orthography. In the case of non-native speakers of Malayalam and native speakers of Malayalam, both groups were slower to respond to similar looking aksaras. Both the groups identified the different looking aksaras faster. The study adds to the previous literature by stating that indeed L2 reading could be shaped by L1 and that the underlying core properties of alphasyllabic scripts can elicit a common processing strategy.

2.1 Introduction

Jean Piaget, 1983; argued that there are two process involved in the process of cognitive development; assimilation and accommodation. The resulting cognitive growth is often the result of the frequent mix of assimilation and accommodation. Assimilation is defined as the process that changes or modifies our schemas (of what we already know) as a result of modification or when we learn anything new. Essentially, this new experience or information is added on to what we already know. Accommodation on the other hand is how we restructure our existing information so that new experience or information can be fitted in. Such a scenario happens when our thought process is shaped by new perception and when it does not fit with what we think we know. The process of accommodation and assimilation has been deployed to comprehend the response of the brain to learning when having to learn a new language, one that has different writing system (Perfetti et al., 2007). Through the process of assimilation, our overall beliefs and understanding of the world do not undergo a change. Instead, it is only a fitting in of new information into the existing schema of cognition, our perception and our understanding of the world. So, when we encounter a new information, we make sense of this information by forming association or trying to link it to the information we already have, making genuine attempts to fit it into the already existing information. For example, when a child sees an old man, who probably shares most of the physical features of his/her grandfather, the child is likely to exclaim “grandpa!”. The old man need not necessarily be the child’s grandfather, however what the child has established is how he/she is able to make this association with something it already knows. The child’s idea is not altered. It still is the same. The child has only assimilated the new information into its perception that all old men are necessarily my grandfather. The world-view also does not change. Instead, he/she has only added this new bit of extra information into its already available percept. Accommodation on the other hand changes the cognitive schema because the old information does not seem to work anymore. It is more of revisiting the existing schema and perception, along with the understanding that the individual has, so that any new information can be added. This happens because the already available schema cannot work and therefore, needs to be replaced so that it can deal with a new situation. To put it simply, you tend to adjust the information that is already available to make space for this new information. For example, when a child sees a bird, it recognizes it to be a bird and probably has its own schema for a bird, such that it has feathers, it flies etc. However, when it sees a plane, something that also flies, it might not fit into the bird schema that the child already has. Thus, the child here adjusts its schema to incorporate the information that not all flying objects are birds. The concept of assimilation and accommodation is more relevant to writing systems. Assimilation is the process of using the procedure of existing reading network in acquiring a new writing system. Accommodation on the other hand refers to the process of acquiring new procedure for reading a new writing system (Cao, F., Kim, S. Y., Liu, Y., & Liu, L., 2014). In the present study, such a pattern of assimilation-accommodation was observed to understand if the perception of L2 remains same for naïve speakers of Malayalam. Alphasyllabic scripts share the core psycholinguistic properties and as such, mastery in one alphasyllabic script might pass on to the reading pattern of another alphasyllabic script. When scripts differ significantly in their writing style, brain mechanisms supporting the two-language reading also is modulated, for example in Korean-English and Chinese-English bilinguals, where L2 activation was similar to that of L1 activation for both the Korean-English and Chinese-English bilinguals (Kim, Liu & Cao, 2017). Reading in the first and second language is associated with the similar areas of the brain, with only differences in some regions (Hernandez, 2009, Meschvan and Hernandez, 2006, Neslon at al., 2009). Throughout the many studies that has been conducted in Chinese and English, it has been found that L1 network (Chinese) is used in L2 (English) processing the language. This includes both early (Chee, Tan , & Theil, 1999) and late bilingual (Tan et al., 2003), as well as for high and low proficiency bilinguals (Cao, Tao, Liu, Perfetti, & Booth 2013). Studies in bilingualism have also shown that words in English can be read using the Chinese network, while in the case of monolinguals, studies have shown that English participants' word activation involves a different network from that of Chinese reading network (Bolger et al., 2005, Tan et al., 2005). Therefore, there is some evidence here that there might be a transference effect at play, i.e., the L2 language reading strategy may be modulated by L1 and that proficiency can also matter. Therefore, what can be the processing strategy when a speaker of any alphasyllabic language is asked to read another alphasyllabic script? Does the processing strategy change or does it remain the same for both native and the naïve speaker? Specifically, what effect visual similarity can bring in when both the groups are asked to read them?

With respect to the perception of the sounds of a language (L2), adults are observed to be comparatively poor at the perception of L2 speech sounds. Infants on the other hand are described as the "citizens of the world" (Werker and Trees 1984) when it comes to perceiving and distinguishing sound units. Such a disparity arises because of the specialisation to the native language (L1). This process happens much before the first year ending and further causes an apparent decrease in the L2 perception (of sounds) and its contrasts (Kuhl et al., 1992; Polka and Werker 1994; Werker and Pegg, 1992). Researchers have pointed that this specialisation of the L1 does not mean that the speaker loses the perceptual ability, but only a shift of attention happens, which could be because of the phonemic development (Werker 1994, 1995; Werker and Curtin 2005). The essential question is how the speakers of L2 when learning, make use of the underlying abilities (of access to the perceptual abilities of L1) and how they interact with the consequences of L1 specialisation, more so, in the light of individual variation. The effect of L1 is extensively discussed in the light of transfer or Crosslinguistic Influence (CLI) and is known to play a central role in the L2 speech learning.

2.1.1 Transfer or Crosslinguistic Influence in speech. The fact that L2 speech learning will be influenced by the previously acquired knowledge, is clearly established in the L2 speech field and research. Some major theories in the area include the Perceptual Assimilation Model (PAM; Best 1994, 1995) and is extended to L2 learners, PAM- L2 (Best and Tyler 2007), the Native Language Magnet theory (NLM; Kuhl and Iverson 1995, Kuhl et al., 1992, 2008) etc. All of these theories include a role for listener's in L1.

These theories however vary in how the L1 influence is conceptualized. For example, the Native Language Magnet Theory stresses the role of the developing L1 prototype, on the other hand, PAM-L2 emphasizes the different ways in which L2 contrasts are perceptually assimilated to the contrasts in L1. This has a consequence for not only identification, but also for discrimination of the sounds in L2. Despite such small differences, theories of non-native perception of speech is similar when it comes to providing an account for the negative effects of L1development in the perception of L2. However this by no means should be understood that L1 experience can handicap the perception that happens in L2 (Bohn and Best 2012; Chang 2016, 2018), but is portrayed such that listeners who have a developed L1 are at a disadvantage compared to the listeners who do not yet have a fully developed L1. To state an example, the

English speaking adults showed the ability to discriminate the contrasts of Thompson Salish in a poor light when compared to the English-learning infants (Werker and Tees 1984). Such a disparity is understood as a decline in the sensitivity to the contrasts in the non-native language during the development of L1.

We as humans have the ability to learn many languages. This skill is understood to be to be arbitrated by the both structural and functional plasticity in the brain (Mechelli et al.,2004). The assimilation hypothesis is seen to argue that learning of a second language makes use of the same brain network that is used in the processing of the native language. Second language learning is the interaction between the system for L1 (native language) and a new linguistic representation. Behavioural studies have shown that characteristics of L1 reading mechanism to affect how L2 reading happens (Lallier et.al., 2016, Wang et.al., 2003). Wang et.al., (2003) showed that Korean or Chinese reading skill (L1) influenced the reading of English, an alphabetic writing system. That is, Korean readers were more sensitive to phonological information in English, because Korean rely on phonological information in reading their script. Chinese readers on the other hand, who depend on the orthographic aspects in their logographic script, were similarly more sensitive to the orthographic information in English. Quite a large number of studies have taken place in the Chinese-English bilinguals to understand the influence of L1 (Chinese) processing strategy in L2 (English). Evidences have also supported that some important brain regions for L1 is carried over to L2 reading and sometimes this effect is more profound high proficient bilinguals (Kim, Liu & Cao, 2017). Functional specialisation in the brain therefore arises with time and is considered as one of the hallmark for processing efficiently and thus, it should not be a surprise that there might be brain areas that are specialized for letters.

Second language learning is in effect an interaction between the L1 system that already exists within us and a new representation system, and it is also possible that fluent readers of a language would have encountered a lot of instances of letters and therefore would have unconsciously decided what features are essential for identification. Behavioural studies have also shown that with Spanish-Basque bilingual children, they showed a better visual processing strategy when it came to visual attention span task (Lallier et. al., 2016). This means, learning to read in another language affected the literacy in Basque differently. This is probably dependant on if this additional language is opaque (such as French) or if it is transparent (like Spanish). So, in effect these studies show an evidence that L1 can affect the learning of L2 at the behavioural level.

The present study is conducted among speakers of two alphasyllabic languages. The aim is to understand how the core psycholinguistic properties affect visual processing or perception of letters. The study will further help in understanding how mechanisms in L1 can facilitate or restrict the visual processing of letters. For example, in case of an alphabet like ‘P’, the letter ‘P’ has more visual features than that of a letter like ‘I’. So the letter ‘P’ may be identified on the basis of only few features that may be needed for its processing, and the other features may stand redundant. This is the distinctiveness property of a letter (Wiley & Rapp, 2018) may be put to effective use in identifying a letter. Therefore, expert readers or observers are likely to process the letters that are considered complex, much more easily than the omes that are simpler, if complexity (the number of features that make up a letter) is highly correlated with distinctiveness (Wiley & Rapp, 2018). While the current study did not take into account the proficiency of the speaker/participant, the aim was to shed light on how L1 perception is carried on to the L2 perception, in light of two alphasyllabic languages.

2.1.2 Reading and Writing in alphasyllabic languages. In the years of early learning, the entire block of aksara is the focus of instruction and is taught in a phased manner. How this is implemented in teaching is likely to vary across schools and teachers. Each school teaches these differently.

Nag 2007, reported that a select set of schools in Karnataka, teach the aksara as a whole. They learnt the syllable entirely by reciting it. However, in the city of Kolkata, the teaching and learning of aksara in school is quite different. The aksara in these schools is taught by breaking up the aksara block to understand their phonemic parts (Nag & Sircar, 2008). Thus, this sort of a difference in teaching can have significant impact on how some will view the aksara block; some as global and others as analytical. This is likely to influence the child's approach to viewing the aksara (Nag 2012). Since the alphasyllabic languages share the core psycholinguistic features, the ligaturing position of the vowels is likely to occur surrounding the base consonant. Thus, there exists a certain predictability in the stacking of the maatras. The biggest challenge in learning to read, more specifically, to write is the inconsistent sequence of mapping between the symbol and its speech sound. It is highly possible that the phoneme marker is not always consistent with the written sequence. That is, कि /ki/ in Devanagari is read क+इ (/k/ + /e/), but, in articulation, is pronounced इ+क (/e/+ /k/). Children learning to write and read typically make errors here.

Aksara is therefore taught in a phased manner. The bare consonants are taught first. Then, the CV structure is taught and finally the CCV or the consonant cluster is taught.

Given these commonalities across alphasyllabic scripts, it may be worthy to note the processing of letters across languages and natives. If letter processing is said to happen in a piecemeal fashion, via its visual components, then identification of the letters (whether between natives or non-natives) should not pose as a problem. However, if the letters are perceived as a whole unit, then the perception is likely to be a problem. The feature detection theory states that letters are recognized by a reader via its component features, such as lines, curves etc., as opposed to the whole letter templates (Palmer, 1999). However, there is also evidence that suggests natives/experts use only some features for identifying letters (see Fiset et.al., 2008, 2009; Wolfe & Horowitz, 2004). It is likely that fluent readers of a language have encountered many instances of a letter and thus could easily influence their identification, which is suggestive that distinctiveness of a letter vis a vis other letters may play a role in identification. Distinctiveness and complexity are two important variables in letter identification. While complexity is the number of shared elements among letters, distinctiveness is the degree of difference (with reference to the ligature) between two letters.

The current study aims to explore how a reader exploits this complexity benefit that lies among letters. Do the shared features of alphasyllabic script have a learning or perception benefit when learning another script? Precisely, does the perception of a letter change due to expertise and experience? To understand this, we examined a group of native speakers of Malayalam language and naïve Malayalam language speakers. If expert readers of a language have ample exposure to reading the script, they are likely to process complex letters faster and distinct letters slower. On the other hand, naïve speakers exhibit a sensitivity to complexity and not distinctiveness (Wiley & Rapp, 2020). In order to grade complexity and distinctiveness of a letter, in Experiment 1 the study asked participants, both native speakers of Malayalam and non-native speakers (who were not speakers of the language) to perform an RT experiment. Their RT measure was used to categorize the letters as ‘complex’ and ‘distinct’. Note that complex and distinct are two terms used in the study to classify the letters of the language. A letter is called complex when it elicits a slow RT and is distinct when it elicits a faster RT, keeping in mind the hypothesis projected by Wiley and Rapp, 2020. The hypothesis states that with an increase in exposure to reading a script, the influence of complexity is likely to be replaced by distinctiveness. In Experiment 2, the participants (natives and naïve) were shown

Malayalam letters, made of smaller other Malayalam letters, like the Navon's compound letters. (Insert Table). Letters were matched with respect to their similar/distinct combination.

Although the two sets of participants are not speakers of Malayalam, the central aim is understand if letter processing is shaped by expertise and experience over reading related scripts in general. According to the feature detection principle, letters are identified via their component features, or the features that make the letters, as opposed to the whole-letter templates (Palmer, 1999). There is also evidence that expert readers only use a subset of the feature for identification (see Fiset et.al., 2008, 2009; Wolfe & Horowitz, 2004). One possible explanation could be that the expert readers have encountered millions of instances of the letters and thus they exactly know which feature is required for them to differentiate F and E. For example, R has more visual features than a letter like I. Thus, R can easily be identified on the basis of very few of its features, leaving the other features R redundant. This is the distinctiveness property of a letter, that which helps in letter identification in relation to other

2.2 The study

The study is aimed at understanding how letters of alphasyllabic scripts is perceived by speakers across languages of alphasyllabic readers. The precise question is when a reader acquires ability to read in a writing system that is new, does the brain network assimilate the properties of writing system 1 to the writing system of 2nd one? Or does the brain network try to accommodate the new features of the new writing system (of 2nd one)? However, the current study does not use fMRI or other brain related apparatus to understand this. The tasks are RT or Reaction Time tasks and is a perception task. Reaction Time is chosen because the existing literature has already in length and breadth discussed about the consequences such transfer can cause on L2, especially when the reader is adept at L1 writing system or language. The current study enables to understand how letters are perceived by a native speaker and a naïve speaker. Does the processing strategy change? Ideally it should not, because of the shared properties that both the scripts have. To understand this, similar and dissimilar looking letters were chosen. This was just one factor of the script used to understand the processing strategy among both groups that shows there might be a perception effect that can be visible through their reaction time and not just on the areas of the brain. That even the perception changes physically is an indication of the strong transfer effect that lies within languages. Critically, what effect does complexity and distinctiveness play in mental representation of letters is the central aim of the study. Do the expert readers exploit this complexity benefit or do both the groups perform the same way?

2.3 Method

2.3.1. Participants. The participants were from the University of Hyderabad, in the age group of 20-29. A total of 50 participants volunteered for the study, out of which 25 were native speakers of Malayalam (M=22.70 years, SD= 2.51). The naïve speakers were selected based on their ability to read and write any one alphasyllabic language. This was assessed by means of a questionnaire. Participants provided their consent to be a part of their study. The Institutional Ethics Committee of the University of Hyderabad had provided their approval to conduct the study.

2.3.2 Stimuli. In order to be able to categorize aksaras as similar and distinct, native speakers of the language were asked to grade them. After this, the stimuli was categorized as similar and distinct. These aksaras were then used for the main experiment. In all, there were two phases; (a) the grading phase and, (b) the experimental phase. A total of 40 pairs of aksaras were presented, out of which 20 were similar and 20 of them were distinct.

2.3.4 Aksara grading

Native speakers of Malayalam were asked to grade the aksaras of Malayalam for their orthographic similarity, on a scale of 1-10, 1 being highly similar and 10 being distinct. Random aksaras were chosen, both vowels and consonants were chosen. The participants were instructed to grade them based on the shape of the aksaras. A total of 12 people graded the aksaras and a mean score was calculated. The participants were also regular readers of Malayalam script, as confirmed from a language questionnaire. The language questionnaire included questions on the frequency of language use (L1) in the spoken form, their frequency of reading Malayalam (either newspaper, magazine or other related) and their self-rated proficiency of writing in Malayalam. A similar understanding of naïve speakers were ascertained to get an idea of their language use. They could be speakers of any other alphasyllabic language. Their frequency of language use in spoken form, their frequency of reading the language (either newspaper, magazine or other related) and their self-rated proficiency of writing was also requested. Table (3) outlines the details.

Table 3 *Language proficiency of the participants in L1*

Legends	Mean	SD
Age (in years)	25.58	0.766
Language usage		
L1	38.83	25.02
Self-reported proficiency (in reading)		
L1	4.46	0.76
Self-reported proficiency (in writing)		
L1	4.13	1.02

The second phase of the study began with an instruction screen on the task. The participants were presented an auditory cue that read the aksara. The next screen showed two options, from which the participant had to select the right auditory cue that they heard. The options screen stayed for 3000ms after which it proceeds to the next trial. The stimuli appeared in a random order. One aksara at a time was displayed on the screen.

A total of 20 native speakers of Malayalam, from the University of Hyderabad, in the age group of 20-30 participated in the study. Participants performed the experiment one at a time in a controlled environment. A written consent was obtained from all of them.

To measure the similarity between the units a simple measure based on image correlation was used. Images were created for each aksara of a uniform font in Karthika script. Two-dimensional correlations were computed between the pairs of these images used in the experiment. The measure was the sum of correlations between the images for a fixed shift in each axis. Sets of aksaras that look identical but differ by means of a single stroke or more are classified in the first step.

Table 4 *Pairs of aksara that look visually similar, based on native speaker intuition*

Aksara	Transcription (in IPA)
ഹ വ	/h/, /ʋ/
ന ണ	/n̪/, /ɳ/
ല ഘ	/l/, /g^{ɦ}/

In set Table (4), /h/ and /ʋ/ look identical in form and only differ by means of a stroke, in the former there is an extra arch that is absent in the latter. In set 2, notice the extra arch on the aksara on the right side, that is absent in the one on the left. This would be the first condition. In the second condition, pairs that look totally dissimilar will be presented to the participants. For example see Table (5).

Table 5 *Pairs of aksara that look visually different*

Aksara	Transcription (in IPA)
ഹ ക	/h/, /k/
ന പ	/n̪/, /p/
ല ഇ	/l/, /i/

Notice how each of the aksara in the set differ from one another in shape. In order to compute their (visual) complexity score, Kohler's measure of complexity (2008) was used; the stroke counting technique (see Table (6) below). The method was used mostly in Chinese script. The method is now employed in the current study to understand how graphic complexity can constitute to processing cost. In this, an aksara such as ര /r/ is computed as follows; ര resembles an arch like form and hence gets 3 points and is written as one continuous unit and gets 1 point, making a total of 4 points for ര. Thus, the graphemic complexity of ര is 4. Likewise, calculations were manually carried out for all the aksaras. This was done so that there is a unit against which the aksaras could be compared.

Table 6 *Kohler's measure of complexity*

Form		Connection	
	Points		Points
Dot	2 points	Crisp	2 points
Straight line	2 points	Crossing	3 points
Arch	3 points	Continuous	1 point

In condition (1), we would expect the subjects to respond slower, because the choice has to be made between two aksaras that look identical and in the second condition, the choice has to be made between aksaras that are completely different. Intuitively, we would expect the choice to be faster in case of (2) as compared to condition (1). The farther the character moves away from its identical counterpart, the longer it will take to respond. Therefore, the study also tried to understand what can be called identical.

Table 7 *Aksara pair and complexity score*

Aksara pair	Complexity Score
അ ആ (/a/, /aa/)	33, 37
ര റ (/ra/, / r/)	9, 4
ണ ന (/ɳ/, /n̪/)	19, 9
ഘ ല (/gʱ/, /l/)	24,19
ഹ വ (/h/, / ʋ/)	13,12
ദ ഭ (/d/, / bʱ/)	12,13
ഒ ദ (/o/, /d/)	17,12
ഗ ശ (/g/, / ʃ/)	15,12
ഷ പ (/ʂ/, /p/)	26,12
ച പ (/t͡ʃ/, /p/)	14,12
ഇ ഉ (/ɪ/, / ʊ/)	17,12
ത ന (/t̪/, / n̪/)	15,9
ഖ വ (/kʰ/, /ʋ/)	15,12

Using the score computed from aksara grading, the aksara was used for image correlation. Pairs of aksara were juxtaposed one on top of the other and the sum, product and difference complexity was computed. The matrix was carried out in MATLAB. The sum of complexity indicates how much portion of the aksara is covered by another aksara (this is the ink space). This was done only to understand similarity from a better perspective. An image correlation was used to understand how much portion of an aksara is covered by another aksara. The results from this were not used from the main experiment. This was done at a pre-analysis stage and complexity as a factor was not used for the analysis of the study. Figure (2) captures this.

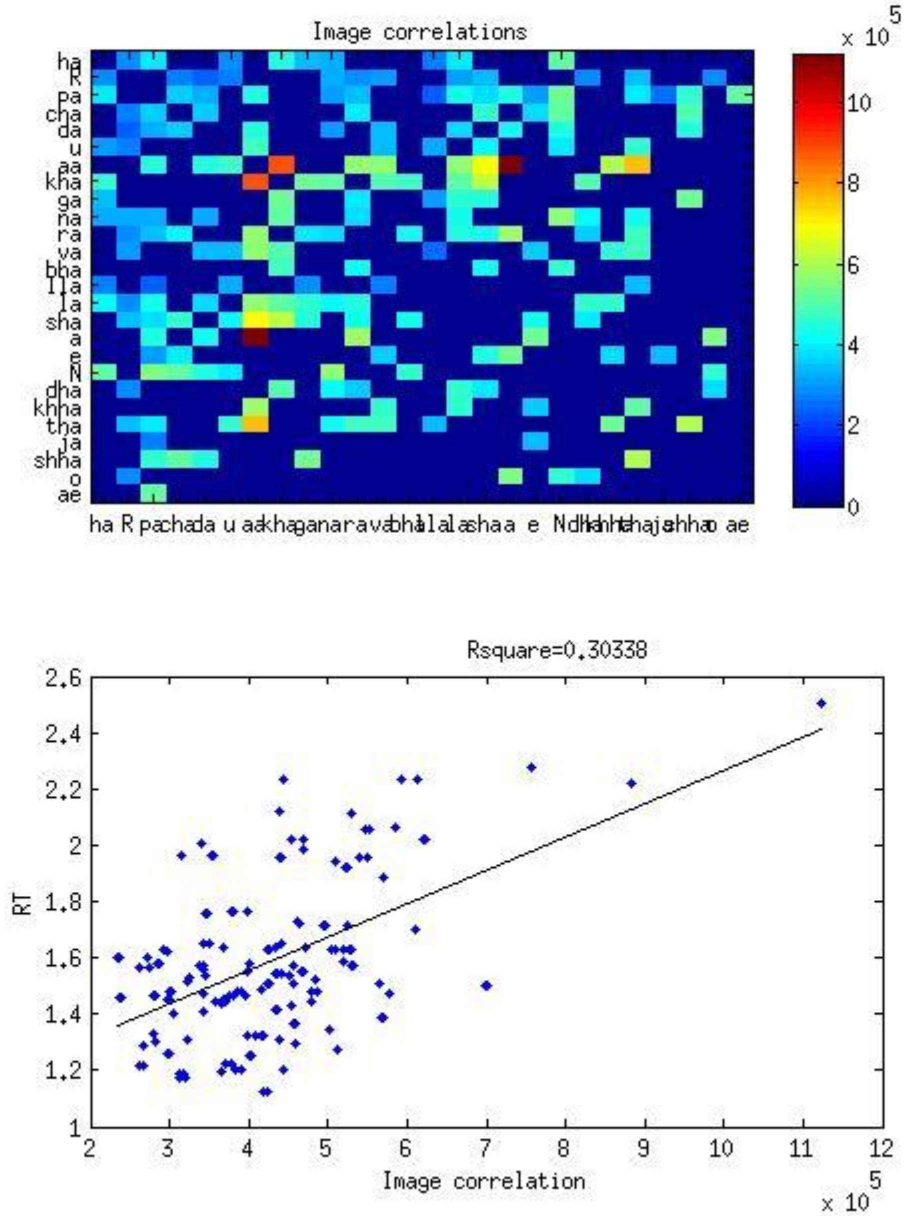


Figure 2 Image correlation of aksaras in Malayalam

Similarity between the pairs tested as measured by correlation between images of the fonts sow positive correlation to the reaction time. A. Correlation between images of pairs of units used in the experiment. B. Scatter plot of reaction time against correlation of the pairs. A positive correlation between image correlations measure and the associated RT indicated by the positive slope and R-square value of 0.30.

2.3.5 Procedure and design. The experiment started with a consent form where the participants had to click on ‘I agree’ that shows their willingness to participate. Post this, an instruction screen appeared where the task was detailed. Once ready, they were asked to press spacebar key to continue.

The main block started with a fixation cross for 500ms followed by the trails. The trail had aksara appear as pairs. These pairs were either similar in shape or were dissimilar. See Figure (3). The participants were instructed to press ‘a’ if they thought it looked similar in shape and to press ‘k’ if it was distinct. The screen was present for 4000ms after which it proceeded to the next trial. All the aksaras were presented in the image form and a uniform font size of 28 in the Karthika font was used. The aksaras were centrally presented. After each trail, a blank screen for 1000ms was presented in order to reduce any carry over effect. When an observer is asked to determine if the aksaras are similar or distinct, the time they take to arrive at the decision is a good indicator of the level of perceptual processing that takes place, which in turn also shows the type of information one may need to classify something or for comparison. The assumption of the study is that classifying two aksaras as “same” might involve the comparison of their form and shape (the curves and angles) for “same” responses and a lower level of analysis for “different” responses.

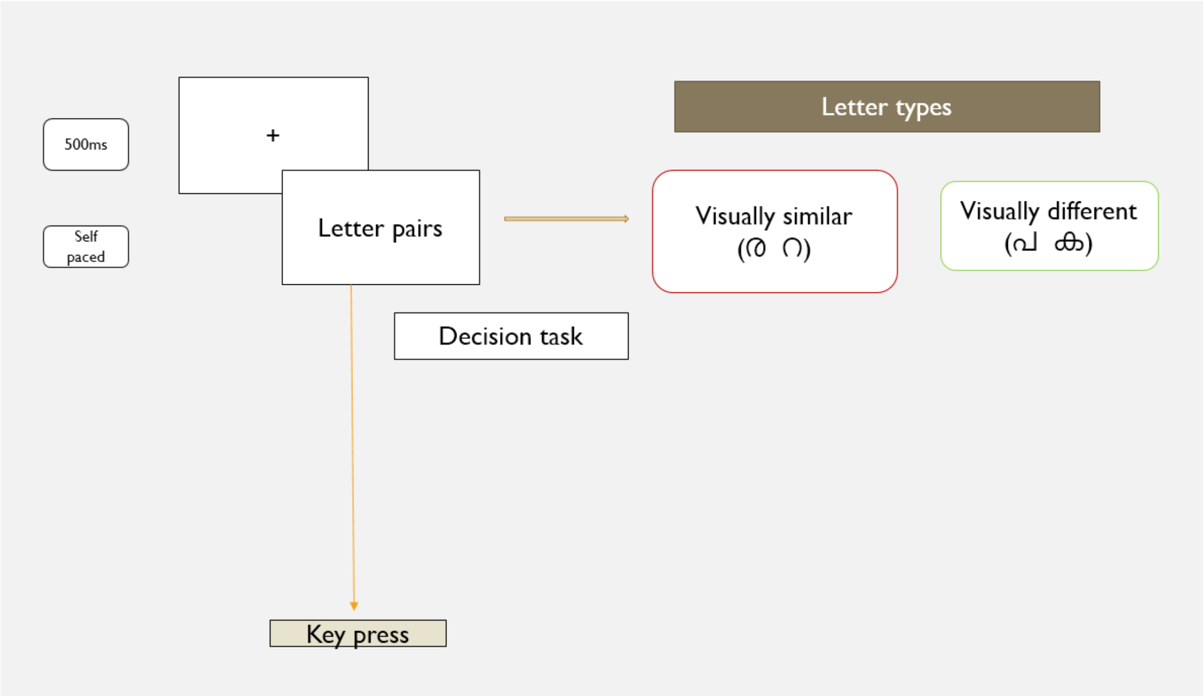


Figure 3 Design of the study

2.3.6 Data pre-processing and analysis. Trails that were incomplete, where the participants did not respond within the given time frame (latency more than 2500ms) was removed. For analysis purpose, 2% of outliers were removed from the overall result. Analysis was done only on complete trails and the incomplete ones were excluded from analysis. A repeated measures ANOVA was carried out with group (naïve and native group) and letter type (similar or distinct) as factors. A between-subject analysis was carried out.

2.4 Results

The analysis showed that the main interaction of the letter type was significant, F=25.78, p<.001, suggesting that the response of the participant was affected by the type of letter in stimuli (similar or distinct). The performance of the natives were faster (M=2068.09, SE=78.8) than that of the naïve readers (M=1801.3, SE=78.0). Pairwise comparison indicate that, both similar (p<.001, SE=52.5) and distinct pairs (p<.001, SE=52.5) were significant. The interaction between group*letter was not significant. However, natives responded to similar letters (M=2067.6, SE=113.6) faster than the naïve speakers (M=2068.5, SE=109.2). The distinct pairs show a smaller mean for native group (M=1739.1, SE=112.5) and a higher mean for naïve group (M=1863.5, SE=108.1). Overall, the natives were faster in their response to the task which is no surprise given their familiarity of the script.

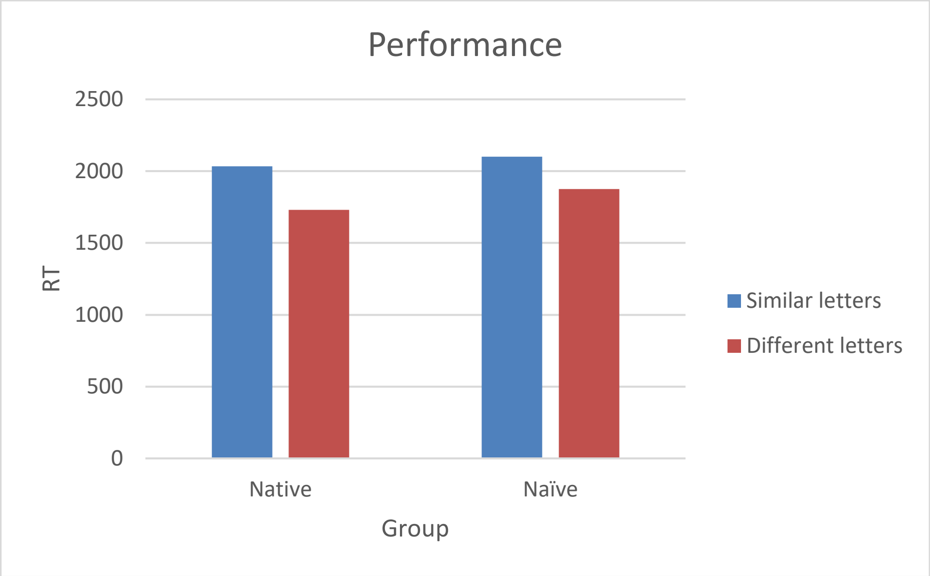


Figure 4 Performance of the naïve and natives

Figure (4) shows the performance of both the groups under the two experimental conditions. Evidently, the performance of the native group was better (measured in their overall reaction time) than that of the naïve group of participants. Figure (5) is a clearer picture of the reaction times of the two groups under experimental condition.

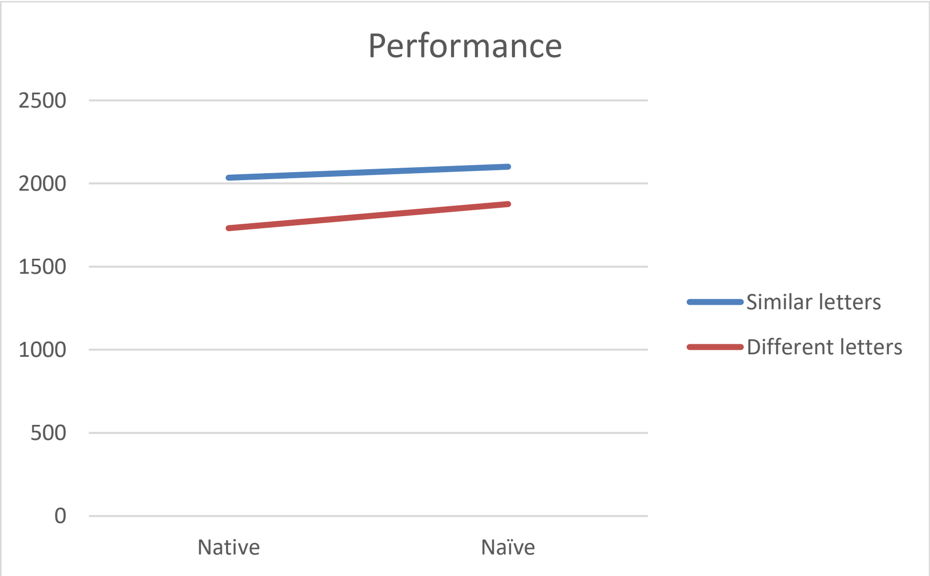


Figure 5 an accurate representation of the difference in RT for similar and distinct aksara pairs

2.5 Discussion

The present study aimed at understanding if native and naïve speakers process a language similarly, especially if the language belongs to the same script family; the alphasyllabary. More specifically to understand what effect complexity and distinctiveness of an aksara play in the mental representation of letters is the primary goal of the study. Together with this, do the expert readers exploit this complexity benefit or do both the groups perform the same way? Reading strategies universally involve the association of the written glyphs to the various units of language, whether syllable or phoneme. Therefore, we should expect to see some manifestation of this universal feature in many behavioural studies and in many simple reaction time studies. Chinese and alphabetic writing system comparison showed a very general and common role for phonology in both the writing systems; while the results from neuroimaging studies showed that there are networks of areas in the brain that overlap, even if partially, across these writing systems (Perfetti, Liu, Bolger, Tan, 2007). It is only when the script differs, we can expect to see difference in processing strategy. The focus of the study here has been to understand how despite being novice to Malayalam script, the perception of letters remain same across both groups. The reading procedure that respond to the visual-spatial properties of the script remain the same across both the groups. In alphasyllabic script, both phoneme and syllable is seen to have a strong influence in learning to read and as such, both of them will be implemented the same way by both a native and a naïve. On the face of it, perception of letters is driven by the number of features (complexity) that make up a letter and it does not matter if a naïve reader or an expert reader is encountering the aksara. Relevant to this discussion is the feature detection principle (Palmer, 1999). The feature detection principle states that letters or objects are identified the component features that make up the letter or object. Given this, it is only a strong evidence in support of the fact that feature detection principle applies similarly for any kind of a reader. Note that this sort of an analysis can change with respect to task in question. In the current study, the participants were explicitly asked to categorize them as similar or distinct. Such sort of a task will bring in the requirement of a finer grained analysis and hence an analytical approach to the problem becomes necessary. Potentially relevant to this discussion is if expert readers have an advantage over the naïve group. This is assumed so because, there is evidence for experts using only subset of a letter for identification, that is only some of the component features for identifying a letter (Fiset et al., 2008, 2009; Wolfe & Horowitz, 2004). This question has not been addressed by the current study. However, if such an advantage existed, then the native speakers should have performed better in the task, such that they identified the complex aksaras faster than the distinct letters. This was not the case. We should expect to see this complexity benefit because if they are regular readers of language, then their identification strategy especially when two similar looking letters are presented, should have been faster. However, the study does not align with complexity benefit and the reason why the current study did not show this complexity benefit is because the participants within the native group was not further categorized as high or low proficient. Some difference ought to exist here because a regular reader will encounter many instances of a letter and given the frequency, a functional specialisation ought to develop. This is one limitation of the study. Also, distinctiveness of a letter can play a crucial role in helping to identify a letter. That is, within each letter is what is known as a distinctive feature, the small feature that is responsible for the distinctiveness of each letter. For example, what distinguishes the letter 'I' and 'L' is the stroke at the bottom of 'L'. An alternative view is the letter 'L' is one extra stroke from 'I'. How this mental calculation happens is not exactly known although this one stroke is considered to be the distinguishing feature here. Whether this means one will be perceived faster than the other is also not clear. Thus, such distinguishing features can act as distinctive features and enable identification of a letter better, especially if the reader is a frequent and expert reader. For example, in a language like Arabic, most letters have diacritic markers. In the case of glyphs that represent "ba", "ta" and "tha", the basic shape is the same with the difference in the placement of the diacritic markers (in the form of dots). Therefore, Arabic letters are considered to be visually complex. These diacritic markers are expected to be the most essential distinguishing feature. Thus, Arabic readers might use this complexity benefit to identify letters faster. Terminations, horizontals, lines and curves therefore become important features in helping to identify letters. Pelli et al., observed when participants were only shown the contour of the shapes of the letter, by presenting them in a visual noise, perturbed the collinearity, rotated the shapes of the letters; that the accuracy dropped when the severity of the perturbation increased. This is suggestive of the importance of the lines and curves that make up a letter. Although one can argue about holistic processing of letters, what part of a letter may be needed for efficient identification has to be clearly understood. This concern is addressed in the final chapter of the thesis.

The trajectory of learning alphasyllabic script also becomes clear; from being able to quickly identify aksaras that are different, to taking to time to identify aksaras whose features overlap with another aksara (as evident from the performance of the naïve speakers). Overall, aksaras seem to be identified faster when they look visually distinct. Therefore, for a letter or aksara (in this case) to be identified efficiently, will need some distinguishing factor. That expert readers will only use a subset of features for identification of a letter (Fiset et al., 2008, 2009), is an evidence that only considers certain features such as lines, curves etc. and as such we cannot rule out the fact that expert readers may also use other features for identification. It is possible that expert readers will quickly identify the new visual feature. This is an expertise effect as studied and argued in many perceptual learning research (eg., Goldstone, 1998; Kellman & Garrigan, 2009). The possibility is suggestive of that fact that expert readers may quickly identify new and more visual features and therefore, dimensionality of letter representation is likely to change with reading expertise (Wiley and Rapp, 2018).

Taken together, the fact that both groups' performance was similar is an indication that processing of scripts within the same language family would not only entail a similar processing strategy, but also a similar perception of the aksaras. Also, the findings provide insight of the nature of letter processing and how the nature is unlikely to change if the processing happens within the same language family. However, this nature of processing is likely to change depending on the expert level of the speaker (Wiley and Rapp, 2018).

Evidences from alphabetic reading expert brain responds to other writing systems differently. As in the case of Chinese and English readers where one is alphabetic and the other is logographic writing system. Instances like these have been explored and research has concluded that the brain responds differently to writing systems (for example, see Perfetti, Liu, Nelson, Bolger & Tan, 2007; Perfetti, Cao, Booth, 2013). There is evidence for assimilation processing of Chinese readers in facilitating alphabetic reading. Note that there is a role for both expertise in alphabet and stimulus properties, in contributing to the functional specialisation that happens in the ventral visual cortex. As the specialisation of brain network increases, there ought to be processing differences in the networks that read Chinese, alphabet or syllabary. Beyond these reading procedures, there are universal and writing-specific functional reading universals that will be seen in the writing systems when adapting to the cognitive abilities of humans (Perfetti, Cao, Booth, 2013). Mishra (2007) argued that the alphasyllabic nature of Oriya entails a syllabic knowledge, especially in the beginning stages of learning to read, than relying on a phonemic knowledge. This result is however observed in population of Down syndrome.

Letter specific processing can happen as a result of experience and neural changes that occur with children as they begin to age. Alternatively, a letter specific processing can also arise out of an increase in the ability to read, rather than an increase in age. Letters also have to be processed meaningfully, i.e., in context with words and sentences for this sort of a letter specific processing to happen. Therefore, individuals who are better equipped with reading abilities ought to be at a greater advantageous position in the processing of letters over non-letters. However, given the high correlation between age and reading expertise, it will be difficult to dissociate the effects of one on the other.

Beyond these, Changizi et.al., 2006, provide evidence that signs (written glyphs of a language, that represent sound) of a language are culturally selected so that it matches the conglomeration of the contours that are found in everyday objects around us. They also state that shapes of signs are chosen such that it can be easily seen and identified by the motor system. In the study, they found that shapes of visual signs are selected keeping in mind the vision, at the expense of motor. To ascertain this, they examined shorthand versus trademarks, where shorthand is selected for writing at the expense of vision and trademarks are chosen for vision at the expense of the motor system. Complexity was not seen to correlate with frequency ranks of the configuration type (stroke or segments and other configuration type that is useful to outline the typological structure of the sign), whereas, visual complexity strongly seemed to correlate.

Impact on learning. Letters of a language tend to be similar and distinct to one another. In ര / ɾ/ and റ /r/, there is a seemingly visible visual similarity in shape. Together, there is also a phonological similarity. Such closeness, both in shape and phonology is likely to add to a learner's difficulty. However, we cannot ask for aksaras that are distinct from one another, as this can mean the learner is faced with yet another burden, of having to memorize the many forms and the associated phonological representation for each of the sound units of the language. So, a compromise has to be made between having to learn new forms or to tolerate the spelling mistakes that typically occur for learners learning the language. Additionaly cognitive demand on memory would be an offshoot of such a need for an elaborate and distinct aksaras for each sound of the language. Also, writing systems are under pressure to be easy to read and write and this pressure is partly for a convenient and easy reading to happen (Changizi, Shimojo, 2005). Consider the case of strokes first. Character/letter/aksara or any unit requires first, the recognition of the strokes that make-up the whole. Strokes are also very small, have a small angular size and thus some redundancy will help, such that misrecognition of two or three strokes do not lead to misrecognition of the character itself (Changizi, Shimojo, 2005). Changizi suggests that visual systems prefer a character length of only 3 approximately. This is probably the limit to which the visual short term memory can store. Until 3 strokes, all of them are perhaps processed simultaneously, after which an increase in the number of strokes can lead to an increase in the processing time as well. While the current experiment does not throw light on the role of strokes in reading alphasyllabic languages, there is a reason to believe that stroke count may not necessarily add to processing cost. Alphasyllabic languages tend to have a fairly simple stroke role and the diacritics are also limited to not more than three. The grain size of aksara is also small and as such there are not many visible units for the visual system to encounter or process. Stroke count as a factor may be more applicable for logographic scripts like Chinese.

One way to direct the attention to the units of alphasyllabic language may be to alter the teaching style. The teaching or classroom instruction can be improved. That is, the teachers can alert the learners on the visual similarity of the aksaras, by stating that ദ is only slightly different from റ; absence or presence of an extra element. This way, the learner is not only alerted to the visual similarity, but will also be in a better position to learn the phonemic and syllabic unit of the aksara. This awareness is important because research in alphabetic languages have shown that one challenge to literacy in alphabetic learning is the need to segment speech into its corresponding phonemic units (Goswami & Bryant, 1994). However, in aksara languages, the challenge is to learning to segment the unit at both syllabic and phonemic level. Once this challenge is overcome, accuracy in spelling and reading will improve significantly. Thus, perception of letters in some sense within the same language family is likely to be shaped by the shared core psycholinguistic features and as such processing can also be a product of this.

Chapter 3: Global and local processing in alphasyllabic scripts

Overview

The visual and auditory skills are the two skills that are generally employed in the ability to read. When these skills are used for the processing of letters and words, the original skills are usually modified, i.e., when listening to a word, it is the auditory domain that assumes primary importance. When processing letters, the visual domain modifies itself to attend to the different objects of complexity at different levels. Therefore, the question is, can we actually notice this modification of the visual domain that emerge in the process of learning to read? In addition, does normal reading (skilled) involve different processing strategies for letters and non-letters? In the current study, we are only concerned with letters, specifically to see if the processing of letters is affected when a letter is flanked by another letter. On the basis of previous studies, we aimed to study the processing of letters in alphasyllabic script (Malayalam) and alphabetic script (English) among native speakers of Malayalam and English as their learned language. We compared letters flanked at both global and local level in Malayalam and English. We found a global advantage for the processing of letters. That is, there was no visible interference of the local letters when processing the global level targets by the native speakers. The same was true of English. When asked to attend the local elements, congruency played a role in their response. That is, the speakers showed latency in the processing of asymmetric congruency trials. Malayalam and English show a Global Precedence Effect (GPE) effect.

Thus, processing of letters could be script specific and the processing difference is likely to be reflected when the nature of orthography changes, whether transparent or opaque language. In saying so, the study believes that analytic processing could be an innate skill that is recruited for special processing strategies and a script specific adaptation can happen with increasing reading experience.

The current chapter includes two experiments; (a) aimed at understanding processing strategy at the phonemic level; and (b) processing strategy at the syllable level. The studying of these two is important, especially given that the script is alphasyllabic in nature, representing sounds at both the phonemic and syllabic level. The speculation of a possibility of differential strategy in both these levels exists because just like faces, letters also represent a class of visual objects, one that is special, which humans have immense exposure to. Individuals can differentiate the phonemes of a native language from an unfamiliar language, and this happens during the development of perceptual processing that becomes fine-tuned with time. That is, a narrowing of perception takes place. Aligning with this thought is that perceptual narrowing occurs even in this domain of 'special' visual objects; known as letters. Therefore, when readers encounter a 'complex' symbol like a syllable and a 'bare' symbol like a phoneme, owing to the cognitive load, a differential processing can be expected to take place. While the first experiment states that phonemes of Malayalam are processed holistically, syllables are however analytically. This is not surprising giving the nature of a syllable and a phoneme.

3.1 Introduction

The world that we see is cluttered and is also complex that contains various objects in many number of sizes, orientation, shapes, colors etc. The visual world that we witness every day is a classic example of vagary of perception. Despite this, the perceptual experience is often complete and is construed with a definite meaning. Understanding the temporal dynamics of visual perception is challenging, because even when the physical properties of an object is constant, the perception of that object over time may change as a function of processing duration. To state an example, when we look at an unfamiliar object (let's say in this case, a table), we may quickly identify it as a 'table', a classification that we make at the most primary level. In this case, to classify something at its basic level, a small glimpse may be enough. However, in order to accurately classify it as a 'dinner table' or 'study table', needs an acute sense of perception, which will come with additional processing time (Potter, 1975). That means, there exists a set temporal order to processing; where the overt stimulus is perceived and processed first, in fact more rapidly than the finer details. Simply put, the global structure receives the first attention followed by the local structures that make up the global one. But what does the rapid processing of global property mean for the cognitive and behavioral activity? This question is still under scrutiny.

3.1.1 Global and local processing. Navon's classical compound paradigm. Researchers have made a wide use of the compound stimuli paradigm, typically to understand how scene understanding, can be generated from the use and the availability of information of information at the many levels of a hierarchical structure. To state an example of hierarchical structure is where a bigger alphabet is made using other/similar alphabets of smaller font.

The idea was popularized by Navon in 1977. The paradigm was however first used by Asch in 1962. In this paradigm of Navon, the observers see a compound letter; a large letter of A made from smaller As. This constitutes the congruent condition. The incongruent condition is where A is made of smaller Bs for example. In the task, the observers are asked either to focus the global level or to the local level. They happen as two separate trials. The predominant finding is that participants of the task responded faster to identifying the global structure. Together with this, it was also hard to ignore the global structure when attending to the local structure. Figure (6) shows an example of Navon's compound stimuli. For expository purposes, English has been used in the example below. The congruent stimuli shows that B is made of smaller Bs and the incongruent stimuli shows that B is made of smaller As. Thus, the congruent stimuli match both at the global and local level, while the incongruent stimuli is a mismatch at the global and local level.

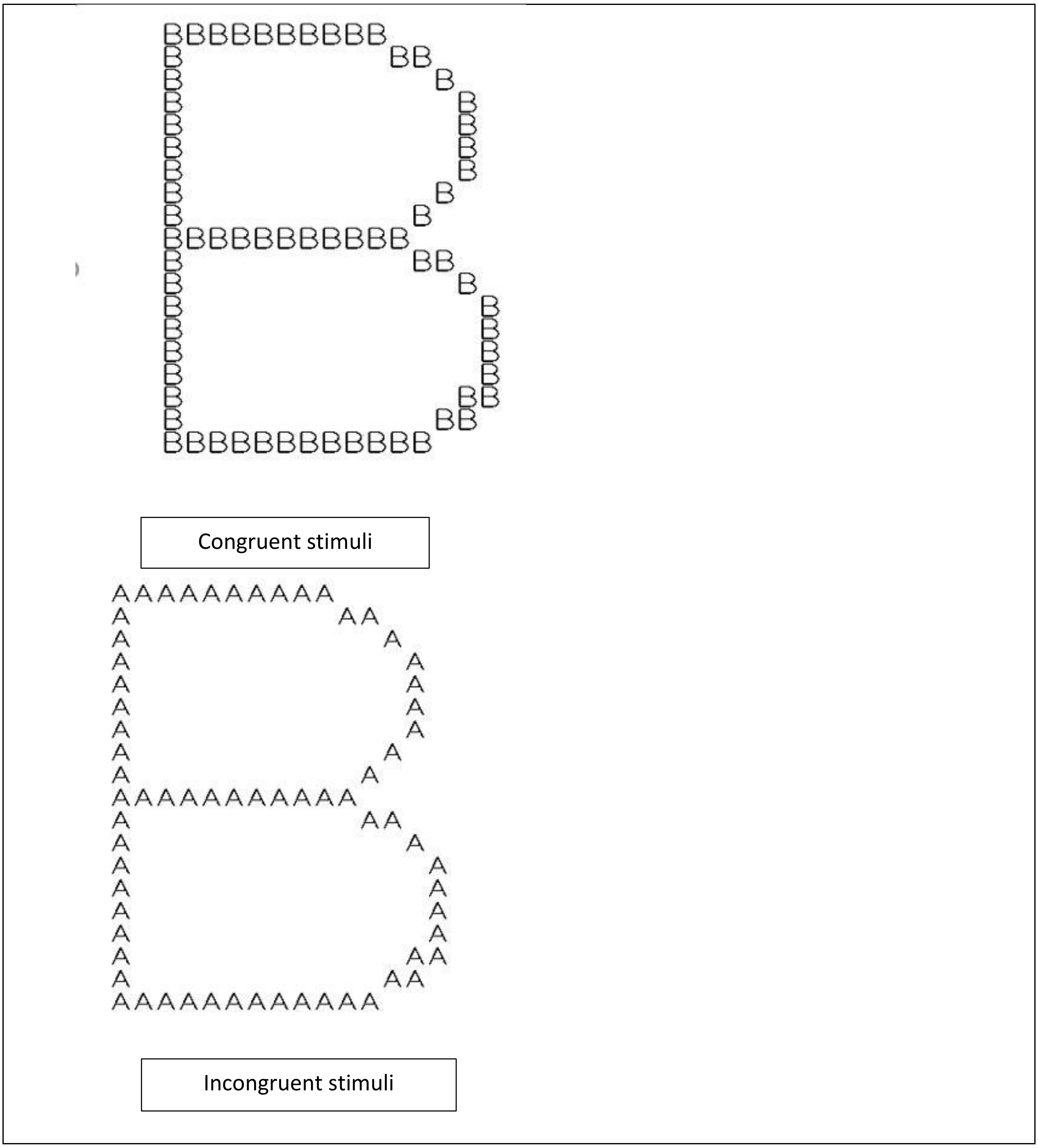


Figure 6 Compound stimuli used in the study

Figure (6) shows a congruent stimuli, where the global and local levels match and the incongruent stimuli in the right, that shows global and local levels different

Navon defines global precedence hypothesis as something that is relates to the temporal organization of the perceptual process that happens when trying to identify an object, which is a global processing dominance that takes place in processing. The theory is suggestive of the fact that perceptual processing happens in a particular fashion; starting from the global structure towards a more fine grained analysis, which is the analytical processing. Navon (1977) stated that identification of the global structure happens first and therefore might act as the obligatory first step in perceptual processing. Specifically, the theory of Global Precedence Effect (GPE) states that the perceptual system of humans is predisposed to process the global structure. In other words, the global processing is the first obligatory process which becomes complete after the identification of the global information, thus making the local information processing at that time, an optional one.

An assumption made in Navon's global precedence hypothesis (1977) is that the global structure is always available and does not weaken over time. Even when the processing of local level happens, the availability of global information does not cease to exist. This could account for the global processing dominance and the global-to-local interference that happens; also known as the asymmetric congruence effect (Navon, 1977). The global precedence also assumes that the global structure is something that is available constantly and because of this, the findings of this global advantage cannot vary over time. Further studies have suggested that this might be too strong an assumption to make.

Since the conception of Navon's paradigm, several studies have adapted the paradigm and exploited it to understand different effects. Some of the areas in which it has been used is understanding attention, masking, masking etc. and several effects have been obtained under these areas. However, three of them are usually found across the studies; (a) a global precedence effect, where there is a faster judgement of global skeletal structure than the local elements that make up the global structure, (b) an asymmetric congruence, where the global element interferes in the processing of local elements. This is also known as the inter-interference effect and, (c) the interference effect, where the there is a steady slower response to the incongruent stimuli than the congruent stimuli.

One of the unresolved issue is the temporal dynamics of visual perception that takes place in within GPE is how the perceptual processing is organized temporally? Essentially, does it mean that the global processing, for example, the face is perceived prior to the local elements like the lips and nose, or if local elements are already processed prior to processing of the global structure? Specifically, is there a global to local processing or a local to global processing? A related question is, can this order be flexible? Is it fixed or does it change with the stimulus in question? A predominant view from existing literature is that in order to perceive a scene, both global and local elements may be needed, but the processing typically follows a global to level kind of processing. What is however not answered is if the order of global and local information that is acquired have a role to play in perceiving a scene. In line with global and local processing in scene, the current experiment in this chapter aims to understand how letters are perceived. Letters are also objects of perception, and also an important one in reading. They are the smallest unit of reading. A script poses challenges to a learner; graphical nature of the script is hailed as complex or simple visually. A letter, the smallest unit of reading is known by different names depending on the script. The alphasyllabic script addresses a letter as an aksara, the Chinese script addresses the letter as a character, for the Roman script it is an alphabet and so on. Each of these letters have its own properties. For example, the Chinese characters are known to be complex given the strict stroke order in reading, having a deep orthography and also a challenging writing system, one that is complete with visual stacking. Characters like Chinese and even Korean, given their complex writing system may entail a differential reading strategy as compared to other scripts. A Chinese script contains complex stroke order, that is, a character is complete only with suprasegmental features such as a tone, diacritic marker etc. A single character contains both phonetic element and a semantic radical, and sometimes one morpheme is often a word in itself. Given this complex nature of character, where processing one character may exert a cognitive demand, the study believes that the global precedence may alter. The local structure has a lot of elements to be ignored or to be giving way to a global processing dominance. Thus, the global precedence effect is likely to alter in cases where the script in itself changes. Processing difference is likely to happen when the nature of the script changes. One possibility is that a there might be a script specific adaptation could have developed when learning to read these scripts.

The very essence of global precedence establishes an inevitable fact; the global processing. According to Navon, global precedence is the result of identification of the global information first, which also according to him, an obligatory stage of perceptual processing. Despite such a strong statement, there has been little attempts to check whether indeed global processing is the first obligatory step or what factors can affect a global superiority effect. So often, languages are divided on their complexity level; Chinese being unanimously accepted as a complex language and the others lying on the medial and less-complex side of the scale. Defining complexity is difficult. Linguistics does not have a clear operational definition for the term complexity. The term has been understood differently, depending on the context. In the current thesis, the central aim was to understand if there are factors that lie in language, that does not obligatorily entail a global processing. This is important because a global processing will happen when there are less distractors within the object at its local level; successfully facilitating a global superiority effect.

Reading is understood as a secondary process. Learning to read typically depends on a combination of visual perception and the ability to use a spoken language. While visual perception takes shape at a much younger age, ability to use a spoken language comes with hearing, practicing and understanding. However, both are ingrained in the process of human evolution. In learning to read, a person’s skill is recruited, modified and coordinated. The coordinated process is automated in order to facilitate fluent reading. (Lachmann, 2002).

As the individual attains success in the process, a differentiation in perceptual processing emerges (Van Leeuwen & Lachmann, 2004; Burgund et.al.,2006, 2009; Pegado et.al., 2011). On the other hand, for children whose reading skills are not fully automated, their processing of geometric shapes and letters will not have a difference, i.e., it will be holistic. In the early stages of visual feature binding, surrounding irrelevant information is always associated with target letters or shapes. This however, does not happen with an adult skilled reader, who is in a position to ignore the surrounding irrelevant visual context, and thus processes letters analytically (Lachmann & Van Leeuwen, 2004, 2008a). This essentially is the major difference in the processing strategies of letters among skilled and not-skilled readers of a language. In a study conducted among primary children with and without developmental dyslexia, using compound figures task with familiar Latin or unfamiliar Hebrew letters, both the groups of children showed an overall global advantage in familiar and unfamiliar letters (Lachmann, Schmitt, Braet & Leeuwen, 2014). Normal children showed asymmetric interference on familiar letters, but they did not for unfamiliar ones. However, children with developmental dyslexia showed no asymmetric interference, neither for the familiar or unfamiliar letters.

Normal reading comparatively involves losing the ability to process letters holistically. A study by Lachmann and Van Leeuwen (2007) showed that with letters and dot-patterns in a non-lexical same-different judgement task, symmetry in dot patterns benefitted both the dyslexic and normal children. However, symmetry in letters benefitted their dyslexic peers and not the normal children. This does not mean the ability to process holistically is lost forever. They are actively supressed and appear when reading calls for specialised processing. If they were lost forever, a holistic processing would not have been seen for dot patterns. Therefore, this loss is only suppressed and resurfaces when specialised reading strategies are called for. Lachmann and Khera, Srinivasan and Van Leeuwen (2012) showed in an experiment among the illiterates that, in them, they only uniformly showed analytical perception of both letters and non-letters. This perhaps means that analytical processing is not a secondary development that emerges from learning to read. Rather, it is a primary mode of perceptual organization and is treated on par with holistic perception.

On the other hand, Lachmann et.al (2014) state that the ‘forest before trees’ disappear for letters and remains intact for non-letter visual shapes. Our results contradict this. First, the paper does not state the proficiency of the native speakers in English, the language in which the experiment was conducted. Secondly, the experiment screen had both letters and non-letter shapes. Comparison of shapes and letters could have altered the results. As evident from previous studies, non-letters and shapes are processed holistically. Given this, and the definition of GPE (global processing is given precedence in processing), it is only natural to expect a global bias towards the processing of non-letters. Ascertaining the processing of letters in comparison with non-letters shapes seems at best dubious. Such a condition essentially brings an element of definite holistic processing for shapes and non-letters which is already established in the literature and comparing that against letters, whose processing is not known yet, is not robust. On the other hand, in the Korean study, the participants who performed the task in English were native speakers of English and the participants who participated for the Korean language were native speakers of Korean. The experiment design consisted of letters only. In the latter task, the English native speakers showed an overall global superiority effect. That means there was a global advantage. When the English speakers performed Korean, the result was analytical. Proficient speakers of Korean also showed an analytical processing of the Korean language, owing to the complexity of the script. Lachmann’s paper does not consider the proficiency of the speakers. In this current study, the experiment was conducted among the native speakers of Malayalam. The speakers showed an overall global superiority effect. The reason why it contradicts with the Korean study could be because of the complexity of the Korean script.

Malayalam script is relatively less complex and is also leaning towards an alphabetic writing system. The linearization of Malayalam script enables a larger perceptual span (Pappachan, 2015). Both the current study and the Korean study show a global superiority effect for the processing of English. Although the participants of the current study are not native speakers of the language, the participants studied in English medium institutions. We thus would like to believe that a differential processing strategy from Lachmann's paper was due to the proficiency of the speaker and also the experiment design. In this study, the experiment design contains only letters.

To further ground the conclusion, in a study conducted among the illiterates, (Lachmann and Van Leeuwen, 2004; Jinchoet.al., 2008) participants showed a negative congruence effect that prevailed in the illiterates. That is, they preferred incongruent surroundings, implying that an analytic perceptual strategy prevailed. Therefore, proficiency could be one factor that can affect the perception and subsequent processing of letters.

An interesting study in this regard is with the speakers of Korean Hangul. The Korean Hangul script is also known as the Great Script and belongs to the featural writing system. The language is written as blocks, is non-linear, and are as such visually complex. In Korean, there is representation for both consonants and vowels. However the way these signs are placed around the unit of representation, makes some scholars to call it a syllabary. On the other hand, the letters are combined into a syllable block. Each block only has one syllable and contains other supra-segmental features like lexical stress, place of articulation, sentential stress and intonation. Thus, their script is intuitively and evidently more complex than the alphabetic script. In the experiment conducted by Winskel, Kim and Cho (2018), they used English speakers and native Korean speakers. In the forced-identification task the participants performed, the English speakers were familiar with Roman script but not Korean or Thai, however, the Korean speakers were familiar with Korean and Roman script but not Thai. The experiment was conducted in Roman, Korean Hangul and Thai. In the task, Navon's compound stimuli (larger letter made of smaller other letters) were used. Roman script, Korean Hangul and Thai letters were used. Each of the letter was constructed of smaller letters of the same script. They were either congruent (small and large letters matched) or incongruent (smaller and bigger letters do not match). The results showed that, among the English speakers, there was GPE for familiar Roman and unfamiliar Thai letters. GPE is defined as the Global Precedence Effect. Global Precedence Effect states that it is always the global that we perceive first, before the local ones. To put it how Lachmann states, we perceive the forest before the tress that make up the forest. This GPE effect was absent for unfamiliar Korean letters. In contrast, the native speakers of Korean did now show GPE for familiar Korean and Roman letters, but they did for Thai. This suggests that Koreans process Korean and English in an analytical manner than the native speakers of English does. The characteristic of the Korean script has a huge role to play in their processing strategy. Sometimes, processing strategy is a function or influence of their native language on the L2.

Korean Hangul appears in non-linear blocks and are small, complex and densely crowded with suprasegmental features. In this language, both phonemes and syllables are important phonological units. Given the visual complexity of the script and its heavy syllable blocks, readers of Hangul Korean tend to process the letters in a more analytical manner. Therefore, when the presented stimuli is perceived as complex or if the task is difficult, an analytic processing occurs (Lachmann, Khera, Srinivasan, & van Leeuwen, 2012; Roelfsema & Houtkamp, 2011). An alternate validation to this could be the specialized script-specific adaptation that could have developed when learning to read these different scripts.

This essentially means, we are not losing perceptual skills while learning. Rather, we are acquiring habits that can lead us to perform sub-optimally on specific tasks (Lachmann and Van Leeuwen, 2007). We must note that children early in the process of learning, develop holistic processing uniformly for both letters and non-letters.

The preference for analytic letter processing is in contrast with the GPE or Global Precedence Effect. The GPE states that usually for letters when they are flanked by similar or other letters, the global level target receives faster response. The second observation of GPE is the asymmetric congruence effect that states incongruency interferes with the local level target response but not with the global level. Both these together constitute the GPE (Lachmann, Schmitt, Braet and Leeuwen, 2014). GPE states that the global level processing is given priority in processing compared to the local ones. This type of processing is known as holistic processing. The present study aims to investigate if global level processing is given priority even in alphasyllabic scripts. Alphasyllabic scripts represent sound at two levels; the phoneme level and the syllable level. At the phoneme level, the aksara is bare and is just one unit without vowel markers. However, it contains the inherent schwa. The complexity level is very less at the phonemic level. That is, the cognitive load it imposes is very minimal given that the visual system only has to focus on aksara as one unit and at the graphemic front, there are no additional diacritic markers.

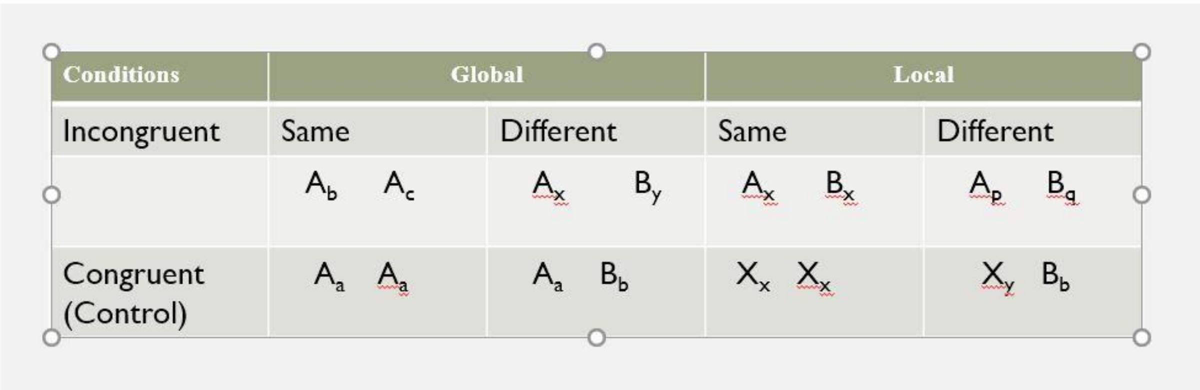
The current study hypothesizes that at the phonemic level in alphasyllabic scripts, there might not be a processing cost and will thus process the phoneme only holistically. If nature of the script has a role to play, then phonemes have a straight one-to-one connection, sound to grapheme. Therefore, the reader does not have to bear the load of trying to map the sound to the grapheme. With respect to syllable, a processing cost is likely to incur, because the reader has to additionally map the phoneme to grapheme, even the diacritic markers. Most often, the diacritic markers are in a non-linear arrangement, a mismatch in temporal sequence of articulation and its written form (detailed in the introduction chapter). So, the reader has to expend a lot of cognitive effort to comprehend the non- linear arrangement first, followed by having to process two units of aksara at the same time. Alphasyllabic scripts are known for their diacritics markers all around the aksara. That being the case, we might prima facie expect the role of congruency of letters in the processing of global/local levels. If normal reading involve a special strategy for processing of letters, do they take analytic or global processing as the norm? The central issue the study explores is the nature of processing at the phonemic level and at the syllabic level. Does processing strategy change with respect to the levels or the complexity of script? One crucial mechanism is likely to affect the level selection. The complexity of grapheme can push the visual system to direct attention to a particular level. This often is the physical salience, which is a sensory factor that can direct attention to a said level as evident from the work by Stoffer, 1993, 1994, who demonstrated that there was a global advantage even when the local level was cued.

Excise of attention on the letter or on any visual scene will elicit more and more information from the visual object at display. If it is so, we might have to believe that interpreting a visual object happens in a piecemeal fashion and that the perceptual whole is constructed out of the smaller details or elements. The idea put forward in this present study is that processing happens from a more global structuring towards a more fine-grained analysis. Therefore, the question of our study was whether global processing or local processing can be affected by the level of grapheme in question. That is, the phoneme level and syllabic level of representation can affect the processing. Going by the studies which suggest that analytic or global processing can be based on complexity of the script in question, there is a good possibility that as the load of the letter increases, a more analytical processing can be expected.

3.1.2 Method

3.1.3 Participants. Thirty-two native speakers of Malayalam were chosen to do the experiment. The participants were also English speakers with varying degree of proficiency in their native language Malayalam. A total of 16 males and 16 females volunteered for the study. The experiment was conducted in both Malayalam and English among the male and female speakers from the University of Hyderabad and had agreed to be a participant of the study. All the participants had normal vision to corrected vision. All the participants consented to do the study by agreeing to the consent form that was projected on the screen before the start of the experiment.

3.1.4 Stimuli. Two types of stimuli each in Malayalam and English were administered for the study. The stimuli were entirely composed of letters of Malayalam and English in separate blocks. The letters could be in the combination A made of C (incongruent condition) or A made of A (Congruent). The participants were shown two images of Malayalam that were congruent or incongruent. Figure (7) is a sample stimuli condition used for the study.



Conditions	Global		Local	
Incongruent	Same	Different	Same	Different
	A_b A_c	A_x B_y	A_x B_x	A_p B_q
Congruent (Control)	A_a A_a	A_a B_b	X_x X_x	X_y B_b

Figure 7 Stimuli conditions

3.1.5 Design and Procedure. The stimuli of the experiment was developed using Python, a programming software. Combinations of congruent and incongruent letters were manually selected and programmatically developed. The letters are uniformly of the same size and Karthika font of Microsoft Word was used to type them.

Participants performed a same-different task. There was a total of four blocks with 30 trials in each. Participants saw pairs of alphabet on the screen that were either congruent or incongruent entirely (see table 1). In the first block, the participants were instructed to focus on the global aksara and ignore the local and in the second block, the participants had to attend to the local aksara and ignore the global aksara. Participants responded to the same choice by using the alphabet ‘k’ and if they were different, they were instructed to press ‘a’. The third and fourth block was English trails. The third block asked the participants to focus on the global level and ignore the local level, while the fourth, the participants had to focus on the local level.

Figure (8) is the design of the study and how it was conducted. The study was self-paced, although the stimulus disappeared after 4ms. The participants are expected to respond within this time period.

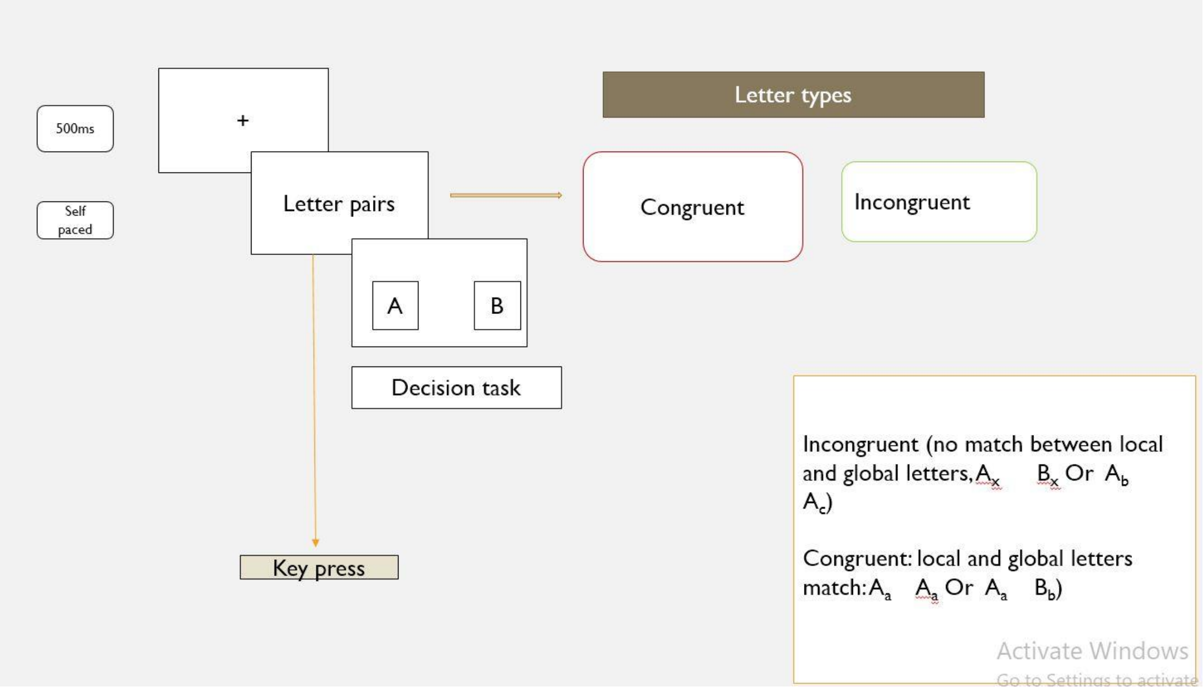


Figure 8 Design of the study

Each block started with an instruction screen. The stimuli were centrally presented without any positional uncertainty. Six practice trails were given with feedback for each. The experiment was designed in Testable, an online software for experiments. Figure (9) are the four conditions for Malayalam block. The experimental condition had all the conditions, a congruent global and an incongruent global condition, a congruent local and incongruent local condition in both Malayalam and English.

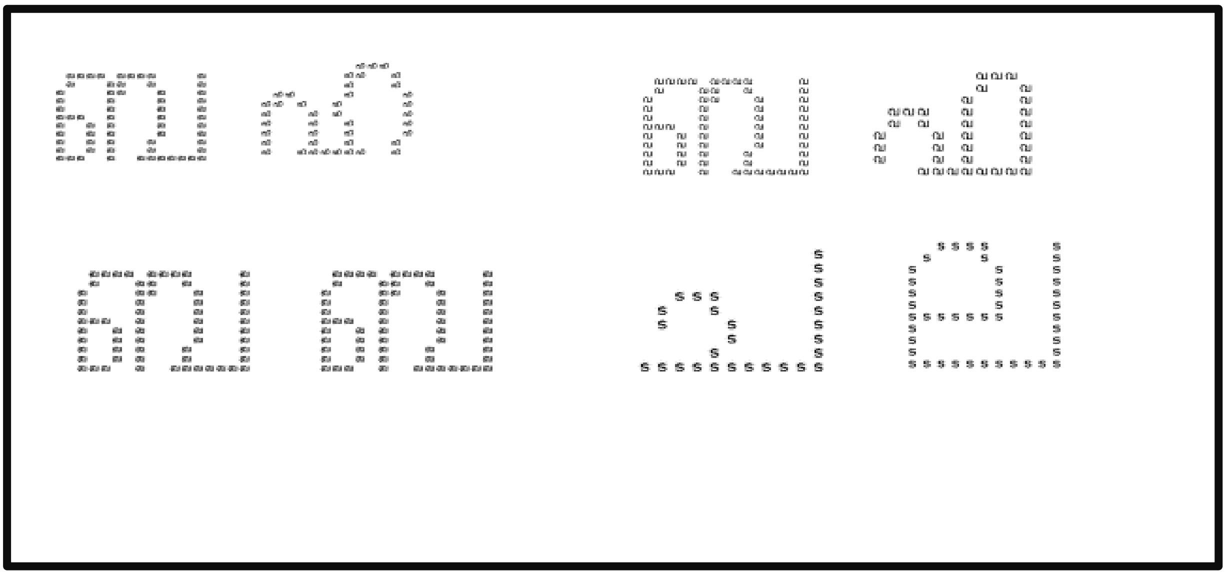


Figure 9 Stimuli conditions

In Figure (9), from left to right Image (a) is incongruent. Image (b) is a congruent condition. Images (a) and (b) are at the global level. Image (c) is congruent at the local level and, image (d) is incongruent.

3.1.6 Results

Results were analysed in the range of 500ms to 3000 ms. Errors and outliers of 2% were removed. Results of two participants had to be removed because of too many errors and incomplete trials. The RT was recorded in milliseconds. The obtained RT data was analysed using repeated measures Analysis of Variance (ANOVA) in the following factors: Level (global or local) and Congruency (congruent or incongruent) and Language (Malayalam and English).

The overall performance for Malayalam and English showed that Malayalam had a slower RT or were responded to slower than that for English, see Figure (10).

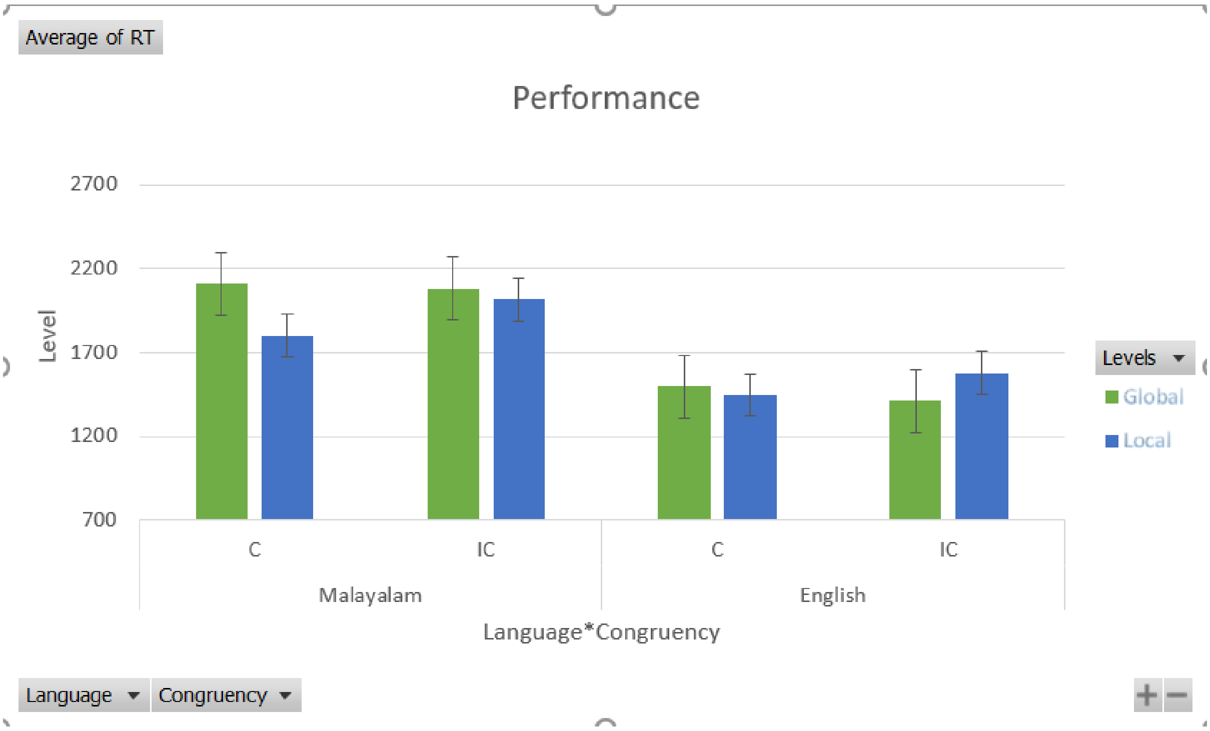


Figure 10 Overall performance in English and Malayalam

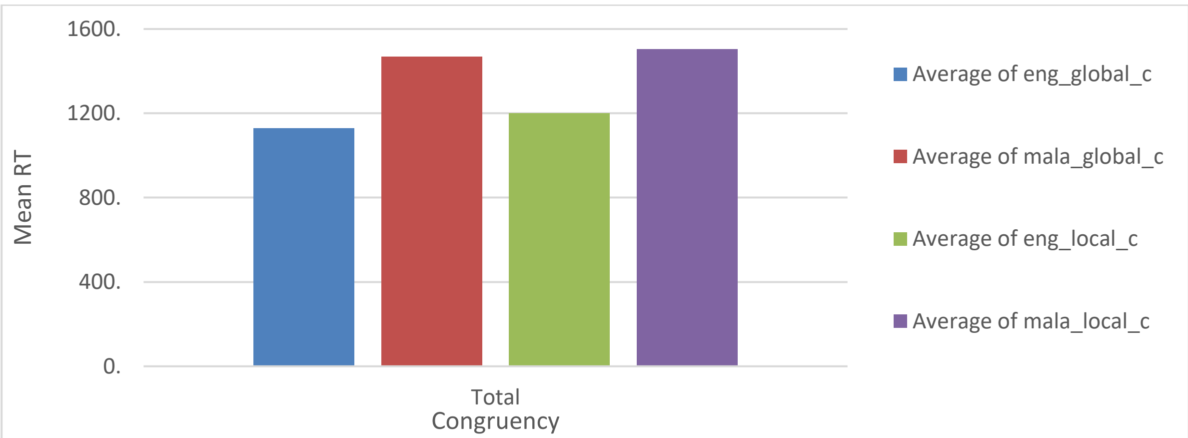


Figure 11 Factors of compared against RT in the congruent condition.

Main effects were observed for all the factors: for level, Malayalam was marginally significant F=3.85, p-value 0.06 with a faster response to global (M=1453.03ms, SE=127.3) than to local (M= 1614.16ms, SE= 96.37) level targets. For congruency, there was no significant difference, however, incongruent trials were slower (M=1580.4ms, SE=120.6) and congruent trials were faster (M=1486.7ms, SE=95.9). See Figure (11).

In addition to this, a two-way interaction between level and congruency was observed, which is, within the levels, we aimed to check whether congruency will have an effect. This showed within the local level, the responses were affected by the incongruency condition, p-value<0.05, p=0.033 (M=1724.3ms, SE=129.5). On the other hand, within the global level, incongruency condition (M=1504.03ms, SE=81.2) showed faster response. At the global level, there was no significance observed.

Next, congruency and level were observed, which is to see if within the congruent condition, did the local/global conditions play a role in processing. In this, we found that at the incongruent conditions, the level had a role to play, with slower responses for local condition (M= 1724.3ms SE=129.5) p-value<0.05, p=0.014 than for global (M=1436.5ms, SE=135.4). In the congruent condition, there was no significance difference or an interference of the congruency condition in the processing of global or local level.

In English, we found that there is faster response at the global level (M=1100.9ms, SE=59.3) as against the local level (M=1284.5, SE=86.3), p-value<0.05, p=0.001. Congruency showed no overall significance.

In the two-way interaction between level and congruency, a significance was observed for the local level (M=1368.2ms, SE=77.1), p-value<0.05, p=0.033, as against the global level (M=1200.8ms, SE=101.1). Incongruency of the letters had an effect at the local level (M=1368.2ms, SE=77.1), p-value<0.05 as against the global level (M=1072.4ms, SE=56.1). In the congruent condition however, levels did not affect the processing.

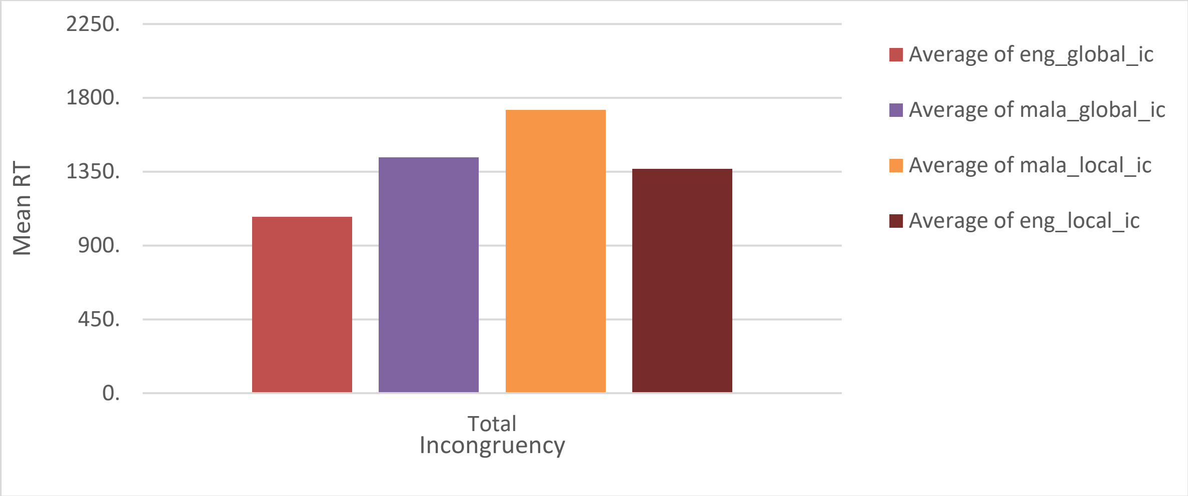


Figure 12 Factors were plotted against RT in the incongruent condition.

The main effect of level was observed with faster responses in both English and Malayalam to the global level. Incongruency also affected responses at the local level, which means there was significant interference of the incongruency condition at the local level, with slower response to local than at the global level. Also, there was significant interference of the levels when attempting the congruent and incongruent conditions, with slower response to local incongruent trails. See Figure (12).

Overall, there was a higher error rate observed for the local level in both Malayalam and English. That means, the response at the local level was interfered by the global level targets. The case with similar with English too. However, the reverse, an interference of the global level by the local was not seen.

Figure (13) shows the accuracy level (identification efficiency) under the global and local level for Malayalam and English. For Malayalam and English, there was an easy identification at the global level when compared to the local level in both these languages.

Figure 13 Error rate (accuracy of identification) in English and Malayalam

3.1.7 Discussion

The study investigated the GPE for letters in Malayalam and English. Both these had congruent and incongruent conditions at the global and local level. The study used stimuli in central presentation and without positional uncertainty. In the present study, it was found that GPE or Global Precedence Effect remained intact for letters of Malayalam and English. This implies that for GPE, global-level target elicit faster responses than for local level ones. Together with this, there was also evidence for asymmetric congruence, i.e., incongruency interferes with the local-level target responses but not with global level. This effect was observed in both Malayalam and English. The local elements however did not affect the processing of the global letters, leading us to understand that processing of letters not only is global, but also analytical, depending on the task in question. Specific skills are employed when having to process letters. Another area of interest among psycholinguistics is, if continual use of multiple languages have any consequence for cognition. Green (1998) proposed that when speaking, words of the non-target language are inhibited. Yet others believe that the usage of language among the bilinguals might involve conflict monitoring (Abutalebi et al., 2012). These evidences point to the speculation that being a bilingual can exercise some pressure on strengthening these processes, in what is known as bilingual advantage. In the current study, evidently the speakers of Malayalam exhibited a global advantage even for English letters. English was processed more analytically. This result in favor of a global advantage for English is in line with the study conducted by Winskel, Kim and Cho, 2018; who also found a global processing strategy for Roman English alphabets. However, this was not the case with Lachmann, 2014, wherein he found that a global advantage disappeared for letters. The participants were Germans, whose script is also alphabetic. This means, the influence of one script over the other could have facilitated the holistic processing. Another possibility is that German is a transparent orthographic language in comparison to English. The grapheme to phoneme correspondence is easy to map. In that sense, English has an irregular orthography with no exact mapping of the phoneme and grapheme. Also, the relative small grain size of English orthography (Zeigler & Goswami, 2005) could have influenced the skilled readers, thus leading to a processing in a less analytic fashion and more holistically than the German readers. An alternative theory is the theory of 'transfer'. 'Transfer' is a term in linguistics that is used to refer to the transfer of the properties and elements of first language into the second language. Also, if the speaker is a multilingual, then all these languages are said to influence the learning the newer language. According to Corder (1967), mother tongue is said to act as a cognitive element that can subsequently affect the other developmental process of the target language or TL. Thus, it could be possible that frequent readers of Malayalam have been constantly processing the phonemes more holistically and this processing strategy could have passed on when processing English too. Processing strategy is clearly a function of the nature of script in question. Together with this, there might a specialized script specific adaptation that is likely to be shaped by the characteristics of the orthography, which could have led to the influence of analytical or holistic processing of the letters in those respective scripts.

Kinchala and Wolfe (1979) noted that when global letter was small and not easily visible, the stimuli in question was located much faster on the global level than at the local level. Contrary to this, there was a reversal of this effect for displays that were larger. With this, Kinchla and Wolfe (1979) suggested that there might be an optimal size for stimulus and when forms that are larger/smaller than this optimum, could cause a disadvantage in the speed of processing. These findings point to Navon's (1977) finding of global precedence, where the global level was simply easier to process than the local level. Martin (1979) varied the local elements of a letter, ones that are used for constructing the bigger letter (the global). When there were many element patters at the global level, a global precedence was observed and when there was a sparsity in global letters, local precedence was observed. Hoffman (1980) manipulated the discriminability of both the levels. He did so by selectively distorting the overall form of the stimuli in both the global and local level. He found that when the local level was distorted, a global precedence was observed and when the global level form was distorted, local precedence was observed. Miller (1981a) found that when participants search for the target letter in a compound stimuli, they tend to respond faster when the target letter is present in both the levels, contrary to when it is found only at one level. This is suggestive of the fact that both the levels become available for processing at roughly around the same time. Detection of the targets usually happens faster for global level, but not necessarily faster than the local level (Hoffman, 1980), was inconsistent when the reaction time was observed for each level. This made Miller conclude that global precedence may not be perceptual, and that it may reside at a pose-perceptual stage of attention or when a decision has to be taken. Likewise, Ward (1982) suggested that the source of this global advantage will happen at the feature integration stage. It is at this stage, a focused attention may be warranted.

However, we must note that analytic processing is not a function of reading expertise. If it were so, analytic processing of letters and non-letters would not have happened with illiterate adults (Lachmann, Khera et.al., 2012). Evidently, analytical processing is an innate skill and not something acquired during training.

While people can voluntarily attend to the global pattern without an interference of the local features, it seems difficult to process the local features without being aware of the whole. Their ability to restrict their attention to the whole and not be interfered by the local elements suggest that they can switch off their recognition process after the categorization of the global pattern has been completed (Navon, 1997).However, the local features are still processed if a deliberate attempt were to be made.

On the other hand, we cannot rule out task requirement as a factor for the differential processing of letters. In tasks where the figures are changed such that, more than part-whole structure, only the finer details are relevant, the strategy of perception becomes analytical and the preceding context is ignored (Lachmann, 2014).

Thus, skilled reading has the ability to recruit a general perceptual strategy for letter recognition. Following this, there might be a stage of processing that is likely to happen in a more coordinated fashion, along with phonological, motor and attentional information in order to meet the specific demands of reading. Also, this automatization of letter specific processing while learning to read does not lead to the loss of any perceptual skills. On the other hand, what essentially happens is that there is a gain of suboptimal performance on certain tasks. (Lachmann, Schmitt, Breat and Leeuwan, 2014).

In conclusion, the study is consistent with the existing theories of GPE. The study has shown that GPE has an effect on the processing of letters. Reading strategies globally show that analytic and holistic processing exist side by side, although there is a greater preference for global effect. However, when having to attend to relatively complex tasks (in this case, the identification of the local elements amidst congruency and incongruency condition), there is a preferential association for analytic processing. Nag (2011) theorized three levels in which aksaras are taught to children in schools. She proposed the global approach, the analytic phase and then the strategic phase. The global approach becomes applicable only when a speaker or a child has attained the highest degree of automaticity for recognition and equally for writing. The second approach, which is the analytic approach may be called when the learner is new to the letters of the language (which is what happens in Experiment 1, where naïve participants use the analytical mode). The aksara symbol set is extensive and as such there will be a strategic use of both the global and analytical mode. This strategy remains essential for both expert readers and for readers who are only beginning to read.

3.1.8 Source of global precedence. A matter of intense debate surrounds the question of the source of global precedence. The two differing opinions are that global precedence originates from the perception and the other is that global precedence resides in the attention (Kimchi, 1992, 2004; Miller, 1981a,b; Navon 1981, 2003). Based on this, two mechanisms of level selection can be discriminated. The perceptual accounts suggest that the objects are available in the percept and therefore global precedence arises from an early process of perceptual organization (Han & Hamphreys, 2002; Kimchi, 1998, 2000, 2003a,b). Attentional accounts suggest that the physical salience of features and attentional resources such as effort, can modulate the global precedence effect (Kinchla et al., 1983; Lamb et al., 2000, Roberston, 1996). Navon also noted that ate ntion will enlarge the biases that originate just before the focusing of attention.

Whether they can skip the global processing in certain circumstances cannot be understood from this study and one way to do this could be to expose the participants to the stimuli for a brief time. The different or not task can be used in a self-paced set up to understand if global differences were detected more quickly than the local ones. Also, the present study does not throw light in the property of global processing being inherent. What might be interesting to see is what factors at the global level may interfere in the identification latency at the global level, especially given that Malayalam takes a holistic approach.

Experiment 2: GPE effect in syllables

3.2. Introduction

The previous study was aimed at understanding the Global Precedence Effect in phonemes. The results showed that for phonemes, the Global Precedence Effect stays intact. That is, the there was an overall global advantage. The phonemes at the global level was recognized faster than the local level phonemes. Together with this, there was also an overall interference effect, where the global level aksaras interfered in the recognition of the local level. This was evident from the latency period. This was true of English and Malayalam, the two languages in which the study was conducted.

Experiment 2 aims at understanding what are the factors that can affect a holistic processing of letters. At the syllable level, the aksaras are different. They are not bare. They have at least three phonemes and each of them are represented separately via diacritic markers. These diacritic markers however are not linearly arranged on a plane. They appear variously around the aksara. Sometimes, apart from this, the written representation of the sound does not match with the temporal sequence and this is one classic hallmark of alphasyllabic scripts. Understanding this is important, especially the role such heavy aksaras can play. In the education field, it has been reported by Nag & Perfetti, 2014, that a complete mastery of the aksaras happens only by the class 4, for a child learning an alphasyllabic language. This is not surprising given the extensive orthography. For example, the total number of symbols that an alphasyllabic language like Hindi contains about 200 to 500 syllables. This is much larger when compared to the number of symbols that have to be learnt in an alphabetic system (24 to letters in English, Arabic languages and in Arabic languages). Several researches have also concluded that learning of the aksara or all the symbols of a language depend on the inventory size (of symbols) in that language. In Latin scripts, 20 to 40 letters are expected to be learnt by the first year of school. There might be a slight variability in the letters depending on the consistency of the grapheme to phoneme correspondence in the various Latin scripts (Seymour, Aro & Erskine, 2003). On the other hand, for the Indic languages, the aksara set is large and have between 200 to 500 symbols, all of which do not frequently appear in the script. Because of this large inventory of symbols, learning of the entire aksara set happens only by as late as fourth year or sometimes even late (Nag, 2007); suggestive of the exhaustive range of symbols in these languages and the complexity it induces when having to learn it. Nevertheless, for children who are learning to read and write in alphasyllabic languages display a good awareness of phonemes and syllables. In a study conducted by Nag & Snowling, 2011, among the readers of Kannada, an alphasyllabic script, it was observed that readers of 9-12 years of age, who were less fluent in the language, could not perform the phoneme tasks, that is, they had less awareness to phonemes. On the other hand, fluent readers with a greater knowledge in orthography displayed a significant phonemic awareness. The study further asserts that with an increase in the literacy in alphasyllabic scripts, can promote a dual representation at both the phonemic and syllabic level of an aksara. Therefore, the analytic process that is involved in acquiring this knowledge in orthography and then the phonological mappings seem to be one universal aspect of reading irrespective of the language (Nag & Snowling, 2011). One commonly held view is that awareness of phoneme comes from large units; the syllables and then the awareness of the small units such as a phoneme (Carroll, Snowling, Hulme, & Stevenson, 2003). The alternate view states that having a phonemic awareness is only a repercussion, rather than acting as a precursor to in the process of learning to read (Castles & Coltheart, 2004; Goswami & Bryant, 1990. Morais, Carey, Alegria, & Bertelson, 1979).

A majority of the debate surrounding the relation between phoneme awareness and the reading skill comes from readers who are alphabetic languages. Also, the role of phonological skills when learning to read a non-alphasyllabic language is not clear. Studies in Chinese have shown that each symbol mapping on to a syllable is a clear evidence that phonemic awareness may not be a necessary precursor to logographic literacy. At the same time, studies have shown that, when learning Chinese, there is a phase that requires the learners to use their phonological skills; (Ho& Bryant, 1997; Line et al., 2010), found out that, the poor and good reader of Chinese differed when performing tasks which had a both syllable and a phoneme level.

One thing to speculate is if phonemes and syllable are perceived and processed the same way. Processing of them can depend on several factors, including the availability (or accessibility) of the different phonological units, consistency of the orthography-phonology mappings etc. (Ziegler and Goswami, 2005) leading to the aim of the second study; to understand how an aksara is perceived at the syllabic level. If syllables and phonemes are processed the same way, then syllables must also show a holistic approach. However, with support from the other studies, the current experiment aligns by saying that syllable processing may be different from a phoneme processing, not because the phoneme is bare and the syllable is heavily loaded, but because syllables are most often the units of perception. Phonemes, especially in isolation, is hardly used. Syllables on the other hand are the most commonly occurring forms in text. But does this mean that we can expect a processing difference among a phoneme and a syllable? Many psycholinguists and also the phoneticians have consented that the sublexical representation may play a trivial role throughout the process of word recognition.

Sendlmeier, 1995, stated that the speaker or a listener of a language have their own kind of mental representation of speech at their disposal. That is, depending on what they focus for perceiving, units of varying sizes are primarily followed in the process of recognition. That means, a listener can easily modify the temporal window for analysis to some extent. In any case, syllable remains the focus of a perceptual focus primarily. This is precisely where the current experiment contributes. Experiment 2 shows the shift from the processing strategy, from a holistic one (experiment 1) to an analytic level. This shift was expected, because we are to expect that processing or even perception start from the global structure to a finer grained analysis (consistent with GPE), we should expect the same at level of letter processing. Of course both phonemes and syllables are the two levels in the hierarchy. Phonemic level is considered as the basic level and we may process speech working our way upwards into the hierarchy. We first begin by recognizing phonemes, and then could perhaps use this analysis to recognize the other higher level linguistic units, like the syllable and words. Healy & Cutting, 1976, through their study, compared the phonemes and the syllable targets. They found that when the levels (phonemes and syllables) did match, phonemes were identified faster than syllables, provided the phonemes are in fact easy to identify, and syllables are detected faster than phonemes, when the phonemes were difficult to identify. That is to say, identification of the target sound in written representation is a crucial factor in being able to acutely identify the sound.

The literature has contradictory findings. One that supports that phonemes are typically identified before syllables and second, syllables are the basic units of perception and phonemes are identified only after perceiving the syllables. A further identification of the phonemes happen after the syllable identification stage, where the phonemes are decomposed from the higher level units (Savin and Bever, 1970). They concluded this through a study that reported that participants were faster to respond to syllable than phoneme targets when they were asked to search through a list of syllables. Thus, one approach to resolving this contradiction is by assuming that the processing is concurrent and not sequential when it comes to processing of syllables and phonemes (Healy & Cutting, 1976). That means the perceiver more or less enters into the decomposing state, at the same time. However, this cannot be taken at face value because some level of analysis may be performed in the preliminary stage of perception, but may not necessarily be accessed through a detection task. Identifiability of the stimuli is a necessary factor to be factor to be considered before making an assumption that in what stage a decomposition in processing happens.

Taken together with all these as reference, Experiment 2 focuses on syllables, in trying to understand the role syllables can play in letter perception. That is, are phonemes and syllables processed differently? However, the study does not state that because phonemes show a Global Precedence Effect and they are weightless as compared to a syllable, that the former is the first step in letter perception. The Experiment only tries to understand what effect alphasyllabic syllables induce; are they generally processed analytically or if they are holistically processed.

The current study used syllables of Malayalam. The syllables were classified into six categories based on the appearance of the vowel marker on the side of the consonant. See Figure (12). In alphasyllabic scripts, the vowel markers appear on the left, right and either side of the consonant and 20 of them under each direction was chosen for the study randomly. Each vowel marker appeared with a primary consonant. The consonants were randomly selected for this. Two categories were made based on congruent and incongruent condition. Together with the direction of the vowel marker and the congruency condition, a total of six categories were made; (a) left congruent category and left incongruent condition (b) right congruent and right incongruent condition, (c) circumvowel congruent and circumvowel incongruent condition.

3.3 Method.

3.3.1 Participants.

Forty one native speakers of Malayalam were chosen to do the experiment. The participants were also English speakers (learned through a formal education) with varying degree of proficiency in their native language Malayalam. A total of 20 males and 21 females volunteered for the study. The experiment was conducted in Malayalam among the male and female speakers from the University of Hyderabad and had agreed to be a participant of the study. All of them had normal to corrected vision. All the participants consented to do the study by agreeing to the consent form that was projected on the screen before the start of the experiment.

3.3.2 Stimuli

The stimuli was generated via programmatically through Python software. The selection of the syllable was random. The font of the stimuli remained uniformly the same and for the font, Karthika was used. The font is specific for typing Malayalam script. Combinations of congruent and incongruent letters were manually selected and further programmatically developed for the experiment,

Participants performed a same-different task. The participants were directed to focus on the global level and report if the aksaras were same at the global and local level. The participants saw pairs that were either congruent (matching global and local level) or were incongruent (mismatch at global and local level). Figure (14) is the representative sample set. They only had to follow one condition; to focus both at the global and local level and then report if they were similar or not.

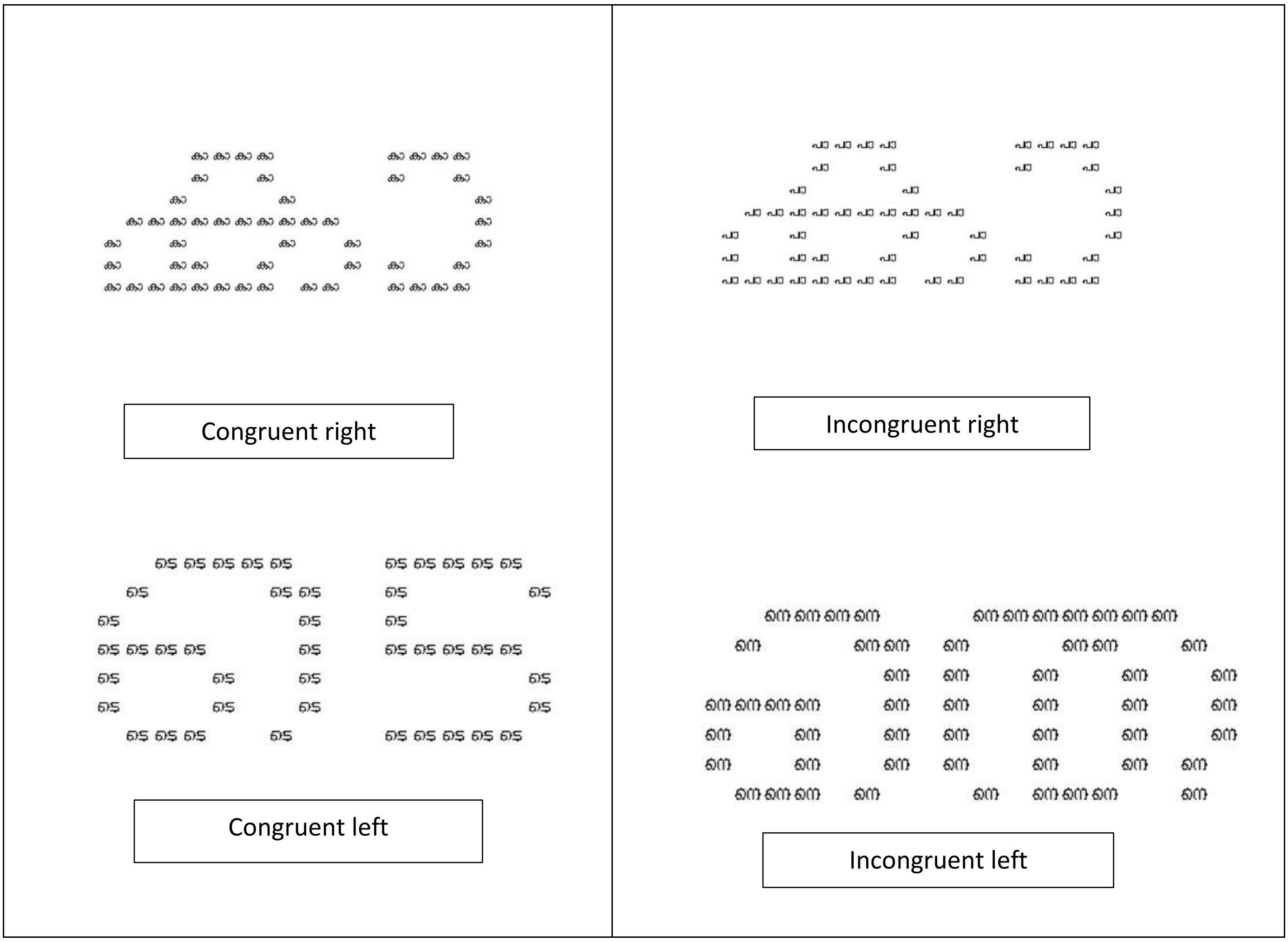


Figure 14 Congruent conditions, along with the direction of the vowel marker.

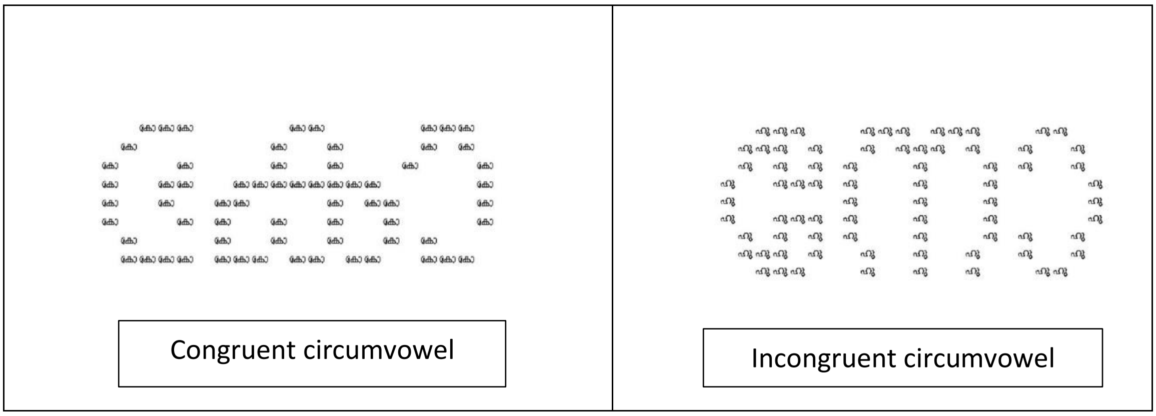


Figure 15 Congruency and vowel marker for a circumvowel

In the above figure (14) and (15), the representative sample is from Malayalam. Notice that they are matched for their congruency and vowel marker position. That is, congruency is when the global level target and upper level target match (identical aksaras at both level) and right and left denotes the position of the vowel marker with respect to the consonant. The condition ‘Congruent right’ means that the aksaras match at the global and local level, but the vowel marker appears in the right side of the consonant. For example, കാ, is /ka/, where ക /k/ is the consonant and ◌ാ (the reduced vowel marker for /a:/) is the vowel marker, reduced to a diacritic that always appears on the right side of the consonant. Under the Congruent left condition, ടെ /te/, ട /t/ is the vowel marker and െ◌ is the vowel marker for the vowel /ae/, that always appears on the left side of the consonant. Therefore, the mismatch is clear here. In articulation, it is pronounced /te/, the written sequence is however /e+t/. This sort of a misalignment is a hallmark of alphasyllabic languages and a great number of studies have been discussed on what implications such a graphemic representation can have. The last case is the circumvowel. Circumvowel is commonly seen in Dravidian languages like Tamil, Malayalam and Telugu and in Indo-Aryan languages like Bangla. A circumvowel is called so because the vowel appears on either side of the consonant. Under the Congruent circumvowel condition, കോ, the consonant is ക /k/, the vowel markers appear on either side of /k/ as േ◌ാ /o/.

3.3.3 Design and procedure.

The experiment was designed on Pavlovia, an online software for conducting behavioral and psycholinguistic experiments. The Malayalam aksara, the stimuli set, was image based. A link was provided to the participant via email and they had to click on it to get started. The first screen displayed a consent form which elicited their consent to participate in the study. ‘I agree’ button was enabled, if they agreed to be a part of the study. Following this, an instruction screen appeared. The instruction screen had clearly mentioned what has to be done. The screen was not timed and ensured that the participant had the time to read and understand the procedure. Once done, they can press the 'spacebar' key to continue to the next screen. In the next screen, practice trails began. Ten practice trails were given. In the experimental block, the screen began with a fixation cross which lasted for 500ms. After this, one compound letter at a time appeared on the screen. The participants were instructed to press *a* if the global and local level matched and *k* if there was a mismatch. Figure (16) shows the design of the study.

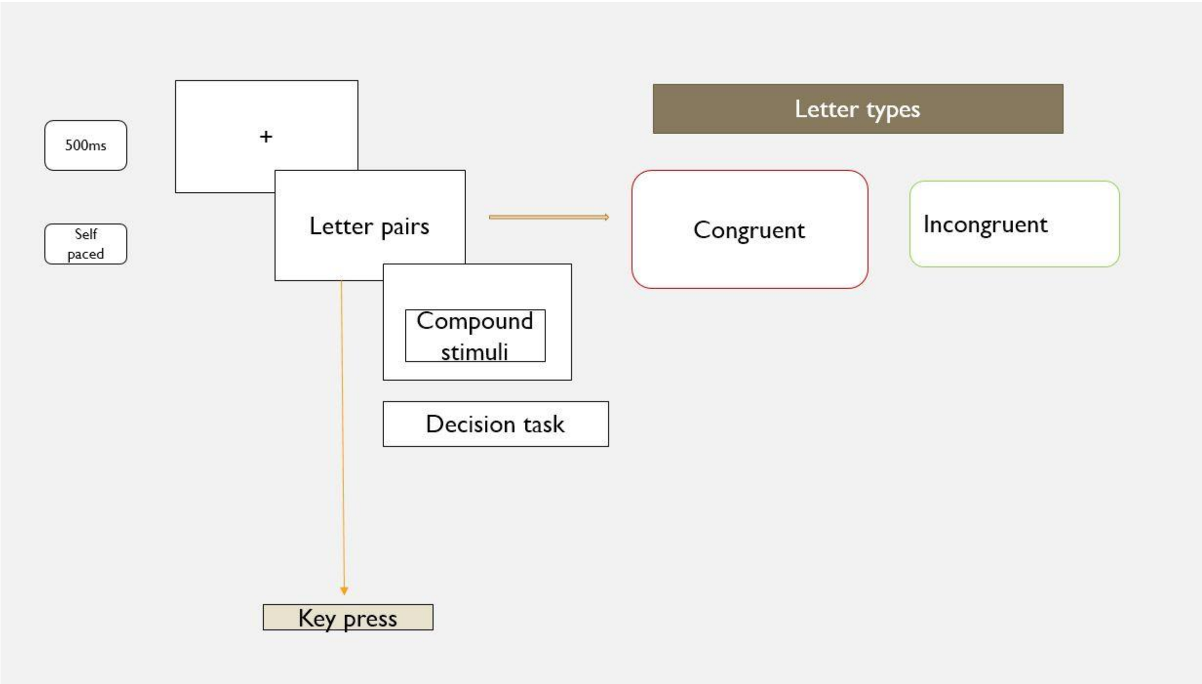


Figure 16 Design of the study

Lachmann, et.al, 2014 state that letters are processed analytically. However, if letters were processed analytically, then the local elements of the compound stimuli should be easily discernible and the GPE should not affect letters. Thus, in this case, participants may be sensitive to the elements that make up the compound stimuli. The study therefore aims to see if phonologically dense letters can impose or affect the processing time, at the global level.

3.3 Results

The results were analyzed in SPSS, using ANOVA. Data of 41 participants were analysed. A total of 42 participants volunteered for the study, but one of the result had to be removed because of many number of incomplete trails. Overall, direction (of the vowel markers) were significant, F=49.58, p<0.001. Congruency (global and local match) was also significant, F= 6.92, p<.012. Direction* congruency was not significant, F=0.92, p>0.05.

The direction was categorized as left (indicated by 1), right (indicated by 2) and circumvowel (vowel marker on either side of the consonant, indicated by 3). Within direction and congruency, a higher mean value was observed for left incongruent condition (M=2.33, SE=0.69), followed by the left congruent condition (M=2.23, SE=0.72). After this, the circumvowel incongruent condition showed a higher mean value (M=2.08, SE= 0.63) and the circumvowel congruent condition (M=2.05, SE=0.69). The right took the least time of all. The incongruent condition (M=1.75, SE=0.84) followed by the congruent condition (M=1356, SE=0.66). See Figure (17). All the directions taken together, were significant, at p<.001. Figure (16) shows pairwise comparison of direction.

Pairwise Comparisons

Measure: MEASURE_1

(I) congruency	(J) congruency	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	-.113*	.043	.012	-.200	-.026
2	1	.113*	.043	.012	.026	.200

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Figure 17 Pairwise comparison of Congruency as a factor

Pairwise Comparisons

Measure: MEASURE_1

(I) direction	(J) direction	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	2	-.214*	.058	.001	-.331	-.097
	3	.409*	.064	.000	.280	.538
2	1	.214*	.058	.001	.097	.331
	3	.623*	.062	.000	.498	.748
3	1	-.409*	.064	.000	-.538	-.280
	2	-.623*	.062	.000	-.748	-.498

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Figure 18 Pairwise comparison of the vowel markers on RT

Figure (18) represents 'left', 2 is 'right' and 3 is 'circumvowel'. It shows the effect of the vowel markers in a pairwise comparison.

3.4 Discussion

The study was conducted with an aim to understand if syllables, which are heavy, both phonologically and visually complex, impose any additional processing cost. While in Experiment 1 the phonemes were only affected by the congruency and incongruency condition, Experiment 2 identifies that aksara processing at the level of syllables is analytical. Had the direction of vowel markers not mattered, then the processing would have been holistic and the direction as a dependant variable would not have been significant. In the experiment, the participants were not asked to focus on global or local level. They were free to choose. Despite that, the participants' responses were affected by the direction of the vowel markers. Even under the congruent condition, the left condition showed a higher mean value. They carry more than one phoneme, many diacritic markers, with a contrasting written sequence. In the light of this, letter perception should happen differently, that is, it has to be analytical. Following Vaid and Gupta (2002), view that readers who segment words at the phonemic boundaries, the inconsistency in spatial arrangement would incur processing cost while for readers who segment words at the syllabic units or at the level of aksara there will be no processing cost; the second experiment concluded that participants' processing time was significant for the inconsistent vowel marking (as in the case of कि). While the first experiment proved that there is a holistic processing at the phonemic level, the second experiment suggests that an analytic processing happens in the case of syllables. This means, readers of Malayalam language segment a word at its phonemic level, thus incurring a processing cost. Also, the nature of processing is not fixed, suggestive of the fact that both analytic and holistic processing may be inherent. One gets actively suppressed and either of them are recruited depending on the nature of the script. Additionally, a study conducted by Perea, M., Abu Mallouh, R., Mohammed, A., Khalifa, B., & Carreiras, M. (2016), showed that diacritical marks play an active role in feature level model of the word recognition in the Arabic language. Specifically, the study examined if visual similarity of letter plays a role in the early stages of word processing. A series of masked priming tasks were conducted where the primes and the target had the same visual ligature. The results showed that substituted letter primes where the replaced letter had the same basic shape as the original letter, were not observed to be effective in activating the base form of the word than substituted-letter prime, where the replaced letter was different visually (Perea, M., Abu Mallouh, R., Mohammed, A., Khalifa, B., & Carreiras, M. 2016). Diacritical marks serve as an important feature that helps both in identification and discrimination of the letter and as such, an analytical process will kick in.

Admittedly, phonemes and syllables contribute to the two levels within a linguistic hierarchy. Studies (see McNeill & Lindig, 1973) have proposed information processing models for speech perception, which states that phonemes are a perceptual unit of speech. That means, speech is processed by us, by making an entry into the hierarchy at the lowest tier, phoneme and then working way up to make sense of the speech utterance. The model suggests that we first recognize phonemes and then the syllables and units of higher order. However, this has been rejected by Savin and Bever (1970) showed through an experiment, where subjects had to search a list of syllables and report it. The participants responded to syllables faster than they responded to phoneme targets. McNeill & Lindig hit back at Savin and Bever (1970) saying that the list of words chosen as stimuli was artefactual. Savin and Bever suggested that people who perceive speech enter into the linguistic hierarchy only at one level higher than the phoneme, and then the speech perceivers decompose the phonemes subsequently. This means, speech perceivers typically have to divide their attention depending on the stimuli in question, between focusing on the level (whether linguistic or global-local) as well as the letters (aksara here). While doing so, some amount of processing differences ought to occur. Thus, phonemes and syllables while they form the core as perceptual units of speech, Healy & Cutting suggest that a non-overlapping processing stage. That means, both phonemes and syllables are processed concurrently and not sequentially. Typically, a speech perceiver is said to enter the level of phoneme and syllables more or less at the same time (Healy & Cutting, 1976). At best, phonemes and syllables can be considered as two units that are equally required for speech perception. However, there is evidence from Cutler (1976) who found that phonemes were identified faster when the stimuli was a monosyllabic word.

The one central question is that we have to try to answer is why might the RT depend on the degree of mismatch (global-local) and the nature of the aksara? The answer is that listeners/speakers have to expend cognitively, when it comes to dividing attention between the perceptual units of speech and the different levels. Note that the direction of the vowel markers will still affect processing, even if the experiment was conducted without using the compound stimuli, owing to the nature of the grapheme-phoneme correspondence. While in most of the alphabetic languages children are seen to learn the alphabets by the end of first year of their school, the learning of aksara continues until grade 4 and 5 of school ((Nag, 2000). That is, an aksara with its inherent vowel (Ca) is learnt first, followed by the aksara with its vowel (in the reduced form) and finally the consonant cluster (CCV). Each phase of aksara learning happens when there is a complete mastery of the other phase. However, in textbooks, the consonant clusters frequently appear in textbooks, such as /mma/ as in /amma/ (‘mother’) and /kka/ as in /akka/. That is to say, children are rarely taught in such phased manner, inherent vowels, followed by CV structure and then the CCV structure. Each of this phase is heavier than the last one. Usually, the consonant cluster is taught last or a complete mastery in learning to write by a child happens much unto grade 4, because the structure is visually and phonologically dense. Vaid and Gupta, 2002, pointed out that native Hindi speakers are slower to name words when their spoken order and written sequence did not match, when compared to words whose order matched. This is the seriality effect (Vaid and Gupta, 2002).

Neuroimaging studies. There is also evidence from neuroimaging studies that there are separate brain regions that mediate the processing of phonemes and syllables (Siok, Jin, Fletcher & Tan, 2003). The study was conducted using an fMRI, where the neural substrate of these units were observed among Chinese speakers. The results showed that the left middle frontal cortex facilitated a syllabic processing, while the left inferior prefrontal gyri facilitated a phonemic processing (Siok et.al; 2003). This means, there is strong evidence for distinct cortical areas that facilitate the representation of these phonological units; syllables and phonemes. Note that Chinese is a logographic language. The important observation from the study is that when the tasks required a syllabic and phonemic level phonological information, there was a strong activation of the left middle frontal cortex. As for Devanagari, where vowels are either arranged linearly or non-linearly around the consonant, there was a strong bilateral activation in the middle frontal gyrus region of the brain; in reading syllabic scripts, there was activation for the right superior parietal lobule and for alphabetic scripts, activation in the left insula, fusiform gyrus and inferior frontal gyrus (Das, Kumar, Bapi, Padakannaya & Singh, 2009). A host of work has been carried out in various writing systems like Chinese (logographic), English (alphabetic), Korean (alphabetic and logographic), Japanese (syllabary) all of which have shown that there is an activation of the common cortical network, primarily in the left hemisphere (Das et.al, 2009). Additionally, for complex writing systems such as Japanese kana and Chinese have shown that right hemisphere is activated when processing of complex visuo-spatial information. Since Devanagari presents a case of syllabic and alphabetic style, attempts have been made to see if processing happens like that of alphabetic and syllabic script in the brain regions. Das et.al, 2009, showed that true to the nature of Devanagari, the language processing corresponds to those of alphabetic and syllabic scripts, which is the temporo-parietal, inferior-parietal lobule (as seen for alphabetic scripts) and superior-parietal lobule (as seen for syllabic scripts). Thus, the case of Devanagari or other Indic scripts is a case of a complex writing system that is seen to exert demand on the visuo-spatial processing.

Nag, Treiman and Snowling, 2010, show that among Kannada readers, there is a trajectory of errors that is followed. Significantly, when the aksaras has a lot of diacritics, many number of errors were seen to occur, and so consonant clusters visibly had a lot of errors.

Thus, the study wishes to reassert that, at the phonemic level and syllabic level, there exists a processing bias. This should not be surprising, because of the alphabetic and syllabic nature of the script. In an alphabetic script, there is a clear relation between the grapheme and the phoneme, although the phoneme is read differently in some words, as in c-a-t and k-i-t. Here, c and k in both the words represent the sound /k/. Yet, one sound stands for one grapheme. In syllabic scripts, the unit of representation is a syllable, with an inherent vowel, as in ಕ /k/ where there is an inherent vowel. This one is therefore an example of a syllable, whether the vowel marker is visible or not. Thus, at the phonemic level, there is a holistic processing and at the syllabic level, there is an analytical processing happening. The complex nature of the script is one factor that is responsible for a differential processing strategy at the two levels.

Chapter 4: Which area of an aksara is crucial for recognition?

Overview

Chapter 4 reports an experiment, which examines the crucial area of an aksara that might be important for accurate recognition. The study was conducted online among 48 Malayalam speakers who were students. The aim of the experiment was to understand what part of a letter is crucial for correct recognition. The participants were first asked to fill a language questionnaire that contained questions on their language use under different contexts, language use frequency among other things. Based on the mean score for reading (self-rated), the participants were categorized into high and low proficient speakers. They were subjected to Malayalam aksaras blurred from top to bottom, bottom to top, right to left and left to right. They had to identify the letter and type response. The error analysis of the results showed that maximum number of errors were made only by low proficient participants when the left part and top portion of aksara was blurred. The effect of all forms of blurring was correlated with the aksaras and it was found that only left blurring had a significant impact on incorrect responses, followed by top-to-bottom blurring. The results is suggestive of the fact that left and top portion of an aksara maybe an important component in the process of accurate identification. Together with this, the study reasserts that a fine-tuning of letter identification happens with experience to reading. Note that the overall identification efficiency was only 48.48% and this in part might be due to the nature of alphasyllabic scripts and hence cannot be ruled out here. As a learner of alphasyllabic scripts, the reader has both phonemic and syllabic knowledge. However, as far as a phoneme is concerned, the overall size of the aksara is too small to be perceived in analytical manner. Also, the stroke count may not have a role, as the script is linear, and phonemes are written as one whole unit. In Chinese, the characters are written in a strict codified stroke order, with the basic ordering being left to right and, top to bottom. Hence, such strong rules can mean strokes Chinese character recognition may be impacted by the stroke count and every character has a phonemic element and a semantic radical, thus increasing the phonemic density.

4.1 Introduction

Given the nature of alphasyllabic scripts and its unit of representation, the aksara, which is a small unit, the perception of it is an interesting area to look into. There has been clear evidence that eye movement patterns in reading is often varies with respect to the grain size and transparency of orthography (Padakannaya, Pandey, Saligram and Shruthi, 2015). At the phoneme level, an aksara is a very small unit. It contains only one unit with no vowel representation. Chapter 1 gives us an insight into the nature of processing when the level of aksara changes. Chapter 1 proved that a holistic approach happens at the phonemic level and subsequently the nature of processing changes when the unit of focus is a syllable. Various eye-tracking studies have shown that eye movement patterns when reading, can vary depending upon the transparency of the orthography and the grain size of letters. Transparent languages are those which follow a simple grapheme-phoneme conversion rules, such as Spanish and German; while English and French are defined as opaque languages, whose grapheme-phoneme conversion is not straightforward (Ziegler et al, 2001; Seymour et al., 2003; Simon et al., 2006, Bar-Kochva and Breznitz, 2012; Joshi et al., 2012). Alphasyllabic languages are in that sense, is opaque. The grapheme to phoneme match is not entirely transparent and a mastery is required until a child can fully learn to read in the language. In a study conducted by Rey, Jacobs, Schmidt-Weigand and Zeigler, 1998; the results conclusively showed that word identification times were longer for when a low frequency word with fewer graphemes were presented when compared to the control words which had more graphemes. Note that both the words had the same number of letters. The slow down happened because of the extra cost of having to map more than one letter into one single unit, as in the case of BREAD which has five letters but pronounced /bred/. The study showed that graphemes can act as perceptual units when reading.

In the case of alphasyllabic scripts, the phonemic density is by default two, although only one unit is explicitly expressed as aksara, as in t क /k/ which contains the phoneme /k/ and the inherent schwa. Given this relative small size of the unit, which is bare and less complex, the study sets forth to understand what part of this aksara might be crucial for recognition. Also given that graphemes can act as units of perception, it is worthy to understand how efficiency is affected when the phoneme is presented under a noise condition. More than holistic or analytical processing, the study points out that accurate identification necessitates some elements of the letters to be present as a prerequisite for processing.

The question of how letters are processed has been a topic that has been studied extensively. Many works have also been carried out in this area. The most dominant framework on the perception of letters is the one based on the features; the idea that letters are perceived by identifying its features. The features of a set is its arbitrary code, one that helps distinguish letters from one another. It helps distinguish one letter from another, by activating the abstract letter code (e.g., Fiset et al., 2009; Gibson, 1969; Massaro & Schmuller, 1975). To understand this, there has been research that have sought to determine what are the features of letters as such. Many of these researches presented individual letters. Individual letters were presented under the assumption that the features that are used in identifying letters in isolation is also used when reading letters in context. Some potentially relevant ideas have come up in many of these researches and they may be worth mentioning here.

4.1.1 Feature detection theory. One of the earliest method of understanding the features of a letter is by presenting it briefly to the participant and explore what confuses the reader. The underlying assumption that is usually held is that letters that look similar will be confused with each other owing to their similarity in shape and form. Similarity as such is then understood in the light of these shared features, that is, similar looking letters are those that have shared visual features. Even after decades of research in such areas, there has been a definitive conclusion to this. In an attempt to summarize the many studies that deal with understanding shared letter features, Grainger, Rey and Dufau (2008) described that the features of a letter is its lines that come in many different orientation and curves. They are also known as 'local features'. As opposed to this, Bouma (1971), proposed that letter have global features too. He defined the global features as those vertically ascending parts, sometimes the slenderness and also the outer features that act as perceptual cues when reading. Pelli et al. (2006) noted that there are only two features that may be needed in understanding a letter; the width of the letter and the roundness of the letter. However, when letters are presented only briefly and in low contrast, can reveal the global features (Fiset et al., 2008).

4.1.2 Image based classification. The image-based classification of letters is a common practice used to understand how identification and perception of letters happen in the mental system.

In a recent study by Fiset et al., (2009), a simple image classification method was used to understand the features of letters and what helps in identification. In this method, the identification efficiency of a letter is tested using many samples of scaled features. In each of the trail in the experiment, combinations of feature samples in many multiple scales is combined and then generated in order to present it as stimulus and the participants are asked to identify. The obtained results are then analysed with regression to understand how feature samples can be associated with efficient identification. It was found that letters in lower case in Arial font, line terminations, defined as the ends of the letter were most important for observers, than the horizontals, which was the second feature. With this, Fiset et al., 2009, argued that termination serve as a crucial information as they represent the critical information even when the font of the letters change.

One another factor that influences reading strategy is proficiency level of the speaker. Proficiency of the speaker also has a crucial role to play in the processing strategy adopted. That is, for a bilingual the choice of a particular language is usually modulated by the proficiency of the speaker, along with the opacity of the language. In a study conducted by Jeon (2002), it was demonstrated that when participants were asked to read ambiguous words in sentences, which was written in an opaque language, readers who were high proficient in that opaque language solicited more brain regions that support the lexical route. On the other hand, readers who were low proficient in the same opaque language, solicited only preferential brain regions that support the non-lexical route which are the inferior parietal lobe and the interior frontal gyrus. These results show that high proficient speakers of a language exhibit a strong link between word forms and their lexical representation, as against the low proficient speakers. Therefore, in bilinguals, the choice of a particular reading strategy is often modulated by not just the opacity of the language, but also by the proficiency of the speaker. Rayner (2009) stated that a differential reading strategy exists for opaque versus transparent languages. This however can be addressed by assessing eye movements in different languages. Together with this assumption is that in languages that are opaque, there will be a global and parallel processing, as against languages transparent languages, where the processing is local and serial.. Recall in the earlier chapter, which tested the Global Precedence Effect for Malayalam, the processing elicited a holistic approach. This means, the language has to be opaque and the GPE theory stands intact. However, in the case of alphasyllabic scripts, the aksaras are in a linear arrangement. They follow the natural order that is left to right reading (nature of the script) and top-to-bottom processing (as in the case of syllable). Any disturbance to this arrangement can cost a processing latency. This is in alignment with chapter 1, Experiment (b) which states that as the nature of aksara changes (from phoneme to syllable), the processing strategy also changes. This coupled with the evidence that Kannada speakers' processing latency increased with consonant conjuncts shows that visual orthographic complexity of an aksara may have a role to play in processing. Although the difference was more pronounced with the Reading Disability group, the paper does not rule out this in the case of typically developing children as well.

Whether the language is opaque or transparent, the proficiency of the speaker in the language can also elicit a differential reading strategy. (Rodriguez, Buetler, et.al, 2016). There is also evidence from Wiley, Wilson & Rapp (2016) that the visual system dynamically adjusts the weight of the visual features, to an extent that expert readers of a language become more efficient and effective to discriminate the letters of a language they are viewing among the finite set of other alphabets. Also, specific characteristics of the alphabet and the participant's prior experience affects how the letters are perceived and processed. Briefly, as indicated by Schyns, Goldstone and Thibaut (1998) one generally accepted argument is that visual feature set is fixed and the other argument which states that it is flexible and thus will be increasingly modulated by learning experience. Thus, the paper has two aims; to understand what part of an aksara is crucial for identification and, the effect of proficiency of a speaker on identification.

4.1.3 Processing of alphasyllabic scripts. The structure of alphasyllabic script is similar across the writing systems that exist within it. In general, the script has separate representation of vowels and consonants.

One common feature of alphasyllabic scripts is that the letters and diacritics of the script is visuospatially complex (Gupta, 2004; Nag, Caravolas & Snowling, 2011).

In a study investigating the role of prominence of phoneme and syllable as units of segmentation in reading among Kannada speaking children, it was found that the optimal unit for beginners is the syllable, while the proficient readers could manipulate the phonemes too (Padakannaya et al., 2002). This means, with increasing alphasyllabic literacy, there is a dual representation of syllable and phoneme. There is also evidence that syllable awareness is more critical than phoneme awareness in alphasyllabic scripts (Nag, Snowling, 2011). There is however an extreme paucity in the area of letter perception in alphasyllabic. Much has been discussed about the role of phonemes and syllables in processing. However, there is very limited to no studies that talk about the feature level processing in alphasyllabic scripts. Precisely, this paper discusses which area of a letter when blurred, affects the accurate identification. This is important because, whether alphasyllabic scripts are processed holistically or analytically, this study tells us that while all the parts may be equally important, it is also possible that certain areas are a prerequisite for efficient recognition. Holistic processing assumes that the letter is perceived as a whole, while analytical processing assumes that letters are processed via their features. Letter and word information of a particular word is usually extracted only from a small region surrounding the fixation of it. This perceptual span includes the fixated word and also the parafoveal word in the text (Radach, Inhoff, Heller, 2004). There is also evidence that readers acquire useful orthographic and phonological information from the parafoveal word. McConkie and Zola (1987) have shown that there is a sharp drop in the letter identification performance from the centre of fixation to the parafovea. Together with this, key evidence from studies conducted by Briihl&Inhoff, 1995; Inhoff, 1989; Rayner, Well, Pollastek, & Bertera, 1982, show that much of the letter information is extracted from the beginning of the letters of a to-be fixated word, as against the centre or the ending of the letters. Typically, in many of the scripts, left-to-right is reading norm and thus, reading can negatively be affected when the left side of the letter is scarred or blurred. Recently, Zhang and

Reilly, 2020; showed that Chinese character recognition was negatively impacted when the upper and lower part of a character was blurred. Chinese characters are two-dimensional and have a high non-linear visuality. Given the square configuration of the Chinese characters, a top-to-down reading strategy would be the general trend.

The present study aims to understand if an area specific attention may be needed within an aksara to identify it, along with understanding if this identification efficiency is affected by the proficiency level of the speaker. This is important, because phonological information plays an early role in the processing of reading of a text. Rayner 1998, showed that phonological codes appeared to be accessed early in the encoding of a word. Although much of the studies are conducted in the context of a word, the results from Rayner, McConkie and Zola and Briihl&Inhoff, 1995; Inhoff, 1989 are suggestive of the fact that the eye is drawn towards the left side of the word. Such a positioning is suggests that left side of the word maybe a crucial identification zone. Much the same way, what happens within an aksara is not clear. The grain size of an aksara is extremely small with many strokes (in some cases). Given this, it will be interesting to observe what area within this aksara may serve as an important factor for efficient identification. Also, motivated by the realisation that an increasing number of studies overlook the importance of letter perception as an essential stage of reading process, especially given that letter is an important functional unit, the study tries to understand what happens when a letter is blurred from different directions. Do people still perceive the whole and process the holistically? Or is the holistic and analytical process change with the nature of task and importance an area within the stimulus unit?

4.2 Method

4.2.1 Stimuli. The stimuli was designed using Adobe Photoshop. Aksaras were uniformly of the size. All of these aksaras were blurred from the top, bottom, left and right side. A Gaussian blurring was introduced as the noise environment, from which they had to identify the aksara. All the aksara was blurred with a 60% of noise, making sure that the central portion of the aksara is not affected and is still accurate. Several studies have also shown that the probability of accurate or correct identification is seen to drop in the case of isolated words when the eyes are further way from the centre of the word, suggesting that the central portion of an aksara is a necessary precondition to identifying them efficiently. Keeping this in mind, the centre portion of the aksara is kept intact.

The stimuli was all the stop consonants and vowels of Malayalam. However, care was taken to ensure that letters that looked orthographically similar was not included. Figure (19) is a representative sample of the phoneme /k/. All of them were semantically void and orthographically distinct from each other.

Figure 19 Gaussian blur applied on the letters of Malayalam.

Read from left (a) left blurring, (b) bottom blurring, (c) top blurring, and (d) right blurring

4.2.2 Participants. A total of 50 participants took part in the study. The data was collected online, via Pavlovia. Out of the 50, only 48 were included in the analysis. Two of them cited internet issues and thus their trials were removed, owing to incomplete trials. All of the participants were native speakers of Malayalam (L1) and acquired English (L2) formally via school or institutions of higher order. The participants are categorized into high and low proficient. This classification is based on their proficiency ratings and their responses to the language proficiency questionnaire. The self-devised questionnaire included questions related to their rough age of acquisition of L1, their everyday usage of L1 in work and other domain, percentage of use of both the languages, everyday exposure to the language (1= rarely exposed, 2= sometimes exposed, 3 = most often exposed). The participants were also asked rate their level of proficiency in both the languages for understanding, speaking, listening and writing abilities. The rated these abilities on a Likert scale of 5, 5 being excellent and 1 being poor. Along with this, they were asked to state their frequency of L1 usage in terms of percentage.

Language use of the participants have been put to use in the current study to understand how proficiency can affect letter perception. To discuss briefly, a participant who has a strong L1, may tend to show that a letter is perceived as a whole, despite the blurring. On the other hand, a low proficient may not exhibit. This is suggestive of the fact that, with experience in reading a particular, the approach to reading strategy may differ significantly. Thus, the study aims to explore two ideas, (a) what part of an aksara is crucial for effective identification; and (b) if proficiency of a participant changes the reading strategy or perception of a letter.

Table (8) is illustrative of the details of the language questionnaire (of both High and Low proficient participants). The participants were all native speakers of Malayalam.

Legends	Mean	SD
Age (in years)	25.53	3.06
Years of formal education		
L1		
L2	2.88	4.15
Language usage	14.86	3.92
L1		
	66.90	22.09
Self-reported proficiency (in reading)		
L1		
	4.46	0.76

Table 8 *Data obtained from the language questionnaire, collected as a part of the study*

4.2.3 Apparatus and Procedure. The experiment was designed on Pavlovia and run online. The data was stored on cloud and later retrieved. The experiment was designed on a 15.6" laptop on with 1366*768 pixel resolution. The experiment began with a consent form where the participant had to 'agree' to volunteer for the study. Followed by this, an instruction screen appeared, which was written in English. After they read the instruction, they had to press the spacebar key to go to the next screen where the fixation cross appeared for 500ms. Later, a set of practice trial block appeared. After the practice trials, the experimental trials began, where aksaras were blurred on any one side. The center part of the aksara however was clear. After every response, a blank screen appeared for 1000ms. Post the experimental block, a control block appeared where the letters were not blurred and the participants had to simply type in the response. The spelling of the aksaras entered by the participant did not matter in either block, because the idea was to only understand if they got the phoneme correct. For example, some participants typed in 'ba' instead of 'bha'. The difference is only the aspiration, but the orthography of 'ba' and 'bha' is different and so there was no way for the participant to get confused.

The experiment avoided all allophones of a phoneme to minimize confusion in identification of the aksara. The responses collected in the current study is used only to understand if they are able to identify the aksaras or not and therefore, the length of time they took to identify the aksara did not matter. The length of time is unlikely to affect the accurate identification. The study did not consider Reaction Time, but only the errors and accuracy. Figure (20) shows the design of the study.

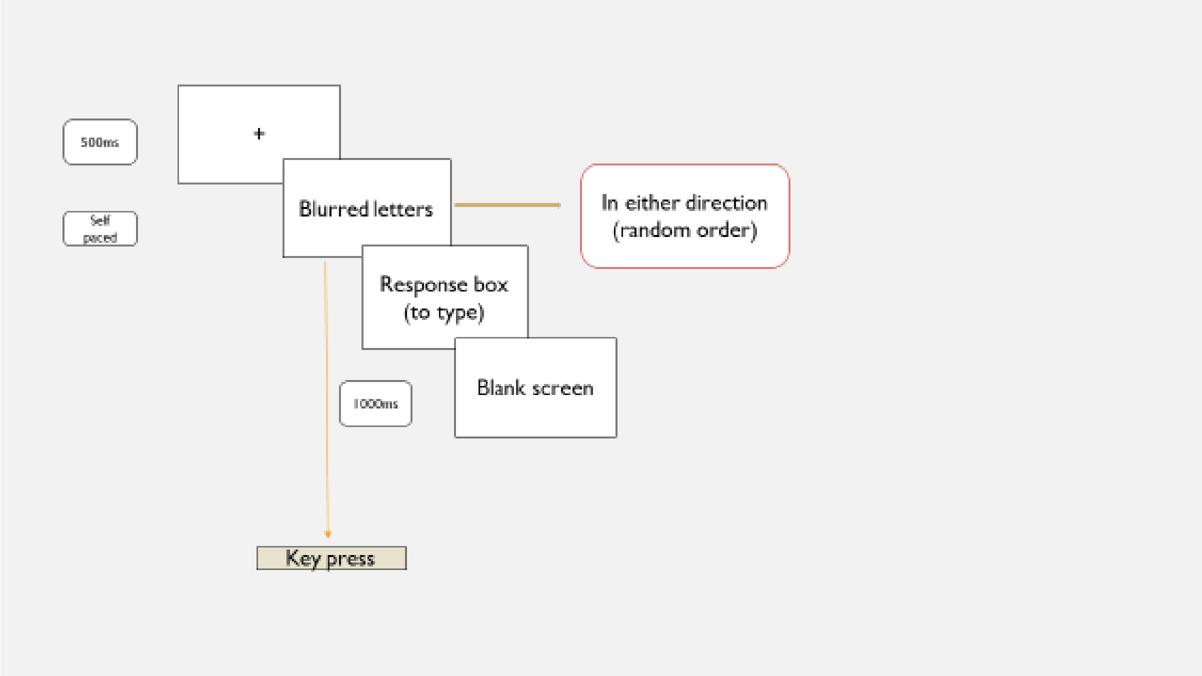


Figure 20 Design of the study

4.3 Results

The correct and incorrect responses were manually filtered out. The incorrect responses were noted and an error analysis was carried out. A total of 12 Malayalam stop consonants and vowels were used for the study. The analysis will focus on four conditions, (a) neutral (b) top blurring, (c) bottom blurring, (d) right blurring, (e) left blurring. There are also neutral trials, which are not blurred. All the analysis was done using ANOVA, on SPSS platform.

4.3.1 Overall recognition. Overall, the identification accuracy was only 48.48%. The results show that accuracy was significant, $F=37.61$ $p<0.01$. Accuracy*group was also tested, $F= 18.37$, $p<0.01$. High proficient participant's performance showed a greater accuracy mean, $M= 0.954$, $SE=.008$. On the other hand, the low proficient participants showed a lower accuracy mean, $M= 0.884$, $SE=.008$.

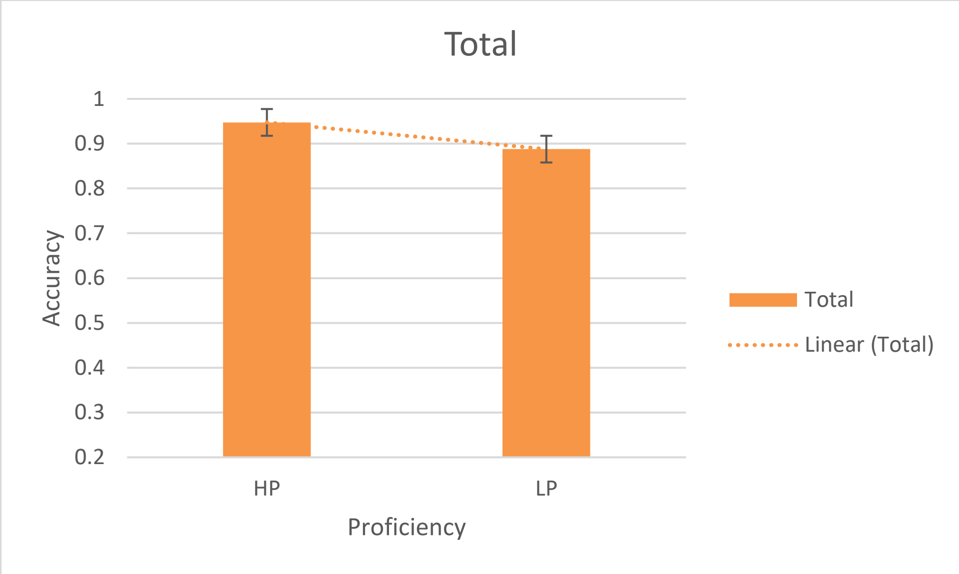


Figure 21 Accuracy of recognition against the proficiency of the speaker.

Figure (21) shows how accuracy (correctness) of identification was affected by being high or low proficient. The high proficient speakers had an edge in accuracy compared to the low proficient group.

4.3.2 Identification efficiency. The results were analysed to understand the identification efficiency despite the blurring. Overall the error rates were 51.2%. Specifically, the error rates were significant when left and top portion of the aksara was blurred. Together with this, there was an overall interaction effect between proficiency of the participants and the blurring conditions. The left and top blurring had an impact only on the low proficient participants and not on the high proficient participants.

The analysis showed that main effect of blurring was significant, across both the groups. The high proficient participants exhibited a significance of blurring condition with $p<0.01$ (M=0.45 SE= .011). This means, there has be an overall blurring effect on the high proficient, but not enough to show a statistical significance. In the pairwise comparison, among the high proficient, a significance effect was absent for all the four blurring conditions, except for the neutral condition, $p<0.05$, (M=.000, SE=.005).

Low proficient (lp) on the other hand, showed a main effect significance for blurring, p<0.01 (M= .115, SE=.008). In the pairwise comparison, each of the blurring condition was compared. The results showed that identification was affected when the left and top portion of the aksara was blurred. For top blurring, p<0.01, (M=0.12, SE=0.16) the left blurring, p<0.01, (M= 0.295, SE=0.23), and the neutral condition at p<.03, (M= 0.14, SE= 0.005). Figure (22) highlights the values of each blurring direction against each other.

The direction of the group affected blurring differently. The main effect of direction* group was significant, F=18.77, p<0.01 and the direction of the blurring was also significant, F=39.34, p<0.01.

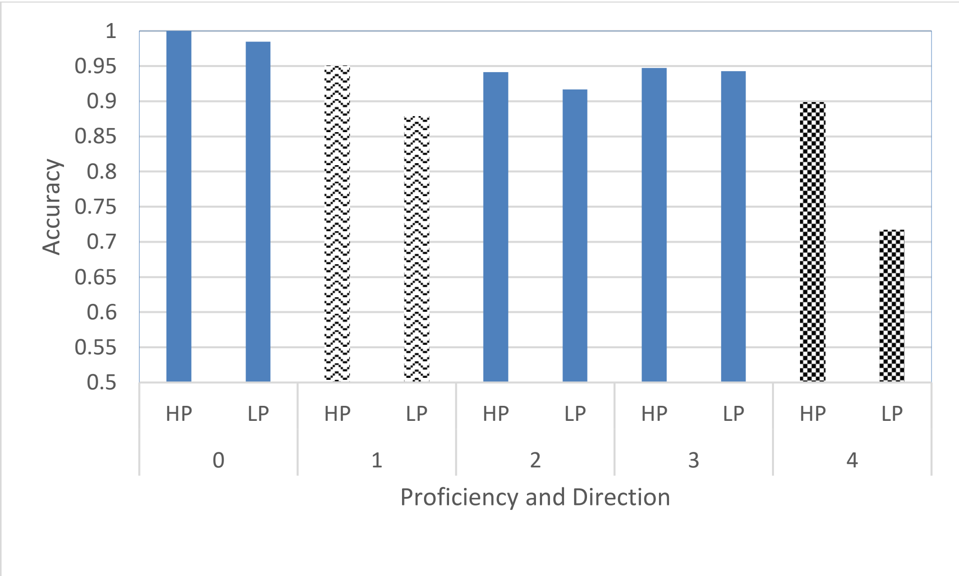


Figure 22 Recognition accuracy of participants

Figure (22) shows the comparison against proficiency of the participant and direction of blurring. Read 0 as Neutral, 1 as Top blur, 2 as bottom blur, 3 as Right blur and 4 as left blur.

Together with this analysis, the participants were measured for the frequency of language use versus accuracy of identification. The data for frequency of language use (L1) was also collected along with the language questionnaire data.

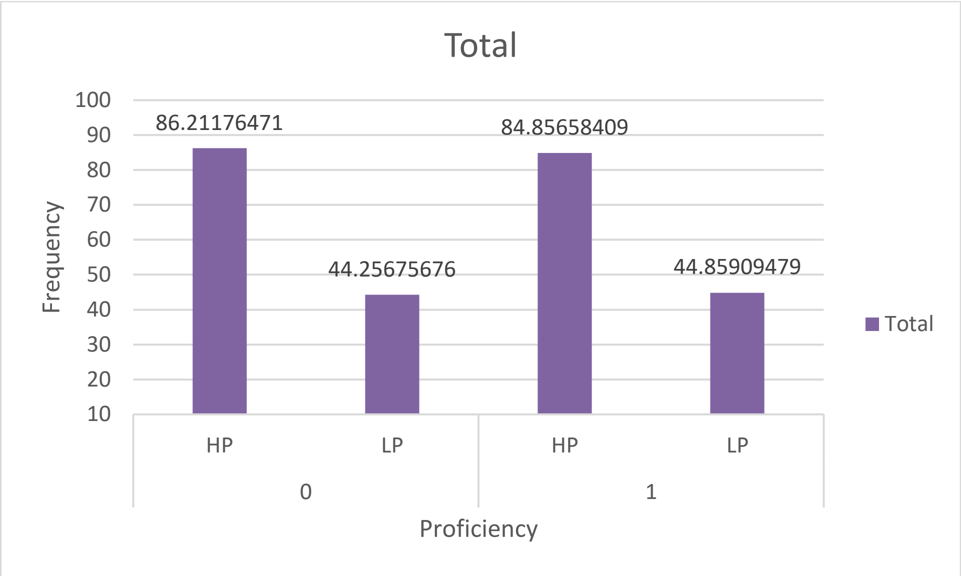


Figure 23 Accuracy of identification against frequency of language use.

Figure (23) shows that with increasing frequency of usage of L1, accuracy has also changed. That is, as the frequency of usage of L1 increases, the identification or accuracy efficiency also increases. Although the difference is less, it is a good indication to look into factors that may affect identification.

4.4 Discussion

The aim of the experiment was two-fold; (a) to understand if there are any crucial areas inside an aksara, whose absence might inhibit the accurate identification, (b) if expertise in a language (developed as a result of frequent reading) can affect the identification despite the blurring or other noise. The results tell us that identification is negatively affected when the left and top portion of the aksara is blurred. This result is seen only with the low proficient and not the high proficient L1 users. The key findings from the study indicate the perception of an aksara. The difference of performance between the two group of participants is in alignment with Wiley, Wilson & Rapp (2016); who state that the visual system has the potential to adjust the weight of the visual features, thus facilitating the expert readers of a language to becoming more efficient and effective to discriminate the letters of a language they are viewing among the finite set of other alphabets. Prior experience of the participants, which is their L1 reading frequency can affect how the letters are perceived and processed.

For a regular reader of a language, the perception of letters or for that matter, objects of nature, become more specialized. For example, a car expert will be better equipped to identify a particular car just by looking at the headlights or a any feature of the car. This sort of a specialisation sets in only with experience, thus producing exquisite perceptual skills. Similarly, as a frequent reader of L1, the reader is better equipped to understand the letter even when presented under a noise condition. The high proficient participant is able to surpass the analytical skill and perceive the letter as a whole. This sort of an acquisition of perceptual expertise can pave way to functional specialisation within the system of the brain, especially dedicated to visual processing (James H., James W. et. al). Similarly, as adult readers today have a wide range of experience in reading; it is likely that this extensive experience can lead to a letter specific specialization of the visual system. Grainger et.al., 2008; suggest that readers employ a feature detection approach to letter recognition. Feature detection theory states that an object or letter is perceived via their component features (features that makeup a letter or object) as opposed to perceiving it as a whole template. However, the study points out that such an approach to letter perception can happen only when the participant is a low proficient. A low proficient may need an analytical approach to letter perception. Fiset, 2008; argued that a specific set of ten visual features may facilitate a better letter recognition. One possibility is that a holistic processing can happen under the assumption that while all other conditions are normal, a holistic processing is likely to take place. In the absence of this, an analytic processing can happen, that is, as the task in hand gets complex, an analytical processing sets in.

In the study here, the left and top portion of the aksara when blurred, affected identification efficiency. That is, maximum errors were made in identifying the aksara when these two areas of the letter was blurred. One reason could be the left to right reading/ writing of alphasyllabic scripts. Since we as human readers are equipped to reading from left to right, our perception is likely to be affected when those portions are blurred. The top blurring and its negative effect on identification is likely because of the processing norm. A top-down approach to perception may likely be the norm given the linearity of the script. That is, our scripts are written left to right and much of the diacritical information is contained on the top portion of an aksara. Whether Devanagari or any other the script of South India, the vowel markers are always placed on the top portion of the aksara. Vowel markers are also variously arranged in the left and right side. The eye is adjusted to a top-down approach and a left to right approach. This is in alignment with McConkie and Zola (1987) who showed that there is a sharp decline in the letter identification performance from the centre of fixation to the parafovea. Together with this, key evidence from studies conducted by Briihl&Inhoff, 1995; Inhoff, 1989; Rayner, Well, Pollastek, & Bertera, 1982, show that much of the letter information is extracted from the beginning of the letters of a to-be fixated word, as against the centre or the ending of the letters. When two different words are presented in the foveal and parafoveal vision, the eyes are directed to the space between them, however the observation is that the eyes initially land at the beginning of the word and then the middle (Dunn-Rankin, 1978; Rayner, 1979; Vitu, O'Regan, & Mittau, 1990; Vitu, McConkie, Kerr, & O'Regan, 1999).

Another possible explanation to why there is a cost on identification efficiency when the initial portion of an aksara is blurred is the LEX model proposed by Kwantes and Mewhort (1999b). In this model, Kwantes and Mewhort state that in order to acutely identify words, readers tend to search the mental lexicon letter by letter, such that the word can be correctly identified. For this, letters in the beginning of the word will be important to narrow down the set of lexical items and as such could be trained to look at the beginning of a word. In this case, the readers direct their eyes to the beginning of the letter in the same anticipation, as the word-initial information can help constrain the number of possible candidates that may get activated.

The one aspect of letter identification that markedly changes the perception strategy is the function of experience in reading. In a study conducted by Dunabeitia et al. (2011), it was found that the readers of language who were skilled, were seen to be insensitive to mirror image letters, which were inserted in unconsciously presented words at the beginning stages of word processing. Thus, it is possible that orientation as a visual property have an impact on the performance of the participants across the various levels of reading expertise. The undeniable exposure to reading has to be considered when trying to answer why the different groups performed differently under the noise, when identifying the letter. There are developmental neuroimaging studies that suggest that the basic structural features of the network that is specialised in visual word processing is present in readers who are only beginners. It is only with greater reading experience that a functional level fine-tuning to letter perception is achieved (Maurer, Brem, Bucher, & Brandeis, 2005). In line with this view, the study also supports the view that expert readers of a language are able to acutely identify the letter despite the blurring, is because of this functional fine-tuning to perception of letters. Several eye movement studies have brought out that information uptake is graded, that is, it begins with an extraction of graphemic details that is near the point of fixation of the eyes and later the information from the parafovea. Futhermore, Rayner's work (eg, Liversedge et al., 2004; Dambacher et al., 2013) have stated that experienced readers of a language look at all the words of a text. However, the ability to extract visual information quickly and with much acumen is the result of skilled reading. This is a clear indication that linguistic processing affects eye movements, especially during reading. To further support that there might be a differential reading pattern and strategy, a case from reading words derived from noun base and those derived from verb base will help. For words that were derived from noun base, the proficiency of the reader played an important role in helping to determine the effect of word length and frequency and what these exerted in the eye movement of children. However, for the low proficient set of children, the inhibition rate was higher for low frequency words when compared to high frequency words. This means, there must be a different degree of automatization when accessing lexical representations and also a differential use of the sub lexical procedure when having to read aloud; and these vary with the degree of proficiency of the reader (Grainger and Ziegler, 2011).

Neuroimaging studies. The possibility of a letter specialized representation in the brain has also been explored in some behavioural studies, among normal participants who performed visual search task. Their studies showed that participants were faster, accurate, and also less sensitive to the number of distractors when they were asked to search for letters among digits, as compared to searching letter among letters (Jonides & Gleitman, 1972). This ‘‘alphanumeric category effect,’’ is possible only in a neural architecture where letter recognition lies separate from that of digit recognition. The effect rests on the assumption that the different letters of the languages are perhaps represented in the same cortical area and as such must interact with each other. In addition, the difference in the form of letters and digits (letters are more curvy, whereas digits are straight) could be responsible for this disassociation and hence can influence the results. In a study conducted by Polk, Stallcup et.al, 2002, where participants had to passively view consonant strings, digit strings, strings of shape and fixation points, and fMRI was carried out while the participants were performing. The idea was to explore the evidence for specialized representation for letters in the visual system. Three sets of experiment were performed; letter/digit versus shape, letter versus digit and digit versus letters. Their results showed that a left ventral occipitotemporal area was more responsive to letters than it was to digits. This result was seen in both the passive viewing task as well as the active stringmatching task (Polk at al., 2002). Their main results were conclusive of the fact that the was an evidence in the left inferior visual cortex that is specialized for visually processing letters. Research among some neurological patients also showed the consistent result; with a critical role for the left inferior occipitotemporal cortex during reading. An analysis of lesion topography across a set of brain-damaged patients suffering from pure alexia, Binder and Mohr (1992) found the ventral temporal lobe including the fusiform gyrus to be the common lesion site. Also, Beversdorf, Ratcliffe, Rhodes, and Reeves (1997) observed a pure alexic reader. The reader's brain was studied intensively post-mortem. It was found that there was a lesion in that affected the left fusiform gyrus and the associated white matter. This evidence was discussed under the light of word-impairment. Results like these suggest a possibility that letter recognition and word recognition might depend on these partially separated neural substrate. Puce et al. (1996) employed an fMRI study to record the neural activity when subjects were asked to process letter strings, faces, and textures. Through this, it was observed that letter strings activated the left occipitotemporal and inferior occipital sulcus, relative to the other stimuli. Also, this sort of an activation was not detected among illiterates and children who have not begun to read (Dehaene et al., 2010) and therefore, the activation strongly correlates with reading performance. Saygin et al., 2016 offer a possible explanation to the puzzle; why our brains dedicate a special area to processing of letters and words. Saygin observed in children at the age of 5, which is before their schooling and later at the age of 8, after their schooling, that if the visual word formation area or VWFA is in place, the children can predict (three years before) where the reading will land in their brain. This is not just limited to the location in the brain, but also the accurate position and contours. It is this pattern of connectivity that exist with the rest of the brain, specifically, the left temporal lobe, that predicts which position can make up the VWFA. This is a hint that the brain is actually pre-wired for letters and even before a child learns to read properly, one can predict that future location of his/her letter processing area, one that can be predicted from the connection to the other parts of the brain (Dehaene, 2016). However, the question remains as to why in the first place would there be an area specialized for processing of letters (in the brain's cortex)?. Researchers postulate that the cortex of the brain has certain specialized areas for processing of faces (Kanishwer, McDermott, & Chun, 1977), places (like buildings, scenes etc.) (Epstein & Kanishwer, 2001) and body parts (Downing, Jiang, Shuman, & Kanishwer, 2001), and other ventral regions of the brain is said to support the recognition of everything else (Grill-Spector, 2003). For instance, stimuli that need a foveal analysis in order to extract the fine-detailed information, like faces and letter strings, are known to activate the regions of cortex that have a central (foveal) representation. On the other hand, objects that do not require such a fine-grained analysis, as in the cases of buildings, activate regions that have peripheral visual field representations (James et al., 2005). Letters tend to differ from one another, depending on the basis of the structure or shape of letters, and as such are recognized at their basic level (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). Common objects (like tables, animals and plants) also exhibit a difference at their part structures. They are recognized at their most basic level. This is in contrast to recognizing faces, which are individuated at a more subordinate level (James et al., 2005). Thus, in order to recognize a letter, the visual system must begin to code the most basic-level differences and then not pay attention to the other subordinate-level features like orientation, font, size, and the like. An 'A' must be recognized as an 'A' regardless of whether it is written "A," "A," or "a," and it must also be distinguished from an alternate alphabet like B. Letters are typically observed and read in their usual arrangement. That is, they are often constant in orientation, size, and font and this is the sort of arrangement that we encounter while reading. This sort of an arrangement enables the visual system to rely on for identification. Together with this, there is also a pressure to identify letters quickly. So, the expert reader may not entirely ignore the subordinate information. What then happens is that, the visual system is set to “tune” to this information. It therefore can take advantage of the regularity that is seen in printed text and thus facilitate letter recognition (James et.al, 2005). Letters are most often recognized in the strings with regularity of font. However, this regularity with a subordinate information is not a common thing to observe in objects. And because of this, font tuning maybe a specific to expertise with letters (Gautheir, Wong, Hayward, & Cheung, 2004). Also, the specialised processing that the study found for expert readers cannot really be explained in terms of familiarity, because in a study conducted by James et al., the participants’ brain activation was studied when they were reading letters and digits. Digits are equally familiar as letters would be. But, the activation level was not similar for digits as it was for letters, in the anterior left fusiform gyrus. In the study, by contrasting fMRI activation between letters and digits and to Chinese characters, it was found that the left fusiform gyrus responded preferentially to Roman letters when compared to other types of characters. A smaller, with more focal area in the posterior fusiform gyrus responded to letter strings than to other character strings.

Finally, the study wishes to stress the relevance of this data in light of educational practices. Acute identification is the result of exposure to print and other forms of reading L1. However, insensitivity to the blurring should not be seen as only a function of expertise. It may be possible that an expert reader is exposed to reading more frequently than the low proficient readers, but this ability to surpass the blurring and identify might vanish if the noise in question is complex, for example, blurring the central portion of the aksara in this case. Therefore, this advantage is exhibited only as long as the task is relatively easy. Despite the traditional experimental design, the approach to understand the crucial area of a letter is novel. The study gives us a clear picture that identification can be affected if the top and left portion of the aksara is unavailable for the reader, subject to proficiency. Further research using an eye tracker may be needed to understand if both group of people even begin looking at the aksara at the same point.

Chapter 5: Discussion and Conclusion

Overview

Chapter 5 summarizes the main results of the experiments reported in the thesis and also relates it to the research objects presented in chapter 1, Introduction. Together, future recommendation for study is also mentioned. The chapter concludes by discussing how the results from the work can contribute to the current state of knowledge.

5.1 Summary of results from Experiment

The idea that a simple object can have a hierarchy of visual forms has changed the way languages processing is understood. The very fact that a particular scene can be decomposed into its subsequent parts that make up the whole parts signals that the value of such representation exhibit a correlation between the different levels that exist within a scene. For example, the human head is one entity and has many other sub ordinate parts that complete the head, like a pair of ears, nose, a pair of eyes etc. exhibiting a visible hierarchy. Extending the same analogy to language; a language or a written representation is seen as having a global and a local form. The global form is the overall structure of letter/aksara/character or even a word. The local form is the specifics of the letter/aksara/character, that is, the strokes, the line segments, the diacritic markers etc. that add to the meaning of this unit of representation. The reason why such a level of local features deserve attention is because in most cases they are capable of slowing down the overall processing speed.

The first objective of the study is aimed at understanding if letters are perceived similarly by speakers of a language, who speak a language of the same family. In Experiment 1, there were two groups of participants; native speakers of Malayalam and naïve speakers (who had no exposure to the language). Participants were asked to judge if pairs of letters (Malayalam) were similar in their shape. Both the groups saw the same set of letters. The results showed that both native and naïve group perceived aksaras similarly. That is, both the groups were slower to respond to aksaras that looked similar in shape and recognized the different looking letters aksaras relatively faster. This experiment threw light on the major question as what effect complexity and distinctiveness of an aksara play in the mental representation of letters is the primary goal of the study. Complexity is understood as the number of features that make up an aksara while distinctiveness the features within an aksara that may overlap with another aksara. In other words, it is the number of shared features. Comparative studies of Chinese and alphabetic writing systems have shown that networks of brain tend to overlap, even if partially, across these writing systems (Perfetti, Liu, Bolger, Tan, 2007). So, when the participants' language family changes (L1 and L2) in question differs, we should expect to see some difference in processing strategy. The results brought out two main understanding;

a) both the groups' performance was similar. This is an indication that processing of scripts especially the ones within the same language family would not only entail a similar processing strategy, but also a similar perception,
b) the nature of letter processing and how the nature is unlikely to change if the processing happens within the same language family. However, this nature of processing is likely to change depending on the expert level of the speaker.

Distinctive features of an aksara can help in identifying them better. The performance of the native group is a testimony to this. When Pelli et al., observed participants' by showing them only the contours of a letter, presented in noise, accuracy dropped when the severity of the perturbation increased. Thus, lines, curves, and other termination can serve as a significant factor in facilitating identification of a letter (aksara in this case). However, this is no reason to believe that a feature detection may be happening as against a template matching approach. The possibility is that expert readers exhibit some complexity benefit, only when compared against the naïve group and not within the native group, as they have better exposure to the script.

Bilingual advantage; the native and naïve group showed a similar processing and perceiving of aksaras, suggesting that the effect of processing on language in a certain way can also be carried on to the processing of another language.

However, this nature of processing is likely to change, depending on the proficiency of the speaker (Wiley and Rapp, 2018) and the task in question. The specific task required the participants to make a judgement call of their similarity and hence a finer analysis at the most basic level may be needed.

The second objective of the study was to examine if the reading strategy or the perception strategy changes with respect to the unit of representation. The experiment tried to understand the reading strategy (holistic or analytic) when a phoneme and a syllable was presented. Participants were asked to do an identification task. The stimulus was the compound stimuli, where the bigger aksara was made of smaller same/other aksara. The results showed two things clearly;

1. the nature of processing changes with respect to the unit of representation. In the case of phonemes, there was a holistic processing. The global units in both Malayalam and English were recognized faster than the local units. There was an interference of the global units when the participants were asked to recognize local units, thus also causing an additional delay. In the case of syllables, an analytical processing was observed.
2. The results support that holistic and analytical processing exists side by side within the system. One is actively suppressed and is awakened only when task demands. In addition, phonemes and syllables are equally important for learning, reading and perceiving alphasyllabic scripts. Adding on to the existing debate, of which units act as the unit of representation, the study states that in alphasyllabic script, both phonemes and syllables are a pre-requisite for reading. What acts as the unit of representation for a language strictly depends on the language and script specific properties. If a language

is alphabetic, the readers have an increased awareness to phonemes and likewise for a syllabary like Japanese, there might be a far more pronounced awareness to syllables. Thus, both phonemes and syllables act as the unit of representation and the selection of either will depend on the task in question.

Global processing need not be the obligatory first step in processing. This will depend on the language in question and also the task that is necessitated; as evident from Korean Hangul (Winskel, Kim & Cho, 2018)

The third objective was to understand which area of a letter is crucial for recognition. The task was carried out among high proficient and low proficient speakers of Malayalam. They were categorized based on a language questionnaire. The questionnaire collected details on their reading, speaking, listening and writing skills in the language. Together, a self-reported proficiency score and a frequency of language use score was ascertained. With this, the population was classified as high and low proficient group. Later, they were asked to volunteer for the experiment. In the experiment, selected aksaras (stop consonants and vowels) were blurred from all four direction (top-to-centre, bottom-to-centre, left-to-centre and right-to-centre). This was the experimental block. They had to identify the aksara and type in the response box provided. In the control block, they had to identify the aksara without any blurring. The results showed that high proficient (HP) and low proficient (LP) responded differently to the aksaras. The HP were better at identifying the aksara despite the blurring and LP group's response were affected by top and left blurring condition. Together, there was a positive correlation between the usage and identification efficiency. That is, as the frequency of language use increased, the ability to identify aksara efficiently, also increased. The results are suggestive of the following observation;

I. for a regular reader of a language, the perception of letters or for that matter, objects of nature, become more specialized. This is similar to the case where a car expert can identify a car by simply looking at its headlight. He/she may not need a more specialized analysis.

II. reading experience can change the perception strategy and as a result, a functional specialisation can be achieved (Dunabeitia et al., 2011).

While a fine-tuning to letter perception can be achieved with expert readers of a language, we must also understand that in Experiment 1 it was reported that native speakers of Malayalam, showed an analytical processing of aksaras. This may seem contradictory; however, the study asserts that perception of a letter is almost always driven by the task. If the participants are expected to report similarity (as in Experiment 1), an analytical processing should be expected. The nature of the task is such that the observer needs more information to classify something as similar or dissimilar. The act of such a comparison demands that the system compares a number of visual components of those letters (Taylor, 1976). On the other hand, in Experiment 4, the task was simply to report the letter they think it was. The task does not need any finer tuned analysis. But speaking generally, the results obtained from the study show that processing on either levels, featural or whole letter approach, is similar. The primary question that has often been raised is whether such comparisons happen serially (one after the other) or in parallel (simultaneously). In order to understand this, the researchers have to begin understanding the unit of perception; where the participants segregate information that is contained in the stimuli, before understanding the manner in which the information is further processed. And this is the issue that has largely been ignored in research conducted so far. Thus, in order to get the clarity of this, experiment 2 was carried out. Through the experiment, it was brought to awareness that in alphasyllabic scripts, the need to process both phoneme and syllable may be a first step and how this processing takes place (global or local) will depend on the task.

5.1.1 Reading strategies. Reading strategies is known to vary across languages depending on the orthographic depth. The orthographic depth is understood as the complexity of the grapheme with respect to the phoneme conversion rules. Reading strategies are also modulated by the language being read (Frost, 2012). There exists certain rules for converting grapheme (the written units) into phonemes or syllables and this will vary across languages. Different languages accordingly involve in distinct behavioural and neural reading processes. It is based on this assumption that the "Orthographic Depth Hypothesis" (Katz and Feldman, 1983; Katz and Frost, 1992)) was developed. ODH or Orthographic Depth Hypothesis postulates depending on the opacity of the language, different strategies change. Languages like Spanish and German are transparent. Here, majority of the words follow grapheme–phoneme conversion rules (GPC), and as such will be read differently from opaque languages like English and French, where most of the words follow ambiguous GPC (Ziegler et al., 2001; Seymour et al., 2003, Joshi et al., 2012). Transparency of a script has much wider implication. Rodriguez et al., 2016 observed that a differential reading strategy, one that is indexed by eye movements, happens with respect to the opacity of the language. That is, when a bilingual reads in his/her L1, and if that L1 is transparent, then the bilinguals tend to use local and a serial reading strategy. On the other hand, if the L1 is opaque, then the reading strategy becomes parallel and will rely more on the lexical route. Therefore, apart from the complexity of the script (in this case, representation at two levels), the other factor that influences the reading strategy is the opaqueness of the script. The development of reading ability strongly correlates with the phonological awareness that a language exposes a learner to. That is, languages differ in their extent to which phonological units are represented in their orthography. This can also lead to developmental differences in the grain size of the letter/character/aksara. Such difference can leave marks in the lexicon of the adult. Therefore, the lexical organization and the processing strategies of a skilled reading in orthographies can be affected by the many developmental constraints imposed by the writing system of that language (Ziegler & Goswami, 2005). Ziegler and Goswami, 2005; enumerate three problems that beginning readers are faced with when trying to learn. The first is the availability problem. That is, not all the phonological units are explicitly available for the reader prior to reading (like the problem with the inherent vowel, detailed in chapter 1, Introduction). So, the reader needs further cognitive development to decipher this. The second is the consistency problem. This means, sometimes orthographic units have more than one pronunciation as in ‘c’ in cat and chap. In this case, the learner does not have to learn an additional sound that may be applicable in specific situation, but faces an additional burden of having to identify where and how a particular has to be used. The third is the granularity problem which state that there might be more number of words than syllables, more syllables than rimes etc. Nag also points out how pace of learning and classroom instruction can have implications on awareness to the global and local reading strategy. That is, when an aksara is taught through explicitly bringing attention to the phonemic markers, the major aksara set is learned by the end of the first two years (Nag & Sircar, 2008). That is to say, when each aksara is taught to be seen as an undifferentiated block, and if the learner is forced to learn every block anew, then the development or mastery of the set will be slow. However, if in the aksaras, the commonalities are abstracted (such as the positioning of primary and secondary vowels, the rules of ligature etc.), then the learner only has to focus on the segmental details within the syllable for further learning. This way, any new aksara learning will be faster and the learner does not have to depend on his/her rote memory. Together with this, the level of knowledge of a sound unit will determine which approach can be reliable. That is, a global approach will be used when the aksara is mastered. The analytic approach happens when the aksara is unfamiliar and also when it is new. Given that the alphasyllabic symbol set is extensive, there is a greater need for both the global and analytical approach even if the reader is matured and skilled. In the current thesis, it was found that reading strategy is largely shaped by reading experience, the task that has to be performed and the availability and the unit of representation in question. The general findings of the research is as follows;

- the global and local processing is dependant on the unit of sound representation and task demands also determines whether the reader will adopt an analytical or global approach,
- no consensus can be arrived with respect to understanding if the reader process the phoneme first or syllable first. In a script that makes use of both for representing sound, is likely to use both depending on the task,
- processing strategy of first language is likely to be passed on to while reading a second language. This is true of cross-scriptal and within the same language family,
- proficiency of a speaker could be one factor that will affect the identification efficiency of an aksara. A better perception strategy emerges with an increase in the reading experience.

5.1.2 Two schools of thought. Given that alphasyllabic scripts have properties of both syllables and phonemes, the following experiment tries to address the question 'is phoneme or syllable the basic unit of perception'. This question has raised debates among scholars. However, no attempt has been made to understand this from a language that has two levels; phoneme and syllable.

Studies from English and other Roman script have differing results. A simple and one of the information processing model of speech (see for example McNeil & Lindig, 1973, for a discussion of this model) opines that the phonemic level is the most basic and that phonemes are indeed the perceptual units of speech. According to this model, speech is seen to be processed by entering the language in a hierarchical fashion, starting from the bottom and then proceeding upwards into the hierarchy (Miller, 1962). That means, we initially recognize phonemes and then, using the information, analyse the next higher level entity (linguistic) which is a syllable, the words and so on. Savin and Bever (1970) however rejected this model through an experiment they conducted, where participants were faster to respond to syllable targets than to the phoneme targets. In this, they searched a list of syllables. With this, they concluded that phonemes are recognized only after recognizing syllables. Alternatively, they stated that the unit of perception is higher than that of a phoneme. Savin and Bever concluded that the perceivers of speech enter into the linguistic hierarchy at one level above the phoneme and it is only from this higher level that a further decomposition happens. In another experiment by Healy and Cutting, it was reported that participants listened to list that had both syllables and phonemes. Unlike the study by Savin and Bever, in this study, two experiments were conducted where in the first experiment, participants listened to targets that would match the linguistic level (phoneme or syllable). In this, it was found that when the targets matched the linguistic level, the response was faster than when the targets and linguistic level was mismatched. In the second experiment, when the targets and response items matched at the linguistic level, phonemes were seen to be recognized faster than that of the syllables, when phonemes were easier to identify. On the other hand, when phonemes were harder to identify, the reverse happened; suggesting that both the phonemes and syllables are necessary for speech perception.

Sonali Nag argued that understanding the syllabic and phonological unit is a prerequisite to learning Indian languages, and therefore readers of alphasyllabic scripts have a dual mode of processing. Typically, an aksara is taught in a staged fashion. It first begins with the inherent vowels (Ca), which is learnt first, followed by the aksara with other vowel markers (CV) and finally the cluster aksara (CCV). This is the ideal and is often the way in which the aksara is taught to children. Instead, what happens is that, children are hardly taught this way.

They begin to master high frequency aksara earlier than low frequency aksara. For example, in Kannada, the CCV structure of aksara is taught like, /kka/ and /mma/ are seen in the textbook in words like akka ‘sister’, amma ‘mother’, nimma ‘your’ etc. and with such an exposure, children are seen to learn these aksara form (CCV) together with inherent vowel aksara. Therefore, there is exposure to both phoneme and syllable starting from a very young age. However a complete awareness happens only with greater literacy.

5.2 Methodology, Reaction Time Experimentation and limitation

All the experiments of the current thesis were carried through reaction time experiment methodology. Experiments were conducted on Pavlovia and Testable, two online software for behavioural experiments. A link for the experiment was sent to all the volunteers of the study. Before the start of all the experiments, a consent form was also displayed where they had to manually click on ‘I agree’ before the link can take them to the main task. Participants were also free to exit the experiment at any point, for any reason. The questionnaire data was ascertained via email and they were free to either identify themselves or leave their ‘name’ column blank.

Reaction Time as an experimental procedure was used because it allows us to study the system while it is properly functioning. That is, the participant is actively performing the task. This is in contrast to some traditional methods such as memory experiments where the system can be understood only through failures or when other issues such as overloading happens (Sternberg, 2010). Reaction Time experiments also facilitate the understanding of the temporal organization of the mental process involved in the task. It is a good indicator to understand the parallel or serial processing that is likely to happen, as in the case of Experiment 2, where the rational was to understand the order of global and local processing. Also, the time that is taken to initiate a response is also an indicator of the underlying process, even if the wrong response is chosen. That is, we are more interested in a specific mental process, such as how a participant takes a decision about a particular aksara presented in a set size and orientation. The RT therefore will reflect the time taken of the mental process. Experimental factors can change RT, that is, the effects that the factors generate and these combine is evident through RT experiments (Sternberg, 2010). Despite these, the problems with RT experiments is that RT is seen to decrease with practice. The participants become extremely adjusted to respond quickly, sometimes this comes with a cost; speed and accuracy trade off.

The studies' limitation is that, the study may have needed more focussed equipment, such as an eye-tracker, especially when having to understand something as small as an aksara. An eye- tracker would have been a better equipment to gauge the eye movement and to understand the exact nature of processing an aksara. Secondly, the pandemic curbed the usage of any equipment (other than online behavioural software) and as such an online experimentation could only make use of smaller experimental set up to set things running smooth.

5.2.1 Neuroimaging studies in Letter processing. Given over a lifetime experience of recognizing, learning and reading letters, it is normal to expect the implications of such an experience in the visual system and the brain (James, W. James et al., 2005). Quite surprisingly there is also evidence for this; albeit limited.

The neural response to letters have been tested by researchers who have agreed through behavioural studies that a distributed network is often seen when humans interact with letters. Letters also seem to involve a disparate processing area (James & Gauthier, 2006). Much like how looking at ball would activate motor programs such as kicking or throwing, perception of such an object can trigger interaction in the sensory-motor systems, leading to a distributed representation in the brain. In this case, letters are an interesting case that will help study the questions of how the sensory-motor system works. Letters though will not elicit an action the way seeing a ball will. The form of the letter has nothing to that suggests how our brain or sensory-motor system should interact with it. A large body of research is often carried out in understanding the neural activity involved when reading a word. Apart from the dorsal posterior system, some more cortical areas in the brain is involved in the process of reading a word; such as left interior frontal lobe and posterior superior temporal sulcus (Bookheimer, 2002, Gabrieli, Poldrack & Desmond, 1998) and the right hemisphere structures (Kircher, Brammer, Tous, Willaims & McGuire, 2001). However, the region that has been the highlight for early visual processing is the left fusiform gyrus (Cohen et al., 2000; McCandliss, Cohen, & Dehaene, 2003; Polk et al., 2002). In contrast to such a huge body of research in word reading, there is relatively less work about single letters. Letters, although initially are learnt in isolation, they are frequently seen in word context. Evidences are present today to show that neural specialisation of letters is still retained. For instance, upon repeated presentation of letters, the lateral occipital region is seen to adapt. But this adaptation is not seen upon repeated presentation of faces (Gauthier, 2000). There were three fMRI studies conducted, where a comparison of letters to objects or symbols were made. One study showed an activation trend for a letter-specific area in the brain, in the left fusiform gyrus (Joseph, Gathers, & Piper, 2003). In the second study, it was found that there was an activation in the middle occipital gyrus when participants processed letters, in comparison to when they were attending symbols or the colour of the stimuli (Flowers et.al, 2004). The third fMRI study showed that there were letter sensitive regions in the precentral gyrus along with the medial occipital region and left fusiform (Longcamp, Anton, Roth, & Velay, 2003). Simply passive viewing of the letters also elicited an activation at the ventral temporal regions (Gros et. al, 2001, Polk et.al, 2002). One study found that the left fusiform activation happens when the task to the participant involves letter categorization is involved (Pernet, Celsis & Demonet, 2005). These studies show that the left fusiform region of the brain is involved in an explicit and top-down letter processing (Pernet et al., 2005) and a selective activation is observed only when the letter processing task is intentional, such as passive viewing. Letters are also a classic example of where perceptual expertise lead to specialized visual areas (Flowers et al., 2004, James et al., 2005, Joseph et al., 2003, Longcamp et al., 2003).

Thus, there are reasons to believe that letter processing may be elicit a differential processing strategy from that of faces and digits. While the studies provide an account of letter processing from a neural point of view, the current thesis helps understand the properties at a more elevated level; perceptual and mental processing.

Besides these, a writing system is also under selective pressure to be able to be easily read and written (Changizi et al., 2005). As noted earlier, alphasyllabic scripts, with particular reference to Malayalam, shows that there are aksaras that tend to look similar to one another. While it is highly possible that such overlapping similarities can inhibit accurate recognition or confuse the learner when trying to learn; another positive way to think about this is to understand that such redundancy is necessary, so that a misrecognition of the present one or two strokes, do not alter the recognition of the aksara in itself. Additionally Changizi observed that the number of strokes in any given symbol is approximately three. Also, that symbols are usually 50% redundant; suggesting that the symbol can be acutely identified even when half of the strokes are removed from it (Changizi et al., 2005).

5.3 Future work

Future work in the area will be needed, which uses aksara to understand how underlying similarities (in terms of strokes, angles etc.) among alphasyllabic script can promote easier learning in a classroom set up. Also, the study has not made an attempt to define complexity in the context of an aksara. Given that linguistics has no clear operational definition for complexity, it would be a good idea to understand what exactly complexity is and how this as a factor may have implications on reading. Exploring the continual usage of multiple languages and how this may have an effect on cognition, will add to overall knowledge.

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Appendix A: Sample Consent form

Subject ID:

Center for Neural and Cognitive Sciences

University of Hyderabad

CONSENT FORM

Title of the project: Processing of syllable under reading like conditions

The purpose of this experiment: To examine how letters are processed and if they differ from the processing strategies from a phoneme and a syllable. The experiment procedure is completely harmless. This study is for research purposes only and may not be directly beneficial to you. The results from the research will not be shared with you.

Procedure: Participant will be asked to read the compound stimuli presented on a screen. The compound stimuli may match at the global and local level or may be a mismatch. In each of the four blocks of the experiment, the participant has to focus first on the global level, then the local level (for Malayalam) and similarly for English. Answers have to be indicated via key press. The reaction time will be recorded for further analysis.

- Participation in the study is completely voluntary. You can withdraw from the experiment whenever you want.
- Data will be kept confidential and Subject's identity will be protected.
- Subject's participation will take approximately 10 minutes.
- If you are still interested in participating and assisting with this research project, please complete the consent form below. Keep the top of this form for future reference. You can contact me at 7382458382 if you have questions, comments or concerns now or in the future about your participation in this study.

Thank you very much for your time and consideration.

Signature of the researcher

____

I give my consent for the participation in the study conducted by Sreerakuvandana and Dr. Ramesh Kumar Mishra.

I understand that:

- My data will be used for research
- My participation is voluntary.
- My information will be kept confidential.

I have read the information above and any questions I asked have been answered to my satisfaction. I give consent for my participation in this study.

Appendix B: Language Questionnaire

Appendix F: Language Questionnaire

1. Name:
2. Email address:
3. Mobile:
4. Date:
5. Age:
6. Sex
   - ☐ Male
   - ☐ Female
   - ☐ Other:

7. What is the highest degree of education you have obtained?
   - ☐ Bachelor
   - ☐ Master
   - ☐ PhD

8. Are you pursuing any degree now? If yes, please select the degree.
   - ☐ Bachelor
   - ☐ Master
   - ☐ PhD
   - ☐ Not any

9. Birth Place:
10. Native language/Mother tongue (L1):
11. Name the third language you learnt (L3):
12. Please list all the language you know in the order of dominance:

13. What languages do you usually speak at home?

14. Write down the language in which you received instructions at each level of education:
    Primary school (1 to 5):
    Secondary school/ High school (6 to 10):
    Intermediate school (11 to 12):
    College/University:

15. Age at which you:

(Age details of L1)

Began acquitting L1:

Began speaking fluently in L1:
Began reading L1:

16. Please rate your proficiency in L1 on a scale of 1-10 (10 being the highest) in:
Speaking:
Understanding spoken language:
Reading

17. Age at which you:

(Age details of L2- English)

Began acquiring English:
Began speaking fluently in English:
Began reading English:

18. Please rate your level of proficiency in English on a scale of 1-10 (10 being the highest) in:
Speaking:
Understanding spoken language:
Reading:

19. Age at which you:

(Age details of L3)

Began acquitting L3:
Began speaking fluently in L3:
Began reading L3:

20. Please rate your level of proficiency in L3 on a scale of 1-10 (10 being the highest) in:
Speaking:
Understanding spoken language:
Reading:

21. Onset age of bilingual usage:

(At what age do you think you started talking in both languages for communication?)

22. In this section, you have to respond to the statements about language attitude by giving mark from 1 to 6.

a) I feel like myself when I speak in my native language

	1	2	3	4	5	6	
Agree	○	○	○	○	○	○	Disagree

b)I feel like myself when I speak in English

	1	2	3	4	5	6	
Agree	○	○	○	○	○	○	Disagree

c) I prefer speaking in my native language most of the time

	1	2	3	4	5	6	
Agree	◯	◯	◯	◯	◯	◯	Disagree

d) I prefer speaking in English most of the time

	1	2	3	4	5	6	
Agree	◯	◯	◯	◯	◯	◯	Disagree

e) I prefer listening to my native language most of the time

	1	2	3	4	5	6	
Agree	◯	◯	◯	◯	◯	◯	Disagree

f) I prefer listening to English most of the time

	1	2	3	4	5	6	
Agree	◯	◯	◯	◯	◯	◯	Disagree

g) I prefer reading in my native language most of the time

	1	2	3	4	5	6	
Agree	◯	◯	◯	◯	◯	◯	Disagree

h) I prefer reading in English most of the time

	1	2	3	4	5	6	
Agree	◯	◯	◯	◯	◯	◯	Disagree

i) I prefer writing in my native language most of the time

	1	2	3	4	5	6	
Agree	◯	◯	◯	◯	◯	◯	Disagree

j) I prefer writing in English most of the time

	1	2	3	4	5	6	
Agree	◯	◯	◯	◯	◯	◯	Disagree

23. When doing math in your head (such as multiplying 243*5), which language do you calculate the numbers in?

☐ Native language

☐ English

24. If you had to choose one language for the rest of your life, which language would it be?

☐ Native language

☐ English

☐ Can't day

25. Please indicate if you are a day scholar.

- ☐ Yes
- ☐ No

26. Answer the following questions by giving mark on a scale of 1 to 7.
a) How often are you in a situation in which you switch between the languages – your native language and English?

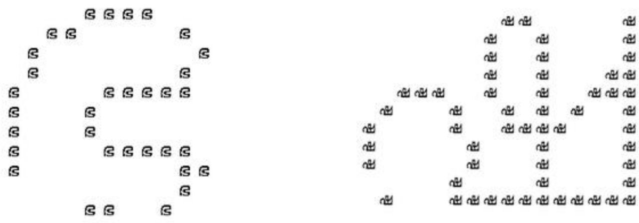
	1	2	3	4	5	6	7	
Never	○	○	○	○	○	○	○	Very often

b) When choosing a language to speak with a person who is equally fluent in all your languages, how often would you switch between languages?

	1	2	3	4	5	6	7	
Never	○	○	○	○	○	○	○	Very often

27. Please list what percentage of the time you are currently, on average, using each language (your percentages should add up to 100)
a) Native language:
b) English:
c) Other (if any) :

Appendix C: Compound stimuli in Malayalam (Phoneme)



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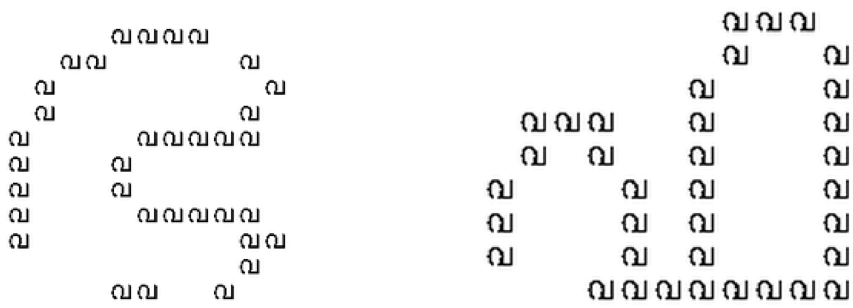

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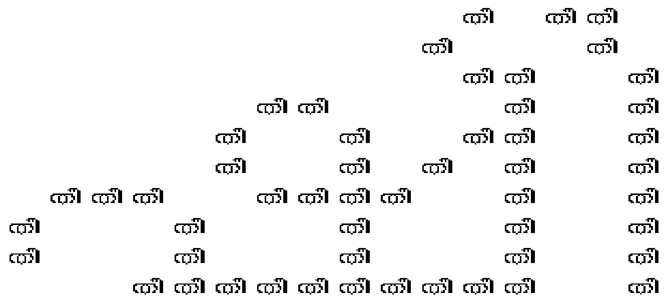
Appendix D: Compound Stimuli in Malayalam (Syllable)



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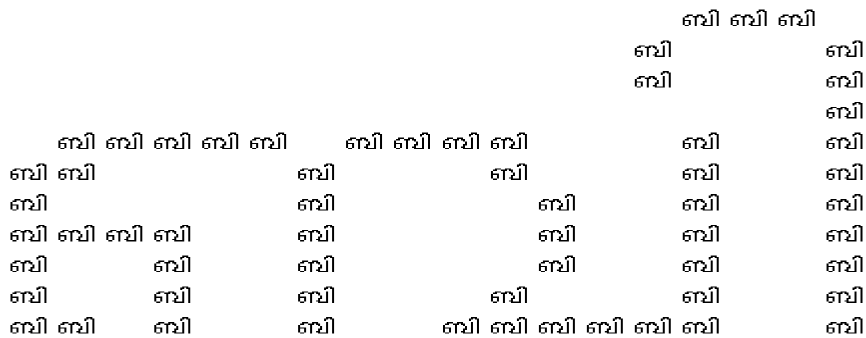

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