Phonological Processing in Bilinguals

Register Number: 05SLP015

A dissertation submitted in part fulfillment for the degree of

Master of Science (Speech Language Pathology)

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ALL INDIA INSTITUTE OF SPEECH & HEARING

NAIMISHAM CAMPUS, MANSAGANGOTHRI

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MOTHER

From seeds
You watered us.

As we sprouted
You helped us grow
With the warmth
Of your radiant love.

Along the way
You trimmed us
To keep us safe
From Harm:

When we grew out of
Our little pods,
You replanted us,
Where you gave us hope
And showed us faith
That we may be able
To do for others
As you did for us.

This work of mine is dedicated to
My ever dearest Amma

CERTIFICATE

This is to certify that this dissertation entitled " **Phonological Processing in Bilinguals"** is a bonafide work in part fulfillment for the degree of Master of Science (Speech Language Pathology) of the student with Registration no. 05SLP015. This has been carried under the guidance of a faculty of this institute and has not been submitted earlier to any other university for the award of any diploma or degree.

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CERTIFICATE

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DECLARATION

This is to certify that this Master's dissertation entitled **"Phonological Processing in Bilinguals"** is the result of my own study and has not been submitted earlier to any other university for the award of any degree or diploma.

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Chapter 1

Introduction

Language acquisition is the process by which a human being develops the language capability. During this process, infants begin to map words onto objects in the world, for which they determine sequences of sounds that form words. They uncover some of the units that belong to their native language from a largely continuous stream of sounds in order to map them onto words. Despite the difficulty of this reverse-engineering problem, infants successfully segment words from fluent speech from approximately 7 months of age.

How do infants learn the units of their native language so rapidly? One fruitful approach to answer this question has been to present infants with miniature artificial languages that embody specific aspects of natural language structure. Once an infant has been familiarized with a sample of this language, a new sample, or a sample from a different language, is presented to the infant. Subtle measures of surprise (e.g., duration of looking toward the new sounds) are then used to assess whether the infant perceives the new sample as same, or different. In this fashion, we can find what the infant extracted from the language exposed to, which can lead to insights regarding the learning mechanisms underlying the earliest stages of language acquisition.

Discovering the words of a language, and their meaning, is only the first step in the process of language acquisition. Further children also discover how the distribution of these elements, including grammatical endings *(s, -ed, -ing)* and function words *{of, to, the)* convey the further combinatorial meaning of an utterance.

That is, children implicitly discover and use the grammar of their language to determine 'who-did-what-to-whom' in each sentence. This applies even for simple sentences like *Mommy gave Daddy the milk* as opposed to *Daddy gave Mommy the milk.* The parsing process is therefore an essential component of the language comprehension device, because it allows children to assemble strings of elements in such a way as to compute crucial, and even novel, relational conceptions of the world.

These examples of language learning, processing, and creation represent just a few of the many developments between birth and linguistic maturity. During this period, children discover the raw materials in the sounds (or gestures) of their language, learn how they are assembled into longer strings, and map these combinations onto meaning. These speech perceptual processes unfold simultaneously, requiring children to integrate their capacities as they learn to crack the code of communication that surrounds them.

Despite layers of complexity, young children readily solve the linguistic puzzles facing them, even surpassing their input when it lacks the expected structure, by means of speech processing at different levels. These levels are considered as two major processes in the present study. The first one is at the level of syllables and phonemes of the language, considered as the *macro level of phonological processing.* The second being at the sub-levels of phonemes or the *micro level of phonological processing* i.e., the spectral and temporal characteristics of the phonemes like, the Fundamental Frequency (FF), Voice Onset Time (VOT), Closure Duration (CD), etc. The macro level of phonological processing has been widely studied using the different syllable level and phoneme level tasks like syllable segmentation, syllable oddity, etc. However, there has been a dearth of studies in the area of micro level phonological processing, specifically in Indian languages.

Earlier research studies have considered the macro level phonological processing as a language dependant measure while the micro level speech processing is generally treated as language independent. However, recent studies indicate that the micro level processes such as VOT and CD are also language dependant. So it becomes important to study these processes individually in all the languages and also its interaction with the macro level processes.

It is also interesting to study the above processes in those who are exposed to more than one language simultaneously. A significant number in the world are bilinguals and many are instructed in a language they do not speak at home, and they are expected to acquire skills in two languages. They should be able to function at the same level as the native speakers and get identified with both language groups. The linguistic representation in bilingual individual's brain and the cognitive-linguistic processing are extensively investigated in the literature. The past literature reveals multifold differences in cognitive-linguistic processing between monolinguals and bilinguals. However, the studies in speech perception and the processes underlying it in bilinguals are scanty.

How a native language affects the second language perception and in turn gets affected by the nature of the second language are important for understanding the phenomenon of second language acquisition. In the Indian scenario it is not only the bilingualism that is of concern, but the interplay of more than two languages also comes to the scene. Therefore it is important to understand the influence of to different language backgrounds on Indian children learning different languages. The study also highlights on certain crucial factors that need to be considered while screening bilingual children for reading and writing abilities and also during the assessment of speech language disorders.

The objectives of the present study are twofold. It aims to examine the nature of phonological processing in Malayalam-English and Kannada-English biltnguals using the micro level measures like VOT and CD continua and macro level measures like phoneme segmentation and phoneme oddity tasks. It also examines the phonological proximity of the two Indian languages Malayalam (phoneme-rich) and Kannada (semi-syllabic) to English (alphabetic-which is widely used as the common language in India).

Chapter 2

Review of literature

Researchers are assembling a variety of methodologies to uncover the mechanisms underlying language acquisition. Months before infants utter their first word their early language-learning mechanisms can be examined by recording subtle responses to new combinations of sounds. Once children begin to link words together, experiments using real-time measures of language processing can reveal the ways linguistic and nonlinguistic information are integrated during listening. Natural experiments in which children are faced with minimal language exposure can reveal the extent of inborn language-learning capacities and their effect on language creation and change. As these techniques and others probing the child's mind are developed and their findings integrated, they will reveal the child's solution to the puzzle of learning a language.

Saffran and colleagues (2001) have examined the powerful role that statistical learning (i.e., the detection of consistent patterns of sounds) plays in infant word segmentation. Syllables that are part of the same word tend to follow one another predictably, whereas syllables that span word boundaries do not. In a series of experiments, they found that infants can detect and use the statistical properties of syllable co-occurrence to segment novel words. More specifically, infants do not detect merely how frequently syllable pairs occur, but rather the probabilities with which one syllable predicts another. Thus, infants may find word boundaries by detecting syllable pairs with low transitional probabilities. What makes this finding astonishing is that infants as young as 8 months begin to perform these computations with as little as two minutes of exposure. By soaking up the statistical regularities of seemingly meaningless acoustic events, infants are able to rapidly structure linguistic input into relevant and ultimately meaningful units. Such significant developments in infants are facilitated by their perceptual skills.

A. Development of Speech Perception

Speech perception is the process of imposing a meaningful perceptual experience on an otherwise meaningless speech input. The empirical and theoretical investigation of speech perception has blossomed into an active interdisciplinary endeavor, including the fields of psychophysics, neurophysiology, sensory perception, psycholinguistics, linguistics, artificial intelligence, and sociolinguistics.

Since the early 1970s researchers have been studying speech perception, partly in an attempt to determine if there is evidence for a specialized phonetic mode of processing among infants. In a neo-classic study, Eimas, Siqueland, Jusczyk, and Vigorito (1971) demonstrated that English-learning infants aged 1 to 4 months show far better discrimination along a synthetic voice onset time (VOT) continuum for two stimuli that straddle the adult/ba/-/pa/phonetic category boundary than they do for two equally acoustically distinct stimuli from within the same phonetic category. This differential discrimination at some, rather than other, points along a single synthetic continuum indicates that speech perception may be "categorical" in infants. This finding has now been replicated many times with infants using several other distinctions (Aslin, 1987; Kuhl, 1987). More recent research indicates that infants form categories across a variety of acoustic contexts (Miller & Eimas, 1983). For example, Kuhl and her colleagues (Kuhl, 1979, 1983) have shown that infants can categorize stimuli according to vowel color across discriminably different variations in speaker and pitch contour. Similar phonetic perceptual constancy has been shown for consonants (Hillenbrand, 1983; Kuhl, 1985).

In spite of disagreements over the specificity of the processing mechanism, there seems to be little agreement that when young infants are presented with speech and speech-like stimuli, they show enhanced discriminability at adult phonetic category boundaries. Such performance is clearly "phonetically relevant" even though it does not specify whether the infant is using a phonetic or an auditory mode of analysis. That is, an infant could show phonetically relevant perception because of discontinuities in auditory sensitivities or because of a specialized phonetic processor. Such perceptual biases can be seen to be advantageous to the infant in the eventual task of language learning. It is for this reason that it is important to document the extent to which speech perception is phonetically relevant in young infants and children. The hypothesis that infant speech perception is phonetically relevant is consistent with countless studies on English-learning children listening to English speech stimuli, while in cross-language research this is further examined using the VOT continuum.

B. Characteristics of Speech Sounds

Perception of speech in infants depends on many factors among which the characteristics of speech sounds play a major role. Speech sounds are varied and have numerous acoustic cues like the formants, their bandwidths and levels, fundamental frequency (FO), preceding vowel duration (PVD), burst energy, Voice Onset Time(VOT), Closure Duration (CD), energy, etc. It appears that the auditory system depends on some of the acoustic cues of the speech sounds to identify and thus to perceive it. Among the variety of speech sounds, Stops appear to be the most highly encoded (Day & Vigorito, 1973) and they are the information bearing elements of speech. Stops are the only kinds of consonants that exist in all languages. Stop consonants are produced by occluding the oral cavity by an articulator and releasing the air stream after air pressure is built. Acoustically, stop consonants have five distinct phases which are as follows:

1. A period of occlusion (silence/voiced).
2. A transient explosion, usually less than 20milliseconds (ms) produced by shock excitation of the vocal tract upon release of occlusion.
3. A very brief (0-10ms) period of frication as articulators separate and air is blown through a narrow constriction as in the homorganic fricative.
4. A very brief period of aspiration (2-20ms) in which may be detected noise excited formant transitions reflecting shifts in the vocal tract resonance, as the main body of the tongue moves towards the position appropriate for the following vowel.
5. Voiced formant transitions, reflecting the final stages of the articulatory movement into the vowel during the first few cycles of laryngeal vibration.

Stops are perceived on the basis of numerous acoustic cues that are intertwined with the acoustic cues for the vowels and consonants surrounding the phoneme. They can be classified on the basis of voicing, place and aspiration. The parameters cueing voicing differ depending on the position of plosives in a language.

a) *VOT as a cue*

In the word-initial position, both the VOT and the F1 transition cue voicing. Voice Onset Time (VOT) is the time difference between the onset of articulatory release and the onset of voicing (Figure 1) and is considered a major cue for differentiation of prevocalic stops along the voicing dimension (Lisker & Abramson, 1964; Abramson & Lisker, 1965).

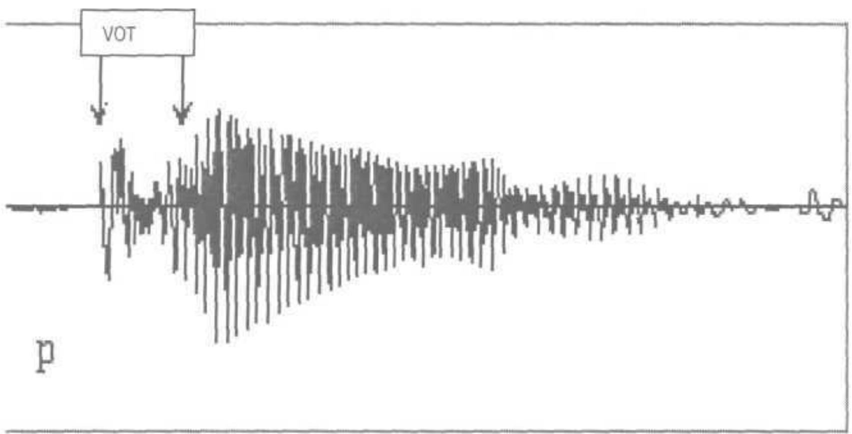

Figure 1: Voice Onset Time for |p|

The differences in VOT have been termed lead vs. short lag for voiced and unvoiced (Figure 2), respectively (Lisker & Abramson, 1964; Keating, Mikos & Ganong,1981). Across languages, Lisker & Abramson (1964, 1967), indicated a fairlyconsistent 60 ms minimum difference in VOT between voiced and unvoiced stops.

Figure 2: Lag VOT for |p| and Lead VOT for |b|

Data from studies with synthetic speech have suggested that the acoustic characteristics providing the simplest and the most direct indication of whether a stop consonant is voiced or unvoiced is VOT. Voiced stops have a well defined transition in the first formant of the following vowel, while Fl transition of unvoiced plosives is essentially non-existent after the onset of voicing (Sussman & Carney, 1989). This lack of formant transitions after voicing onset for the stops indicates that the rapid movements of the supraglottal articulators are essentially complete before the vocal cords are in configuration for the onset of voicing. Based on synthesis experiments, it is known that the duration of these transitions is in the order of 40ms or less. While the exact implementation of VOT for the voicing contrast differs among languages, long lag VOTs, with a long delay between release and onset of laryngeal vibration, generally signal a voiceless stop. Short lag VOTs, with a short delay between release and onset of laryngeal vibration, signal a voiced stop.

In English, Voiceless stops /ptk/ have a substantial delay between the release and the onset of laryngeal vibration, resulting in a VOT of 30ms or longer, corresponding to the aspiration interval. English voiced stops /bd / in utterance-initial position are generally not pre-voiced but released simultaneously with the onset of voicing, for a VOT of approximately zero (Caisse, 1982; Docherty, 1992).

Early work in speech perception has verified the role of VOT in the perception of voicing in utterance-initial position for speakers of English and other languages (Liberman et al., 1958; Lisker and Abramson, 1970). In these studies, listeners have been found to classify stops as voiced or voiceless depending on the VOT value, consistent with the observed VOTs of voiced and voiceless stops for the appropriate language. Stops with values longer than some boundary value are classified as voiceless, while stops with VOTs shorter than the boundary value are classified as voiced.

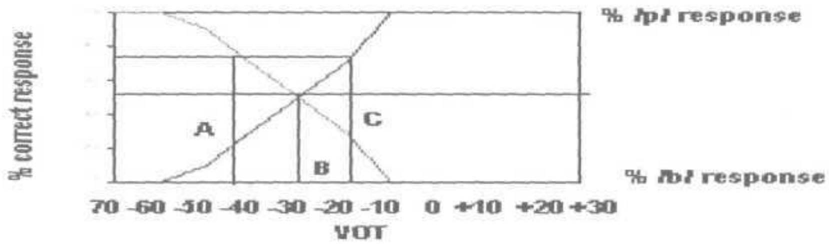

Figure 3: 50% Cross Over for |b-p| responses

The 50% crossover (Figure 3) is that point on the acoustic cue continuum for which 50% of the subject's response corresponds to the voiced/unvoiced category. The50% crossover scores for VOT in English and Spanish is 36.2ms and 19.9ms respectively (Fledge & Eefting, 1986). Some of the studies carried out in various other languages have been summarized in the Table 1.

Author	**Year**	**Language**	50% CO in ms
Yeni-Komshian et al	1967	English	35
Lisker and Abramson	1967	Thai	-20
Simon	1974	English	15-20
Zlatin and Koenigsknecht	1975	English	35
Williams	1977	English and Spanish	+25 and -4
Williams	1980	English	>15
Fledge and Eefting	1986	English and Spanish	36.2 and 19.9
Savithrietal 1995	1995	Kannada	-16.8
Sathya Krishnamurthy	1995	Telugu	-19.5

Table 1: Studies of VOT in different languages

b) *Closure Duration (CD) as a* *cue*

CD is the interval of stop closure indicating the time for which the articulators are held in position for a stop consonant. In adults CD has been found to cue voicing, place and manner of articulation. Also, it has been found to trade with spectral cues. CD is reported as longer for voiceless stops and shorter for voiced stops (Lisker, 1957). Findings indicate that the way in which CD functions as cue for voicing varies as a function of syllable and stress context. Much evidence exists to show that /p/ is produced with longer closure than /b/ (Figure 4), when they occur in words like 'rabid' and 'rapid'. If /b/ closures are silenced and lengthened, listeners tend to report /p/.

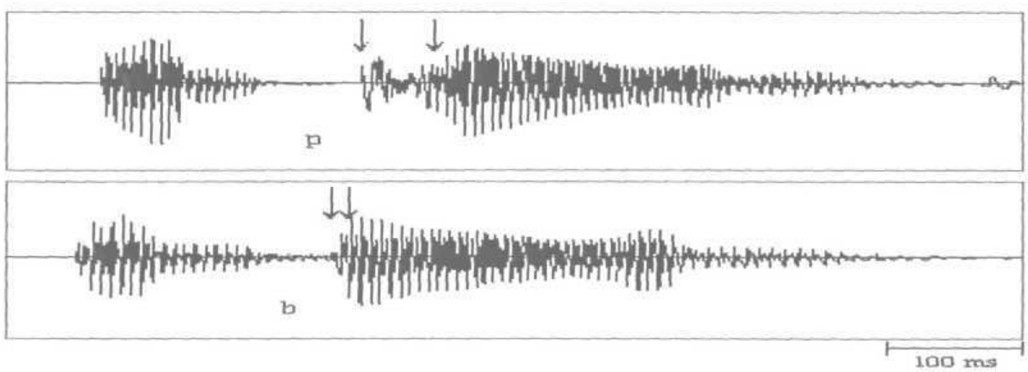

Figure 4: Long vs. Short Closure Duration

There is the temptation to draw from this the generalization that closure duration (CD) serves to distinguish /ptk/ from /bdg/, i.e., CD is a cue to voicing. There is a context, however, in which the manipulation of closure duration has a rather different phonetic outcome; where in fact a longer duration is reported as /d/ and a shorter as /t/. The word pair *center-sender,* where the medial consonants are described for many varieties of American English as a nasalized flap in the one case and as a sequence of nasal plus stop in the other, is such a context: shortening the oral *voiced* closure of *sender* yields *center* when the closure is reduced to 40ms or less. The evidence that closure duration is a cue to the voicing of medial stops in English words is as convincing as any we have for other acoustic features considered to be factors governing the linguistic interpretation of speech signals. Measurements of natural speech show /b/ closures to be regularly shorter than /p/ closures in words such as *rabid rapid*, and there are experimental data to indicate that this difference has perceptual/phonetic significance (Lisker and Price, 1979). Though there are a number of studies that have realized the importance of closure duration as an important cue to voicing in adults, in children this has been dealt in single and multiple cue condition (Sathya, 1995). Port (1979) has been reported it to trade with spectral cues. While Lisker (1978) studies it as a cue for voicing, Repp (1984) showed its importance in perception of place.

In most of the speech perception studies speech sounds are reconstructed from their known spectral and temporal parameters and presented to the listeners for judgment. Normal adults, typically of college age, are the most frequently studied subjects in speech perception research. The next most frequently studied group is the preverbal infant group. Relatively little research involve children between approximately 2 and 12 years of age (Goodman, Lee and DeGroot, 1994). The reasons for this distribution of research efforts are quite straight forward. Research involving adults provides information about the mature perceptual system, while the studies on Infants provide insights into its substrates. The period of childhood appears to offer less valuable information. It might be reasoned that since children use language, their perception must closely approximate adults. At the same time, work with young children is difficult. Task variables such as cognition, motivation and attention affect the studies (Goodman, Lee and deGroot, 1994). The researches that have involved children indicate that speech perception does undergo a developmental change during the period of language acquisition and continues to develop during the subsequent years of childhood, the end result being development of macro phonological units (Yeni-Komshian and Ferguson, 1980).

C. Development of Child Phonology

The focus of research is shifted from mere speech perception to the study of child phonology. Interest in child phonology comes from several sources such as general interest in child development, professional concern with language and speech problems requiring speech therapy or linguistic speculations about the relationship between phonological development in the child and the sound changes in a language. Child phonology also encounters the influence of native and non-native contrasts, issues of bilingualism and the phonological organization in the languages they are exposed to. All these make the study of child phonology an interesting area.

The study of child phonology also presents methodological problems more severe than the study of adult phonology. Children are harder subjects to deal with (Yeni-Komshian and Ferguson, 1980). Also the differences in the task demands between infants and children (identification for children and discrimination for infants) results in an apparent lack of correspondences between infants' and children's perception. For example, it has been reported that 2-3 year olds are not consistent in identifying voicing differences in stop consonants (Garnica, 1973; Zlatin and Koenigsknecht, 1975) whereas infants are able to discriminate similar distinctions (Yeni-Komshian and Ferguson, 1980).

A related problem is the nature of phonemic perception in children that is, does the child respond differently to a given phonetic contrast when the contrast is being tested by the use of known words, non words in comparison to the use of fine-grained acoustic stimuli. Presently an answer to this question is partially available in results of phonological awareness skills in children.

D. Phonological Awareness in Children

The term phonological awareness refers to a general appreciation of the sounds of speech as distinct from their meaning. When that insight includes an understanding that words can be divided into a sequence of phonemes, this finer-grained sensitivity is termed phonemic awareness. (Snow, Burns, & Griffin, 1998).

Listening to and understanding speech involves identifying the individual sounds (phonemes) that make up words. While phonological processing may be defined as the series of processes involved in identification of the sounds and subsequently the words that these sounds make, that of phonological awareness is generally referred to as the ability to attend to the phonological or sound structure of a language as distinct from its meaning. Children need to be aware of the relevant units in spoken language before they learn literacy skills where they understand how orthography represents spoken language. Such awareness evolves at different *macro and micro levels* which include word awareness, rhyme awareness, phonemic awareness, and awareness to the distinctions in the phonemic features, generally called as saliency features within the phonemes. Mastering phonological awareness skill will help children master both phonics and reading (Calfee and Norman, 1998; Chard and Dickson, 1999). This skill includes a child's awareness of phonological units such as words, syllables, onset-rimes and phonemes. More specifically it refers to the ability to store, access, retrieve, and manipulate phonological representations. Phonological awareness can be further grouped into different types:

a) Syllabic awareness: Awareness of the syllabic structure of words, for example, in English, 'Cat' has one syllable, 'hap-py' two, and 'but-ter-fly' three syllables;

b) Phonemic awareness: Awareness of phonemes, or the constituent sounds of a word, for example, 'seat' has three phonemes /s-i:-t/.

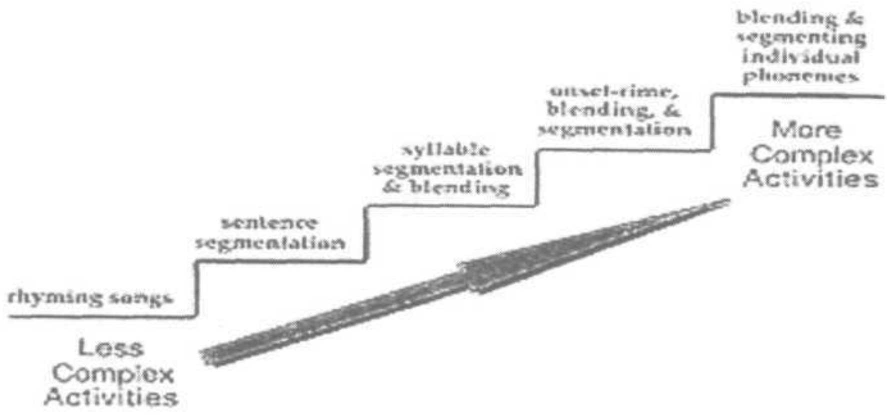

Figure 5: Continuum of complexity of phonological awareness activities

The empirical evidence for a developmental progression (Figure 5) from syllable through onset/rime to phoneme is based on the administration of oral tasks to young pre-readers. For e.g. Treiman and Zokowski (1991) used an oral 'same-different' judgment task to explore whether the awareness to syllables would be easier than awareness to sub-syllabic units of onset and rime for children between 4-6 years. The children tested found it easier to make judgment about syllables in pairs of words. The recognition of shared onset/rime was inturn easier than recognizing shared phonemes. Children typically demonstrate explicit awareness of syllables at around 3 years of age and explicit awareness of internal constituents of syllables i.e., onset and rime from about four year onwards (Carrol, Snowling, Hulme and Stevenson, 2003; Goswami and Bryant, 1990). Before literacy instruction, awareness of phonemes is restricted to sounds that occur as singleton onsets (Kirtley, Bryant, MacLean and Bradley, 1989).

Phoneme is the unit of phonological representation of language learning (Chomsky and Halle, 1968). Fowler (1991) said that phonological representations start out being holistic in nature and become increasingly segmentally organized over time. Metsala and Walley (1998) suggested that the representation of phoneme emerges as a result of vocabulary acquisition. The degree of organization of the underlying phonological representations may be measured by various tasks employed to assess phonological awareness (Swan and Goswami, 1997). There is however, a consistent debate on the issue of phonological awareness. While on the one hand, there are empirical reports to suggest that grain size of phonological representations develop from larger (syllable) to smaller (phoneme) units during childhood (Fowler, 1991; Ziegler and Goswami, 2005), there are also studies to demonstrate that learning to read an alphabetic script is the main source for development of phoneme awareness (Goswami, 1999). Since these studies have examined the performance of English speaking monolingual children, there is a need to examine this issue in bilingual children.

E. Cross-Language Perception

a) Micro level perception

Micro level perception can be operationally defined for the purpose of the present study as the perception of acoustic cues or characteristics of phonemes. It deals with the sub-levels of the phonemes or features within a phoneme. There has been extensive research in the phonological development and its organization in monolingual children, among which maximum is at the *Macro level* of phonology (i.e., phonemic and syllabic levels). How the same is in children exposed to more than one language is not studied much, where in the studies at *Micro level* (features within a phoneme) is further scanty. However there are a few *Fine-grained studies* (i.e., the studies involving the micro-level phonology) that have been done in English and other European languages.

Cross-linguistic research is one way of investigating the effects of exposure to a given phonological system on the perception and production of phonemes from another phonological system. Another avenue of research in this area is the systematic comparison of children's production to their perception of the same phonemic contrasts. One unresolved issue in phonological development is the relationship of the child's perception of phoneme contrast to his or her production of these contrasts (Yeni-Komshian and Ferguson, 1980).

Traditionally, theories of speech perception have sought to explain primarily the way adults recognize spoken language seldom considering the problems off the way this ability develops. The theories of speech perception must also account for the "development" of phonetic processing and the changes that occur with maturation and experience as it does for performance by mature language users.

Cross language speech perception studies help us to understand the development of child's phonology and phonetic capabilities into adult patterns. The initial infant sensitivities prior to the onset of experience and the impact of differential language exposure can be evaluated/ examined through cross language studies (Aslin & Pisoni, 1980).

Cross-language research has indicated that infants and children can discriminate native and nonnative VOT distinctions, but are less able to discriminate VOT contrasts that are not relevant in any language (Eimas, 1975; Streeter, 1976). It has been shown that infants under 4 months of age can discriminate both the /ba/-/pa/ and /pha/-/pa/ distinctions regardless of whether they are used in the infants' language-learning environment (Lasky, Syrdal-Lasky, & Klein, 1975; Streeter, 1976) but cannot discriminate differences in VOT that are not phonetically relevant in any language (Eimas, 1975). Findings of this sort suggest that initial speech perception capabilities (at least for VOT) are phonetically relevant.

The evidence that infants can discriminate nearly every non-native phonetic contrast on which they have been tested suggests a possible universality to infant perception. In some cross-language research, young infants have been shown to be able to discriminate phonetic pairs that may occur as allophones, but are not used phonemically in their language-learning environment (Aslin, Pisoni, Hennessy, & Perry, 1981; Lasky et al., 1975; Streeter, 1976). Other cross-language research has shown young infants to be able to discriminate phonetic contrasts containing at least one phone that is not even produced as an allophone in their language-learning environment (Trehub, 1976; Werker, Gilbert, Humphrey, & Tees, 1981). Although the research indicates that some phonetic contrasts may be perceptually easier for young infants than others (Aslin et al., 1981; Best, McRoberts, & Sithole, 1988; Eilers, Gavin, & Wilson, 1979), it is clear that, if sensitive-enough procedures are used, young infants can discriminate nearly every phonetic contrast, native or nonnative, on which they have been tested.

Some of the findings in children indicate that children's performance may become more accurate when a number of acoustic features cooperate (Simon and Fourcin, 1978). Also cues may differ in value and only linguistically relevant cues would be expected to aid in phoneme perception (Simon and Fourcin, 1978). Category boundaries become steeper as children get older (Strange and Broen, 1980), evidence for improvement of within category consonant discrimination is found in studies by Elliot and Hammer (1993). Category boundaries shift as a function of age (Zlatin and Koenigsknecht, 1975). The reasons for these boundary shifts are unknown. Explanations might be forwarded in terms of experimental effects/ maturation of neurological structures.

In contrast to this high level of infant ability, research has shown that adult subjects more easily perceive those phonetic contrasts that are phonemic, that is, those that are used to differentiate meaning in their native language (Lisker & Abramson, 1970; MacKain, Best, & Strange, 1981; Trehub, 1976). It was once believed that adults had permanently lost the ability to discriminate nonnative phonetic contrasts, but more recent research has shown that adults still possess or can reacquire this ability if they are given enough training (Jamieson & Morosan, 1986; Pisoni, Aslin, Perey, & Hennessy, 1982), are tested in a sensitive-enough procedure (Werker & Tees, 1984b), or spend enough time learning a language in which that contrast is used (MacKain, Best, & Strange, 1981). In addition, the perceptual or phonological status (or both) of the contrast in question seems to influence the ease of adult discriminability, with some nonnative distinctions being almost immediately discriminable (Best et al., 1988; Polka, 1987) and others, considerably more difficult.

Even with the easiest distinctions, that adult discriminate native phonetic contrast with less difficulty than they do nonnative contrasts (Burnham, 1986).

Werker & Tees (1983; 1984a) have tested infants, children, and adults on their ability to discriminate multiple repetitions of naturally produced syllables taken from one English (/ba/vs./da/) and two non-English (Hindi) minimal pair contrasts. They used multiple naturally produced repetitions of each phoneme. English-learning infants as well as Hindi-speaking adults could discriminate these Hindi contrasts, but that English-speaking adults (Werker et al., 1981) and children age 4 and older (Werker & Tees, 1983) had more trouble, particularly with the perceptually more difficult place distinction. Limited training facilitated discrimination of the non-native voicing distinction, but was totally ineffective at facilitating discrimination of the non-English retroflex/dental place distinction in this procedure (Werker et al., 1981).

Cross-sectional and longitudinal studies (Werker & Tees, 1984b) indicated that English-learning infants 6 to 8 months of age could discriminate both the Hindi and the English place-of-articulation distinctions, but, by 10 to 12 months of age, very few of the English-learning infants could discriminate either of these distinctions. By 1 year of age the perceptual capabilities of the young infant do correspond to linguistically significant categories. The developmental change between 6 and 12 months shows that the perceptual abilities of the 1- year-old are not at all arbitrary, do not in any way reflect all the possible discriminatory capabilities of the infant (because they no longer discriminate Hindi-only), and are apparently similar to those phonemic categories used by adult native speakers. One possible interpretation of this data is that it may reflect the first stage in the development of a functional phonology.

This pattern of research findings has led to the hypothesis as suggested by Eimas (1975), that infants may have a biological predisposition to discriminate the universal set of phonetic contrasts, and that there is an apparent decline or reorganization in this universal phonetic sensitivity as a function of learning a particular language. Werker & Tees (1984a), provided data that are consistent with this hypothesis and that suggest that the perceptual reorganization evident between infancy and adulthood may occur, or at least begin, within the first year of life.

Similar to cross-language/ bilingualism studies, effects have been reported by Caramazza, Yeni-Komshian, Zurif and Carbone (1973), with Spanish speakers who moved categories more towards English for |b|-|p| voicing as a function of increased exposure to English. *The bulk of existing cross-language research has focused on VOT distinctions.* Indeed, all of the cross-language research showing that infants can only discriminate phonetically relevant contrasts has been confined to studies of single-exemplar discriminations along the VOT continuum.

Research has shown that the non-native speakers impose their native language phonetic norms on their second language (Mondini and Miller, 2004). Laeufer (1996) reports of acquisition of English like VOT in the French native speakers on exposure to English. Cross language research is one way of investigating the effects of exposure to a given phonological system on perception of phonemes in another phonological system. Native language experience has comprehensive influence on the mapping from acoustic signal to the phonetic category as evident in reports on Dutch-English bilinguals (Mondini, van Alpen and Miller, 2002).

Research shows that the voiced voiceless boundary for a VOT series is located at a shorter VOT for Dutch-English bilinguals than for native English listeners, consistent with the fact that voiceless stops are produced with shorter VOTs in Dutch than in English (Fledge and Eefting, 1997). The perceptual boundaries are found to be located at shorter VOTs for native Dutch listeners (Mondini, Alpen, and Miller, 2002). These studies are suggestive of the fact that phonological awareness is dependant on languages the bilinguals are exposed to. Alternatively, the degree of mapping of acoustic features in a given language (s) is dependent on the structure of languages in which a child is bilingual. For example knowing Chinese in addition to English is less helpful for phonological awareness in each of these languages in comparison to closely related languages such as English and French (Liow and Poon, 1998). Thus, a native language effect could be observed on the non-native language or the second language and vice versa could be seen at the level of micro phonology, or the acoustic characteristics in perception as well as production. This interests us to see what effect are seen on the exposure of more than one language at the level of macro phonology.

b) Macro-level Cross language perception

Macro level perception can be operationally defined for the purpose of the present study as the perception of characteristics of phonemes and syllables and their organization in the language. It deals with phonemes and the syllables, their awareness. There have been several studies that have demonstrated that specifics of phonological awareness skills vary depending on the most salient phonological forms in those languages. Italian children are more adept at syllable and phoneme detection than English children, while Czech children have higher phoneme awareness than English speaking children but lower onset and rime detection. These findings parallel the saliency of those phonological forms in the specific languages in question (Bruck and Genesee, 1995).

There have been few studies on phonological awareness in bilingual children and fewer yet on cross-language transfer of these skills in them. Bruck and Genesee (1995) compared English speaking students in a monolingual and in a French immersion program for phonological awareness tasks in English. They found that the immersion kindergarteners had superior onset/rime manipulation skills compared to monolingual children which are subsided by grade I. The bilinguals had superior syllable awareness skills than the monolingual children, who inturn had better phonemic awareness skills. They explain that the grade I bilinguals superiority in syllable awareness skills by noting that the syllabic structure is more salient in French than in English; again exposure to L2 increased metalinguistic skills. They also believe that the superiority of the grade I monolinguals in phoneme detection is due to the schooling in English reading, which the bilinguals had not received. Because all the testing was done in English these results support the cross language transfer of phonological awareness.

Durgonoglu, Nagy and Hancin-Bhatt (1993) tested Grade I Spanish speakers with limited English proficiency on several L1 and L2 measures and found that L1 phonological awareness helps in developing literacy in both the languages. Stuart and

Martin (1997) tested Punjabi-English students on phonological awareness in both languages and in English literacy. They found that there was strong relationship between L2 phonological skills and L2 literacy and not between L1 phonological awareness and L2 literacy. Durgonoglu anticipate this and maintain that phonological awareness enables a child to see and reflect on the components of a language and that this broader metalinguistic ability -not specific phonemic or literacy knowledge - is what is being transferred.

The micro and macro phonological studies suggest a bidirectional influence of the languages exposed to on their micro and macro level perception. The micro level studies talk about the VOT characteristics showed a shift in perception, while the macro level studies talked about the influence of this shift in the phonological awareness and literacy acquisition.

F. Research in India

Measurement of sensitivity to acoustic features of phonemes has received greater attention these days in studies that tap fine grained auditory discrimination skills in children. Attempts are being made to investigate the importance of these parameters in speech perception as well. Some preliminary work has been done on VOT (Savithri, 1995), CD (Shanthi, Nandini, Savithri, 1992; Sathya 1992), Transition Duration & Pre Vocalic Duration (Sujatha, 1992). Most of these were in Kannada to contrast voiced and voiceless. These studies, in general, report that the differences in voicing contrast in various languages occur due to the phonetic contrast in languages that has evolved to take advantage of the natural physio-acoustic abilities inherent in human auditory system and, the degree of robustness of perceptual salience. According to Savithri, Sreedevi and Santhosh (2005), VOT and CD (Table 2) for Malayalam and Kannada respectively are as follows.

Language	**Voicing**	**VOT**	CD
Malayalam	Voiced	-97	51
	Unvoiced	26	65
Kannada	Voiced	-89	69
	Unvoiced	19	90

Table 2: VOT and CD in Malayalam and Kannada

In Malayalam and Kannada, voiced plosives are characterized by lead VOT and unvoiced plosives are characterized by lag VOT. Voiced plosives in Malayalam have longer lead VOT and shorter lag VOT compared to those in Kannada. However, no significant difference between the transition duration of voiced and unvoiced plosives is reported. Among the two parameters, category separation score was high on VOT, indicating that VOT could contrast voicing in word-initial position in these languages (Savithri, Sreedevi & Santhosh, 2001). Savithri et al (2001) indicated a mean VOT of -97ms for voiced plosives in Malayalam, +26ms for unvoiced plosives in Malayalam, -89ms for voiced plosives in Kannada and +19ms for unvoiced plosives in Kannada.

Savithri, Pushpavathi and Sujatha (1995) found a 50% crossover at -16.8ms for VOT in Kannada and also reported a 50% crossover for closure duration at 33ms for Kannada. 50% crossover for VOT was found to be at -1.48ms in Malayalam

(Swapna, 2005) and 50% crossover was found at 12ms for Malayalam (Swapna, 2005). Sathya (1996) found 50% crossover for VOT to be -19.54ms in Telugu. She also reports that children as young as 3-4 years had a shift in percept from voiced to voiceless at a shorter CD of around 20ms when compared to older children around 7-8 yrs with a shift at around 40-50ms. Sathya (1996) also reports that, in Telugu reducing the CD to around 45ms in unvoiced stop consistently induced labeling of the consonant as voiced irrespective of the places of articulation. All these can be attributed to the differences in the phonological structure of each of these languages.

Though only a little information is available about childhood speech perception, it does imply that perceptual development is very much significant for speech and language. Also, studies indicate that perception of native language categories of voicing contrasts changes with age and language experiences to become more like adult patterns of perception and perhaps the most significant changes occurring early rather than later (Zlatin and Koenigsknecht, 1975; Williams, 1979). Children like adults have also been evidenced to show perceptual advantage in perception of native over non native contrasts (Werker and Tees, 1983). This shows combined effects of age and language experience on phonetic perception. Further, cross language research in phonological processing in older children is required to ascertain the effects of language exposure in phonological perception and language development.

Bilingualism is an integral part of globalization and social mobility. India being a multilingual country is forced to embrace bilingualism as a part of its social and cultural development. In India, the impact of bilingualism is evident on many issues including the acquisition of literacy in children. Since bilingualism facilitates phonological awareness (Bialystok, 1988) and that knowledge of phonological structures of native language influences phonological awareness in a second language (Cicero and Royer, 1995), it would be interesting to examine the impact of bilingualism on acquisition of phonological awareness in Indian children learning to read and write two languages.

G. Need for the study

Malayalam is a semi syllabic phoneme-rich language of the Dravidian language family spoken in the state of Kerala. Kannada belongs to the same family spoken in the state of Karnataka with around 43 phonemes, majority being stops. Previous research on phonological awareness studies in Dravidian languages (Prema, 2006; Shanbal and Prema, 2006) reports the phonological distance is maximum between Malayalam and Kannada in comparison to other pairs of Dravidian languages suggestive of Malayalam being more proximal to phonemic nature as found in English. English is a phonemic language universally spoken and common language being learnt by more than 70%of the Indian population. The differences in the structure of languages as well as the linguistic distance between any two given languages are bound to influence the nature of phonological processing. Given the enormity of bilingual population in India, it becomes very interesting to study if phonological processing differs between bilinguals having second language in common. Do the native speakers of a given language have an advantage over the others while learning the phonological structure of English? These questions become very pertinent given the fact that majority of our schools do offer educational instruction in English, a language that is structurally very dissimilar in comparison to our Indian languages.

Therefore there arises a need to look into the nature of phonological processing in native speakers of different languages having exposure to the common language English. It becomes very interesting to study if phonological processing differs between Malayalam-English bilinguals and Kannada-English bilinguals given the differences between the languages Malayalam and Kannada. With this aim a methodology is devised in the present study to look into the issues stated above.

Chapter 3

Method

A. **Objectives**

The objectives of the study are:

a) To examine the nature of phonological processing in Malayalam-English and Kannada-English bilinguals with the micro level measures like VOT and CD continua and macro level measures like phoneme segmentation and phoneme oddity tasks.

b) To examine the phonological proximity of the two Indian languages Malayalam and Kannada (with semi-syllabic scripts) to English (with alphabetic script).

B. Method

a) Subjects: 20 subjects were taken for the study under two groups. Group I consisted of 10 Malayalam-English bilinguals and Group II consisted of 10 Kannada- English bilinguals. The groups had equal distribution of subjects between the two genders. Table 3 shows the distribution of subjects in both the groups.

Groups	No **of subjects**	**Grade**	**Native language**	**Medium of instruction**	**L1 exposure**	**Proficiency in L1 and L2**
Group I	10 (5M,5F)	VII	Malayalam	English	Learning to read & write Malayalam from Grade I	>50%
Group II	10 (5M,5F)	VII	Kannada	English	Learning to read & write Kannada from Grade I	>50%

Table 3: Subjects for the study

b) Criteria for selection

i**)** Teachers' reports on the Intelligence, hearing, speech and language abilities, vision, motor skills, emotional and behavioral skills and scholastic performance for all the children were collected. Those children whose performance was rated good were selected for the study.

ii) Auditory processing was screened using SCAP checklist (Yathiraj and Mascarenhas, 2002) (Appendix A).

iii) The teachers were given a questionnaire for assessing the childrens' proficiencies in their L1 and L2. The questionnaire (Appendix B) was developed and adopted by Shanbal and Prema (in preparation). All the children showed greater than 50% proficiency in their native languages and in English.

Phonological processing at micro and macro levels was assessed to find the phonological processing in Malayalam-English and Kannada-English bilinguals. Groups I & II were subjected to the micro level and macro level tasks, the details of which are given below.

c) Tasks

I. Assessment of phonological awareness at micro level

Perception of temporal parameters, i.e., the Voice Onset Time and Closure Duration was studied.

i) Test Stimuli

1. VOT continuum: The stimulus consists of mono-syllabic tokens, with the continuum of sounds |k|, |t| & |p| to their respective cognate voiced pairs. Three voiced stop consonants, i.e. velar |g|, retroflex |d| and bilabial |b|, and their counterpart unvoiced cognates were selected. Three syllables with these voiced stops in the initial position and vowel /a/ in the final position was used. Syllables as uttered five times by a native adult female Malayalam speaker (age 21 years) and a native adult female Kannada speaker (age 21 years), were recorded using a microphone, kept at a distance of 10 cm from the speaker's mouth, in a sound treated room of the Speech language Sciences Laboratory, AIISH, Mysore. These were digitized using a 12 Bit A/D converter, with a sampling rate of 8000 Hz and stored on to the computer memory. The digitized data was displayed on the screen of the computer using the program DISPLAY on the SSL (Voice and Speech Systems, Bangalore). The original VOT was measured using waveform display of SSL, for each of the stop consonants.

A continuum of voiced-unvoiced tokens was generated using waveform editor of SSL.

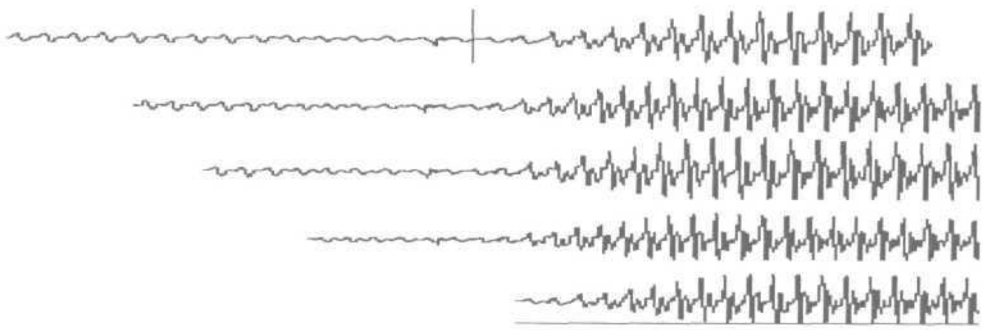

Figure 6: Truncation of Lead VOT

The original lead VOT was truncated in steps of three pitch periods (Figure 6), to form a continuum between lead VOT to 0 ms, i.e. till the burst (the release of articulators) was reached. When VOT was 'Oms', synthetic tokens with lag VOT were generated by inserting silence (Figure 7) in steps of 10 ms between the burst and the following vowel, till 40 ms was reached. The silence was inserted till 40ms as the VOT values in production studies approximated 40ms in both the languages. A total of 117 tokens (13x3x3) formed the stimuli.

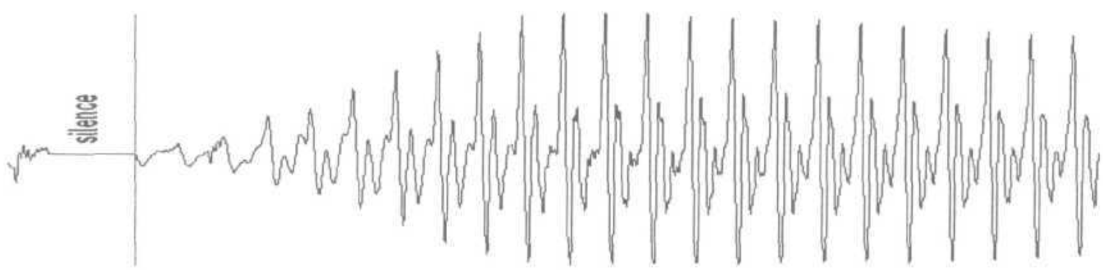

Figure 7: Insertion of silence of 10ms

2. Closure Duration continuum: The stimulus consists of mono-syllabic tokens, with the continuum of sounds |k|, |t| & |p| to their respective cognate voiced pairs.

Three voiced stop consonants, i.e. velar |g|, retroflex |d| and bilabial |b|, and their counterpart unvoiced cognates were selected. Three syllables with these voiceless stops in the medial position and vowel |a| in the initial and final position was used. VCV combination continua were synthesized in the similar fashion as mentioned for VOT, with all the three consonants |p|, |t| and |k|. e.g. |aka - aga|.

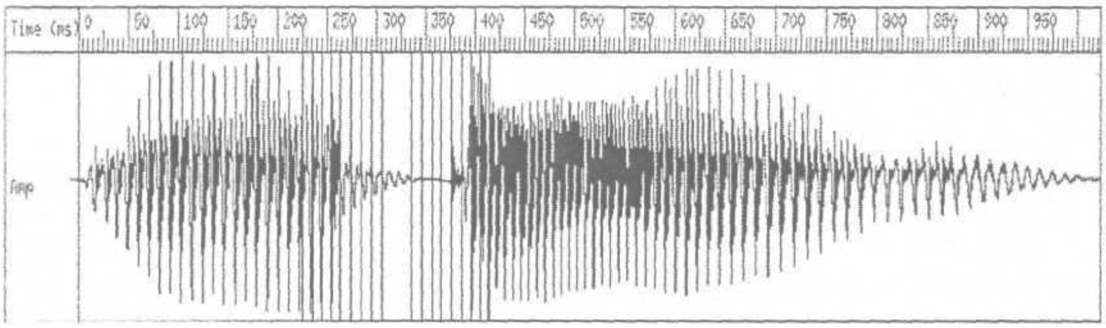

Figure 8: Truncation of Closure Duration in steps of 10ms

The interval was truncated in steps of 10ms (Figure 8) until 0ms closure duration was reached. A total of 108 (12x3x3) tokens formed the stimuli. The tokens thus generated for each cognate were iterated thrice, randomized and recorded onto a CD with an inter-stimulus interval of 3000ms. An inter-stimulus interval of 3000ms would facilitate the listener to adequately mark the responses on the response sheet (Savithri et al, 1995).

ii) Procedure

The material was presented through headphones at comfortable listening levels. A binary forced-choice response was used. Subjects were instructed to carefully listen to each token and identify it as either voiced or unvoiced (for example:

/ka/ or /ga/) and to record their response on the response sheet (Appendix C) provided.

iii) Data coding: The percent response for each token was calculated for groups I and II. Four measurements were calculated for each phoneme and they are as follows:

- ***50% cross over:*** It is that point on the graph which was the actual or interpolated point about the acoustic cue continuum for which 50% of the subjects' response corresponds to the voiced (unvoiced) category.
- ***Lower Limit of Phoneme Boundary Width:*** It is defined as that point along the acoustic cue continuum where an individual identified voiced (unvoiced) stop 75% of the time.
- ***Upper Limit of Phoneme Boundary Width:*** It is defined as the corresponding point for the identification of the (voiced) unvoiced cognate 75% of the time.
- ***Phoneme Boundary Width:*** Between voicing and category phoneme boundary width is defined as the arc boundary cross point along the acoustic cue continuum and is determined by subtracting the lower limit from upper limit.

The illustration of the all the four measures namely 50% Cross Over, Lower Limit, Upper Limit and Phoneme Boundary Width are shown in Figure- 9.

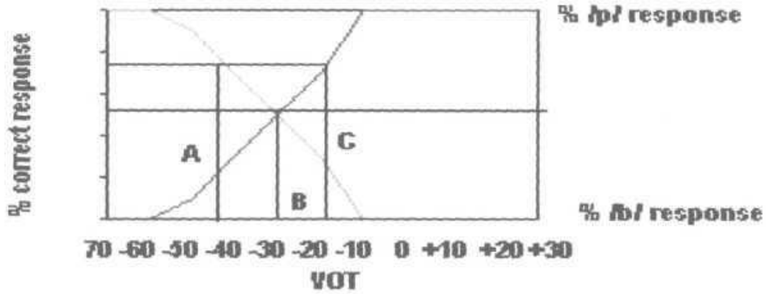

Figure 9: Illustration of 50% Cross Over (B), Lower Limit (A), Upper Limit (C) and Phoneme Boundary Width (C-A).

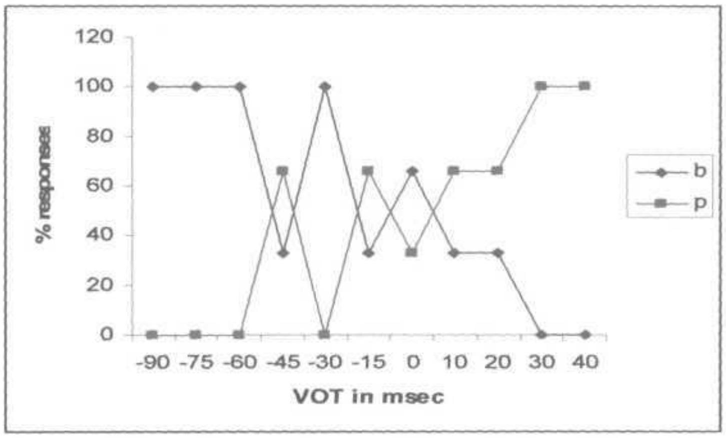

Figure 10: Illustration of multiple Cross Overs

When there was more than one cross over (Figure 10), the first one is considered for computing the 50% cross over. While calculating phoneme boundary width, the first point on the acoustic cue continuum where 75% of the responses corresponded to voiced and unvoiced was considered as the lower and upper limits, respectively. The mean of the percentage responses was calculated and the average 50% crossover, LL, UL and PBW were computed.

II. Assessment of phonological awareness at macro level

Phoneme segmentation (PS) and Phoneme oddity (PO) tasks were carried out.

i) Test Stimuli

The Phoneme segmentation (PS) and Phoneme oddity (PO) tasks from the Reading Acquisition Profile(Appendix D), Kannada (Prema, 1997) & Malayalam phonological awareness (Seetha, 2002)(Appendix E) served as the stimuli. There were 12 items in each category.

ii) Procedure

1. ***Phoneme Segmentation tasks:*** Words were presented to the subjects in the auditory mode. The subjects were asked to delete a particular phoneme from the non-word and say the rest of the word (e.g. |sa:mba:r| - |m| = sa:ba:r|).
2. ***Phoneme oddity task:*** Four non-words were presented to a the subjects in a sequence. The subjects were instructed to listen to all the four non-words and find the 'odd one' out where three out of four had **a** phoneme in common while the fourth one did not. (e.g. | muda, midha, meCi, thadu| = |thadu|)

iii) Data coding: The responses were recorded, transcribed and analyzed for accuracy. The correct responses were scored 'one' while the wrong response was scored'zero'.

The four measurements namely the 50% crossover, lower limit, upper limit and phoneme boundary width were computed for the VOT and CD and were compared across the groups I and II using appropriate statistical measures. Comparison of performance on Phoneme segmentation (PS) and Phoneme oddity (PO) tasks across the groups I and II was made and the interaction of the micro level and macro level performance was examined.

Chapter 4

Results and Discussion

The objectives of the study were to examine the nature of phonological processing in Malayalam-English (M-E) and Kannada-English (K-E) bilinguals with the micro level measures like VOT and CD continua and macro level measures like phoneme segmentation and phoneme oddity tasks. Further the study also examined the phonological proximity of the two Indian languages Malayalam (phoneme-rich) and Kannada (semi-syllabic) to English (alphabetic).

A. Micro level phonological processing tasks

The VOT and CD were the tasks under micro phonological processing. The 50% crossover, lower limit, upper limit and phoneme boundary width was computed and analyzed in the following headings

I. Voice Onset Time

a) Performance of K-E and M-E in |b-p| continuum

b) Performance of K-E and M-E in |d-t| continuum

c) Performance of K-E and M-E in |g-k| continuum

d) Comparison across all the three place of articulation

II. Closure duration

a) Performance of K-E and M-E in |apa-aba| continuum

b) Performance of K-E and M-E in |ata-ada| continuum

c) Performance of K-E and M-E in |aka-aga| continuum

Voice onset Time (VOT)

	Language	50% COin ms	Significance	PBW in ms	Significance
b-p	Kannada	-10.4	NS	22.14	NS
	Malayalam	-0.5		27.6	
d-t	Kannada	-17.0	NS	37.8	NS
	Malayalam	-0.9		21.8	
g-k	Kannada	-9.7	NS	52.8	NS
	Malayalam	-1.3		30.9	

NS = Not Significant; CO = Cross Over; PBW = Phoneme Boundary Width

Table 4: Mean 50 % CO and Mean PBW and significance of differences in K-E and M-E bilinguals for |b-p|, |d-t| and |g-k| continua

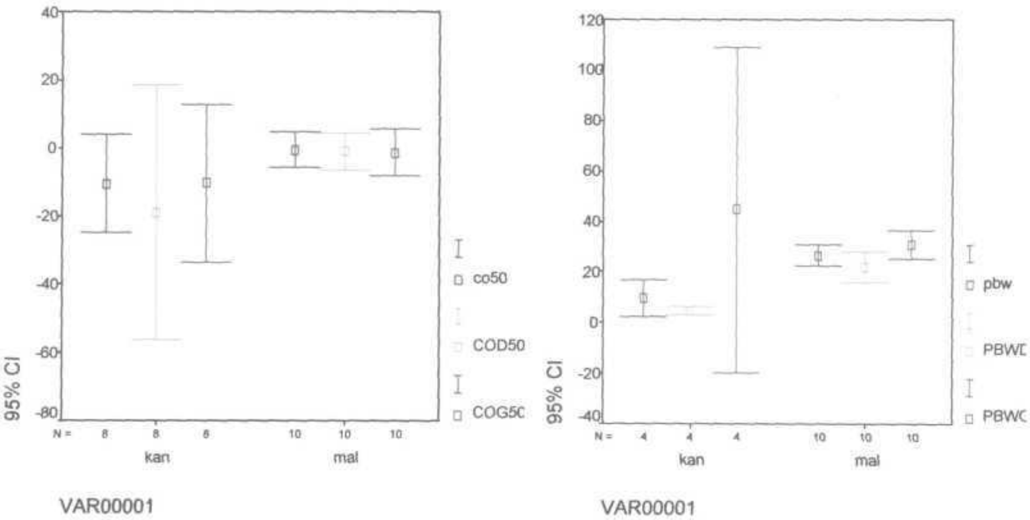

Figure 11: Mean and Range for 50 % Cross Over and Phoneme Boundary Width for |b-pj, |d-t| and |g-k| continua

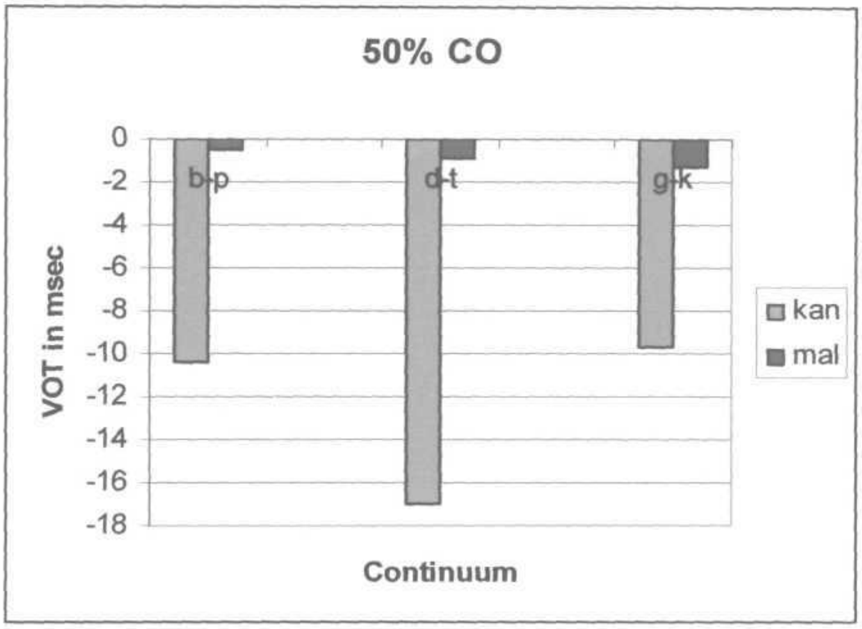

Figure 12: 50% crossover for |b-p|, |d-t| and |g-k| continua in M-E and K-E bilinguals

a) b-p continuum

Measure	Language	N	Mean in ms	Significance
50% Cross Over	Kannada	10	-10.4	0.081
	Malayalam	10	-0.5	
Lower Limit	Kannada	10	-31.9	0.108
	Malayalam	10	-17.5	
Upper Limit	Kannada	7	-6.85	0.000*
	Malayalam	10	9.10	
Phoneme Boundary Width	Kannada	7	22.14	0.484
	Malayalam	10	27.6	

Table 5: Mean and Significance of differences for 50% CO, LL, UL and PBW for|b-p| continuum

In the |b-p| continuum general, 50% crossover was observed in the negative region of VOT in both the languages. However, Malayalam-English bilinguals had 50% cross over at shorter lead VOT (-0.5ms) compared to Kannada-English bilinguals (-10.4ms). Lower limit occurred at longer VOT in Kannada-English bilinguals (-31.9ms) compared to Malayalam-English bilinguals (-17.5ms). Table 5 shows the average 50% crossover, lower limit, upper limit and phoneme boundary width. There was a significant difference ($p<0.05$) only in values for upper limit of the phoneme boundary width. Between the groups the differences in Phoneme Boundary Width (4.5ms) was not significant ($p>0.05$). Figure 13 shows the mean and range of 50% crossover, lower limit, upper limit and phoneme boundary width for the |b-p| continuum.

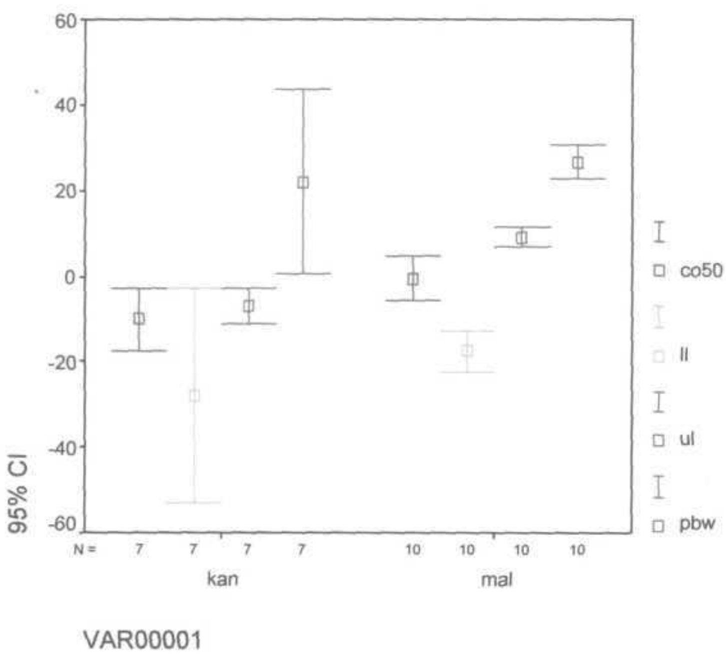

Figure 13: Mean and Range of 50% crossover, lower limit, upper limit and phoneme boundary width for the |b-p| continuum

b) d-t continuum

Measure	**Language**	N	**Mean in ms**	**Significance**
50% Cross Over	Kannada	9	-17.00	0.251
	Malayalam	10	-0.9	
Lower Limit	Kannada	10	-32.60	0.203
	Malayalam	10	-12.2	
Upper Limit	Kannada	8	24.75	0.253
	Malayalam	10	9.6	
Phoneme Boundary Width	Kannada	8	37.87	0.411
	Malayalam	10	21.8	

Table 6: 50% CO, LL, UL and PBW for |d-t| continuum

In the |d-t| continuum, 50% crossover was observed in the negative region of VOT in both the languages. There was no significant difference (p>0.05) obtained for all the measures compared. However, Malayalam-English bilinguals had 50% cross over at a much shorter lead VOT (-0.9ms) compared to Kannada-English bilinguals (-17.00ms). Similar to |b-p| continuum lower limit occurred at longer VOT in Kannada (-32.60ms) compared to Malayalam-English bilinguals (-12.2ms). Table 6 shows the average 50% crossover, lower limit, upper limit and phoneme boundary width. Though there was no significant difference in the Phoneme Boundary Width, however, a difference of 16ms was observed in the |d-t| continuum which was more compared to that of b-p continuum (4.5ms). Figure 14 shows the Mean and Range of 50% crossover, lower limit, upper limit and phoneme boundary width for the |d-t| continuum.

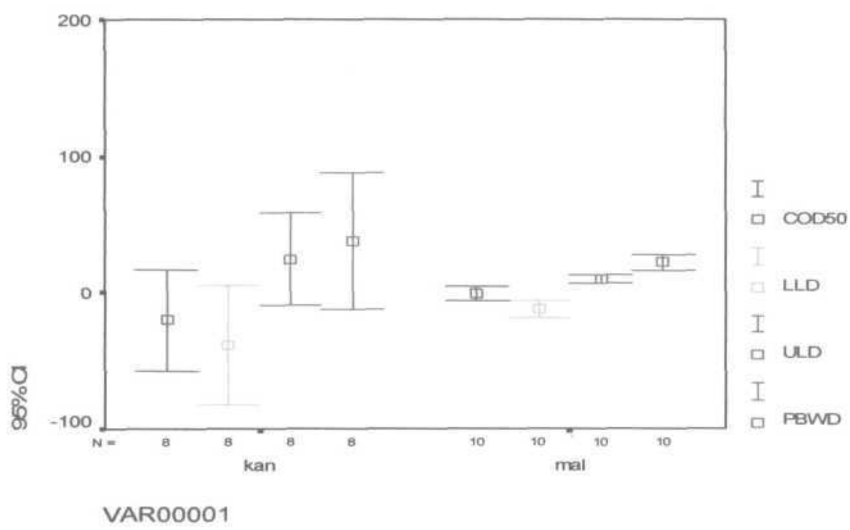

Figure 14: Mean and Range of 50% crossover, lower limit, upper limit and phoneme boundary width for the |d-t| continuum

c) g-k continuum

Measure	Language	N	Mean in ms	Significance
50% Cross Over	Kannada	9	-9.77	0.353
	Malayalam	10	-1.3	
Lower Limit	Kannada	9	-40.33	**0.058**
	Malayalam	10	-18.5	
Upper Limit	Kannada	6	13.16	0.838
	Malayalam	10	12.40	
Phoneme Boundary Width	Kannada	6	52.83	**0.083**
	Malayalam	10	30.90	

Table 7: 50% CO, LL, UL and PBW for |g-k| continuum

For |g-k| continuum, 50% crossover was observed in the negative region of VOT in both the languages. A significant difference ($p<0.1$) was obtained for lower limit and phoneme boundary width measures. However, no signjficant differnce (p>0.1) was obtained 50% crossover and upper limit measures. Malayalam-English bilinguals had 50% cross over at a shorter lead VOT (-1.3ms) compared to Kannada-English bilinguals (-9.77ms). Similar to |b-p| continuum lower limit occurred at longer VOT in Kannada-English bilinguals (-40.33ms) compared to Malayalam-English bilinguals (-18.5ms). Table 7 shows the average 50% crossover, lower limit, upper limit and phoneme boundary width. However, similar to |d-t| continuum a difference of 22ms was observed in the Phoneme Boundary Width between the languages unlike that of |b-p| continuum which had a difference of only 4.5ms. Figure 15 shows the Mean and Range of 50% crossover, lower limit, upper limit and phoneme boundary width for the |g-k| continuum

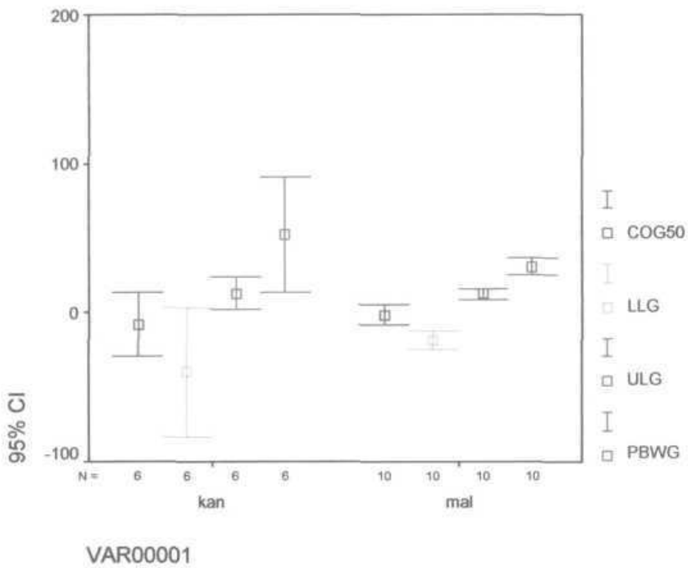

Figure 15: Mean and Range of 50% crossover, lower limit, upper limit and phoneme boundary width for the |g-k| continuum

The results indicate that Malayalam-English bilinguals had crossover at a shorter lead VOT (-0.9ms) when compared to Kannada-English bilinguals (-12.32ms) in |b-p|, |d-t| and |g-k| continua. When compared to Kannada-English bilinguals, the pattern observed in M-E bilinguals is closer to the pattern observed in English monolinguals (Yeni-Komshian et al, 1967; Simon, 1974; Zlatin and Koenigsknecht, 1975; Williams, 1980) which shows crossover at a lag VOT. When comparing the results of present study with results of studies in Malayalam and Kannada respectively by Swapna (2005) and Savithri et al (1995), in both M-E bilinguals and K-E Bilinguals there is a shift from the pattern observed in the monolinguals that is from -16.8ms to -12.32ms and -1.48ms to -0.9ms in Kannada-English bilinguals and Malayalam-English bilinguals respectively. Thus in a continuum of VOT, Malayalam, a phoneme-rich language falls nearer to English when compared to Kannada, which is semi-syllabic. This is illustrated in the figure 15a.

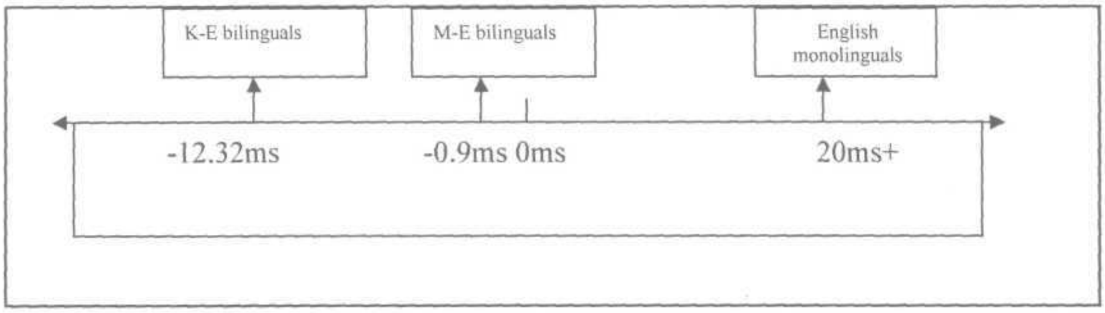

Figure 15a: Illustration of VOTs in Kannada, Malayalam and English in a continuum

Earlier research shows that the voiced voiceless boundary for a VOT series is located at a shorter VOT for Dutch-English bilinguals than for native English listeners, consistent with the fact that voiceless stops are produced with shorter VOTs in Dutch than in English (Fledge and Eefting, 1997). The perceptual boundaries are found to be located at shorter VOTs for native Dutch listeners (Mondini, Alpen, and Miller, 2002). And the shift is seen in the direction towards the pattern seen in English (Yeni-Komshian et al, 1967; Simon, 1974; Zlatin and Koenigsknecht, 1975; Williams, 1980), the L2 they are exposed to. Similarly, the 50% crossover in VOT for

Malayalam- English was more close to the English when compared to the 50% crossover in VOT for Kannada- English bilinguals. Could this be attributed to the fact that Malayalam a phoneme rich language is more close to English, a phonemic language when compared to the syllabic language, Kannada??

A larger phoneme boundary width scores was found for K-E bilinguals, which could be due to more confusion between both the phonemes, a trend generally seen during the period of acquisition. A larger phoneme boundary width may mean confusion in the identification of the tokens, in deciding between voiced and unvoiced. The same could be supported by the observation of a high standard deviation scores observed in Kannada-English bilinguals when compared to the Malayalam-English bilinguals.

The results obtained in the present study are in agreement with the observation made by Laeufer (1996) where he reports of acquisition of English like VOT in the French native speakers on exposure to English i.e. from a lead VOT to a Short Lag VOT as seen in English language. As reviewed earlier, non-native speakers impose their native language phonetic norms on their second language and vice-versa (Mondini and Miller, 2004). Native language experience has comprehensive influence on the mapping from acoustic signal to the phonetic category as evident in reports on Dutch-English bilinguals (Mondini, van Alpen and Miller, 2002). These studies and the present study are suggestive of the fact that phonological awareness is dependent on languages the bilinguals are exposed to.

d) Place of articulation

The comparisons made for the measures obtained in the |b-p|, |d-t| and |g-k| continua (Table 8) suggest no significant difference (p>0.05) between the languages for the 50% Cross Over in all the three continua, lower limit in |b-p| and |d-t| continua, upper limit in the |d-t| and |g-k| continua and phoneme boundary width for the |b-p| and |d-t| continua respectively. Since there were no significant differences observed, the data was further examined to see if the place of articulation has an influence on phonological processing in bilinguals. Therefore, One way ANOVA (Table 9)was performed to compare 50% crossover, lower limit, upper limit and phoneme boundary width for different places of articulation in Kannada-English and Malayalam-English bilinguals. Figure 16 shows the Mean and Range of 50% Cross Over and Phoneme Boundary Width for the |b-p|, |d-t| and |g-k| continua.

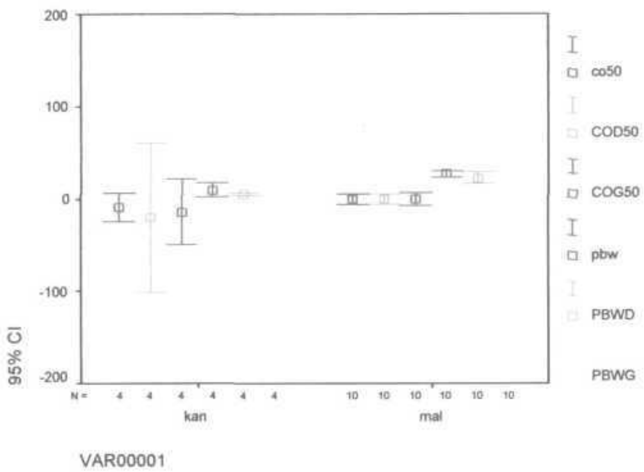

Figure 16: Mean and Range of 50% CO and PBW for the |b-p|, |d-t| and |g-k| continua.

Descriptives

		N	Mean	Std. Deviation	Std. Error
co50 b-p	b-p	10	-10.4000	15.2549	4.8240
	d-t	9	-17.0000	42.1545	14.0515
	g-k	9	-9.7778	26.2001	8.7334
	Total	28	-12.3214	28.6059	5.4060
ll b-p	b-p	10	-31.9000	26.0275	8.2306
	d-t	10	-32.6000	48.0953	15.2091
	g-k	9	-40.3333	32.8177	10.9392
	Total	29	-34.7586	35.8266	6.6528
ul b-p	b-p	7	-6.8571	4.4881	1.6963
	d-t	8	24.7500	40.3936	14.2813
	g-k	6	13.1667	10.2843	4.1985
	Total	21	10.9048	28.1459	6.1419
pbw b-p	b-p	7	22.1429	23.4693	8.8706
	d-t	8	37.8750	59.8771	21.1698
	g-k	6	52.8333	36.6847	14.9765
	Total	21	36.9048	43.6954	9.5351

Table 8: Mean and SD of 50% CO, LL, UL and PBW for |b-p|, |d-t| and |g-k| continuum in Kannada-English bilinguals

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
co50 b-p	Between Group	292.152	2	146.076	.168	.847
	Within Groups	1801.956	25	872.078		
	Total	2094.107	27			
ll b-p	Between Group	408.010	2	204.005	.149	.862
	Within Groups	5531.300	26	1366.588		
	Total	5939.310	28			
ul b-p	Between Group	3772.619	2	1886.310	2.813	.086
	Within Groups	2071.190	18	670.622		
	Total	5843.810	20			
pbw b-p	Between Group	3055.244	2	1527.622	.783	.472
	Within Groups	5130.565	18	1951.698		
	Total	8185.810	20			

Table 9: Analysis of Variance for 50% CO, LL, UL and PBW for |b-p|, |d-t| and |g-k| continuum in Kannada-English bilinguals

There was no significant difference across the bilabial, dental and velar place of articulation for 50% crossover, lower limit, upper limit and phoneme boundary width in Kannada-English bilinguals.

Descriptives

		N	Mean	Std. Deviation	Std. Error
co50 b-p	b-p	10	-.5000	7.3068	2.3106
	d-t	10	-.9000	7.7524	2.4515
	g-k	10	-1.3000	9.7074	3.0697
	Total	30	-.9000	8.0359	1.4671
ll b-p	b-p	10	-17.5000	6.7700	2.1409
	d-t	10	-12.2000	8.4696	2.6783
	g-k	10	-18.5000	8.8349	2.7938
	Total	30	-16.0667	8.2835	1.5124
ul b-p	b-p	10	9.1000	3.2813	1.0376
	d-t	10	9.6000	4.5995	1.4545
	g-k	10	12.4000	4.4771	1.4158
	Total	30	10.3667	4.2789	.7812
pbw b-p	b-p	10	27.6000	5.5015	1.7397
	d-t	10	21.8000	8.5088	2.6907
	g-k	10	30.9000	7.7093	2.4379
	Total	30	26.7667	8.0588	1.4713

Table 10: Mean and SD of 50% CO, LL, UL and PBW for |b-p|, |d-t| and |g-k| continuum in Malayalam-English bilinguals

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
co50 b-p	Between Groups	3.200	2	1.600	.023	.977
	Within Groups	1869.500	27	69.241		
	Total	1872.700	29			
II b-p	Between Groups	229.267	2	114.633	1.758	.192
	Within Groups	1760.600	27	65.207		
	Total	1989.867	29			
ul b-p	Between Groups	63.267	2	31.633	1.826	.180
	Within Groups	467.700	27	17.322		
	Total	530.967	29			
pbw b-p	Between Groups	424.467	2	212.233	3.928	.032
	Within Groups	1458.900	27	54.033		
	Total	1883.367	29			

Table 11: Analysis of Variance for 50% CO, LL, UL and PBW for |b-p|, |d-t| and |g-k| continuum in Malayalam-English bilinguals

There was no significant difference (p>0.05) across the bilabial, dental and velar places of articulation for 50% crossover, lower limit and upper limit (Table 11). However a significant difference (p<0.05) was observed between places of articulation for phoneme boundary width. A post hoc Scheffe's test was performed for grouping the phonemes.

pbw b-p

Scheffe[a]

		Subset for alpha = 05	
PH	N	1	2
d-t	10	21.8000	
b-p	10	27.6000	27.6000
g-k	10		30.9000
Sig.		.229	.610

a Uses Harmonic Mean Sample Size = 10.000.

Table 12: Grouping of Phonemes for |b-p|, |d-t| and |g-k| continuum in Malayalam-English bilinguals

The results of the Scheffe's test (Table 12) indicate that |b-p| and |d-t| were grouped together and |b-p| and |g-k| were grouped together. This is a deviation from the usual grouping of the place of articulation, irrespective of the languages, according to temporal parameter VOT, where in the velars have the least VOT and the VOT shows an increasing trend when the place of articulation moves from velar to bilabial which is explained by the articulatory resistance variations. This calls attention for further cross-linguistic research may be taking into account the spectral features as well which could not be incorporated in the present study due to the methodological constraints.

However, when place of articulation was compared, a significant difference could not be observed in the Kannada-English bilinguals for all the four measures and also in Malayalam-English bilinguals for the measures other than Phoneme Boundary Width. This leads us to the question, that, if a micro level phonological test was to be conducted then we do we need to administer the same individually for all the places of articulation? Further extensive research in this area may lead us to a better answer for this question.

II. Closure Duration

	Language	50%CO	Significance	PBW	Significance
|apa-aba|	Kannada	57.0	**NS**	26.3	**S**
	Malayalam	66.0		48.2	
|ata-ada|	Kannada	39.8	**S**	**23**	**NS**
	Malayalam	79.4		**27**	
|aka-aga|	Kannada	49.4	**S**	19.0	**NS**
	Malayalam	77.5		38.7	

Table 13: Mean 50% CO and Mean PBW with significance of differences between K-E and M-E bilinguals for the |apa-aba|, |ata-ada| and |aka-aga| continua.

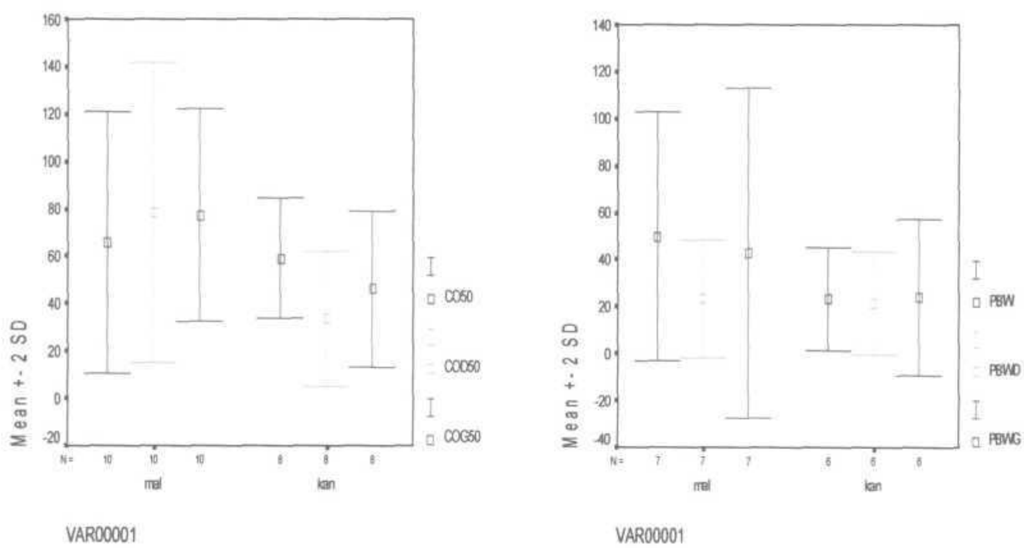

Figure 17: 50% Cross Over and Phoneme Boundary Width for the |apa-aba|, |ata-ada| and |aka-aga| continua

a) | apa-aba| continuum

Measure	**Language**	N	**Mean**	S.D	**Significance**
50% Cross Over	Kannada	9	57.66	12.72	0.420
	Malayalam	10	66.00	27.66	
Lower Limit	Kannada	9	73.77	15.13	**0.077**
	Malayalam	10	89.60	20.74	
Upper Limit	Kannada	9	47.11	14.11	0.290
	Malayalam	8	37.75	20.80	
Phoneme Boundary Width	Kannada	9	26.33	15.03	**0.042**
	Malayalam	8	48.25	24.90	

Table 14: Mean, SD and significance of differences for 50% CO, LL, UL and for the |apa-aba| continuum.

Table 14 shows the average 50% crossover, lower limit, upper limit and phoneme boundary width. In the |apa-aba| continuum, there was no significant difference ($p>0.05$) observed between the languages for the 50% Cross Over and Upper Limit of the phoneme boundary width. However, a significant difference was observed for Lower Limit of the phoneme boundary width ($p<0.1$) and the Phoneme Boundary Width ($p<0.05$). It was observed that 50% crossover, was at a longer CD for Malayalam-English bilinguals (66.00ms) compared to Kannada-English bilinguals (57.66ms). The phoneme boundary width was observed to be larger for Malayalam-English bilinguals (48.25ms). The standard deviation was found to be high for both the groups where N <10 in most of the cases. Figure 18 shows the Mean and Range of 50% Cross Over, lower limit, upper limit and Phoneme Boundary Width for the | apa-aba| continua.

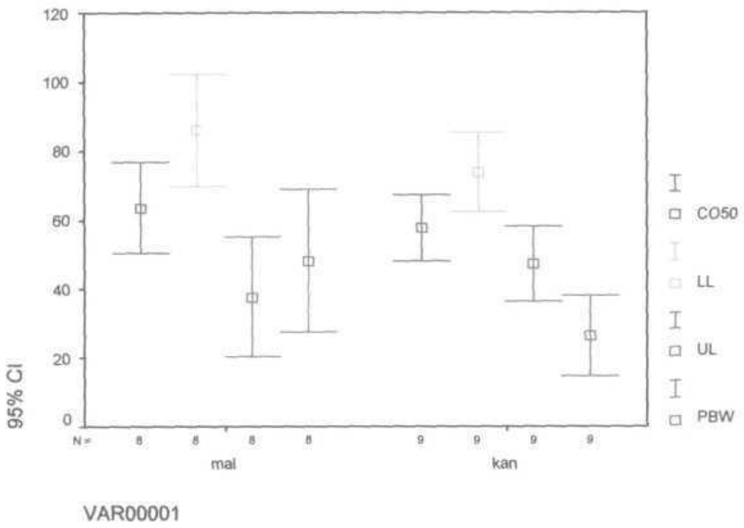

Figure 18: Mean and Range of 50% Cross Over, lower limit, upper limit and Phoneme Boundary Width for the |apa-aba| continua.

b) |ata-ada| continuum

Measure	**Language**	**N**	**Mean**	S.D	**Significance**
50% Cross Over	Kannada	10	39.80	18.59	**0.004**
	Malayalam	10	78.40	31.65	
Lower Limit	Kannada	10	52.50	17.43	**0.008**
	Malayalam	10	87.30	32.42	
Upper Limit	Kannada	9	31.66	18.22	**0.026**
	Malayalam	10	59.40	29.22	
Phoneme Boundary Width	Kannada	9	23.66	17.13	0.708
	Malayalam	10	27.80	28.13	

Table 15: Mean, SD and significance of differences for 50% CO, LL, UL and for the |ata-ada| continuum.

Table 15 shows the average 50% crossover, lower limit, upper limit and phoneme boundary width. In the |ata-ada| continuum, there was a significant difference ($p<0.05$) obtained for both the languages for the 50% crossover, lower limit and upper limit phoneme boundary width. A significant difference ($p>0.05$) could not be observed only for PBW. However there was a difference of 4 ms between phoneme boundary widths obtained in both the groups, where in it was found to be large for Malayalam. It was observed that 50% crossover was at a longer CD for Malayalam-English bilinguals (78.4ms) compared to Kannada-English bilinguals (39.8ms). Figure 19 shows the Mean and Range of 50% Cross Over, lower limit, upper limit and Phoneme Boundary Width for the |ata-ada| continua.

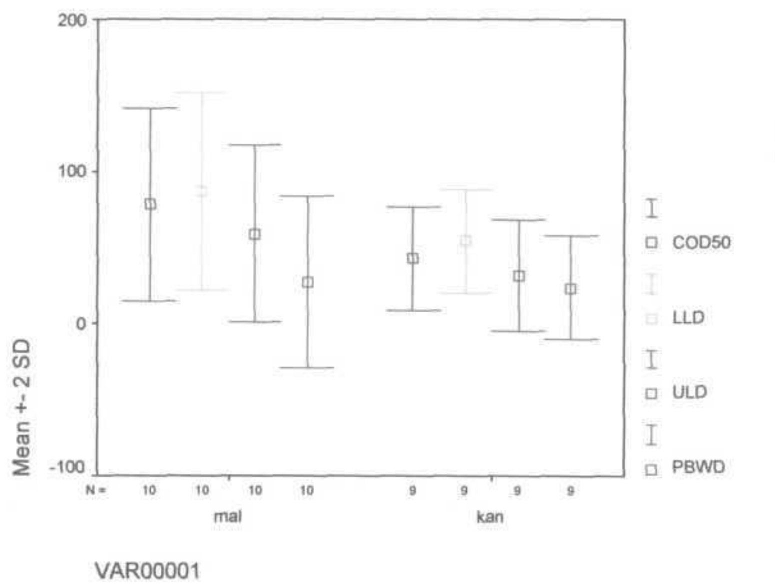

Figure 19: Mean and Range of 50% Cross Over, lower limit, upper limit and Phoneme Boundary Width for the |ata-ada| continua.

c) \aka-aga\ continuum

Measure	**Language**	**N**	**Mean**	S.D	**Significance**
50% Cross Over	Kannada	9	49.44	18.15	**0.009**
	Malayalam	10	77.50	22.48	
Lower Limit	Kannada	8	58.00	14.92	**0.000**
	Malayalam	10	102.50	19.50	
Upper Limit	Kannada	9	39.88	15.49	**0.024**
	Malayalam	9	65.44	26.43	
Phoneme Boundary Width	Kannada	8	19.00	16.73	0.134
	Malayalam	9	38.77	31.53	

Table 16: Mean, SD and significance of differences for 50% CO, LL, UL and for the |aka-aga| continuum.

Table 16 shows the average 50% crossover, lower limit, upper limit and phoneme boundary width. For the |aka-aga| continuum, there was a significant difference ($p<0.05$) observed across the languages for the 50% crossover, lower limit and upper limit phoneme boundary width. However a significant difference ($p>0.05$) was not observed only for PBW. The phoneme boundary width was observed to be more for Malayalam-English bilinguals (38.77ms). It was observed that 50% crossover was at a longer CD for Malayalam-English bilinguals (77.5 ms) compared to Kannada-English bilinguals (49.44ms). Figure 20 shows the Mean and Range of 50% Cross Over, lower limit, upper limit and Phoneme Boundary Width for the |aka-aga| continua.

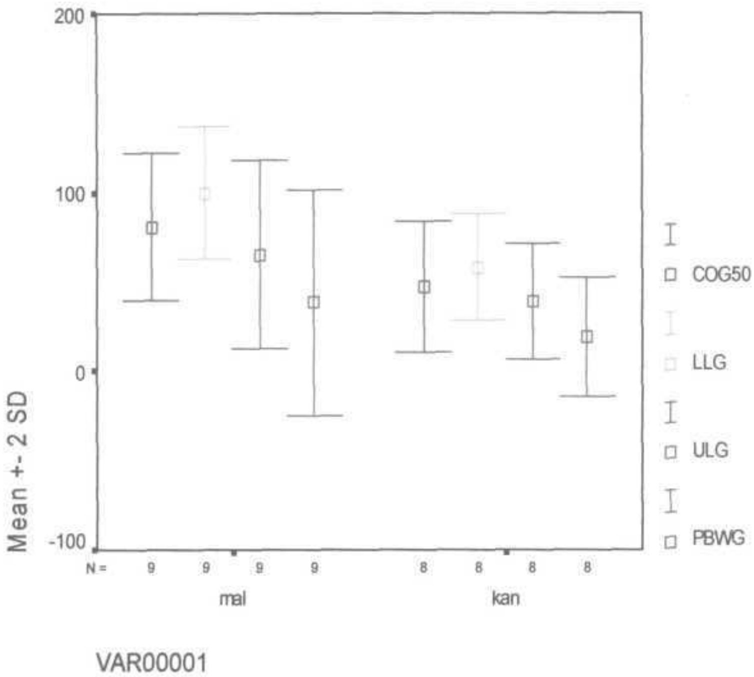

Figure 20: Mean and Range of 50% Cross Over, lower limit, upper limit and Phoneme Boundary Width for the |aka-aga| continua

The results indicate that there was a significant difference (p<0.05) between Malayalam-English bilinguals and Kannada-English bilinguals for the measures 50% Cross Over, Lower limit and upper limit of the phoneme boundary width respectively. Malayalam-English bilinguals had a mean 50% Cross Over at 74.3ms Closure Duration was longer when compared to Kannada-English bilinguals and had a mean 50% Cross Over at 48.7ms for |aba-apa|, |ada-ata| and |aga-aka| continua. A significant difference across the groups for all the three continua suggest that Closure duration is a better cue for voicing in both the languages considering the structure of both Malayalam and Kannada and differentiated the languages better.

Also a larger phoneme boundary width was observed in Malayalam- English bilinguals compared to Kannada-English bilinguals. Malayalam has some linguistic peculiarities like the presence of weak or lax consonants in the word medial position in Malayalam. An explanation for the PBW differences across the groups could be that the peculiarity of Malayalam, when compared to Kannada, having weakly voiced consonants in the word-medial position as in the word |makan| led to a greater confusion in Malayalam- English bilinguals when compared to Kannada-English bilinguals.

The bulk of existing cross-language research has focused on VOT distinctions. There is however dearth of studies focusing Closure Duration distinctions. Kannada-English bilinguals with a mean 50% Cross Over at 48.7ms for |aba-apa|, |ada-ata| and |aga-aka| continua is found to be similar to Telugu which was reported to have a crossover at 45ms irrespective of places of articulation (Sathya 1996). However the values obtained for Kannada are not in agreement with the earlier studies by Savithri et al (1995) who reported a 50% cross over at 33ms for kannada. Could this be attributed to the fact that there are methodological differences between the two studies where in the present study considers children as young as 12 yrs age and the earlier study by Savithri et al (1995) considered adults as subjects of the study? Or is it due to the fact that monolinguals in Kannada were the subjects for the earlier study by Savithri et al (1995) and the present study considered Kannada-English bilinguals? Also, Swapna (2005) observed crossover at a shorter CD (12ms) for Malayalam while the present study reports CD to be at around 70ms in Malayalam-English bilinguals. However, the subjects and also the methodology used in these two studies are different. Swapna (2005) considered a 'same-different' discrimination task.

B. Macro level phonological processing tasks

Tasks	Language	N	Mean	SD	significance
Phoneme Segmentation	Kannada	10	10.90	1.1005	0.370
	Malayalam	10	11.30	0.8233	
Phoneme Oddity	Kannada	10	10.80	0.9189	0.027
	Malayalam	10	11.60	0.5164	

Table 17: Mean, SD and significance of differences for Phoneme Segmentation and Phoneme Oddity tasks

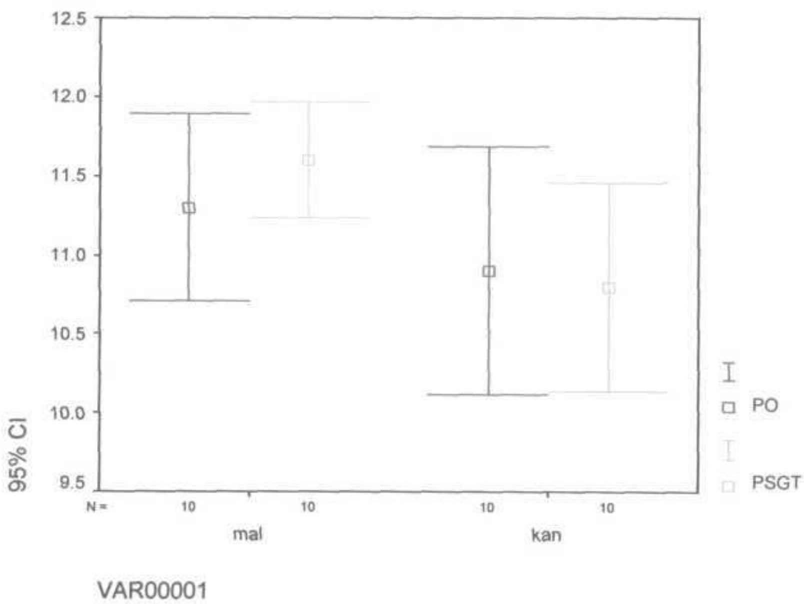

Figure 21: Mean and Range for Phoneme Segmentation and Phoneme Oddity tasks

The phoneme segmentation and phoneme oddity were the tasks under macro phonological processing. The scores in phoneme segmentation and phoneme oddity tasks were compared (Table 17). Higher mean scores on phoneme segmentation (10.90 for K-E bilinguals and 11.30 for M-E bilinguals) and phoneme oddity tasks

(10.80 for K-E bilinguals and 11.60 for M-E bilinguals) suggest a better performance by Malayalam-English bilinguals compared to Kannada-English bilinguals. A significant difference ($p>0.05$) was not observed across the groups in both the phoneme segmentation task. Phoneme segmentation task demands lesser skills compared to the phoneme oddity tasks in terms of short term and working memory and therefore is generally rated to be cognitively a lower level task compared to the phoneme oddity tasks. This is probably because phoneme segmentation task used meaningful words (with lexical cues) as stimuli and had to do online manipulation of single words whereas, phoneme oddity task comprised series of four non-words (without lexical cues). The subjects were required to hold all the four non-words in their working memory and retrieve the odd non-word for a response. Thus the cognitive load placed on the subject was high for phoneme oddity task when compared to phoneme segmentation task. It is likely that the performance of both the groups did not show a significant difference on phoneme segmentation task because of its lesser complexity.

The performance on the phoneme oddity task which is cognitively a higher level task showed a significant difference ($p<0.05$) between Malayalam-English bilinguals and Kannada-English bilinguals. For the Phoneme-Segmentation and the Phoneme-Oddity tasks for non-words, a better performance was observed in Malayalam- English bilinguals when compared to Kannada- English bilinguals suggesting that the phonemic features develop at an early stage in Malayalam speakers learning English when compared to Kannada speakers learning English. This is in conjunction with the earlier study by Jayashree and Prema (2006)-where they reported a better performance in the phoneme awareness tasks by Malayalam-English bilinguals compared to the children speaking other Dravidian languages.

The objectives of the present study were to examine the nature of phonological processing in Malayalam-English and Kannada- English bilinguals with the micro level measures like VOT and CD continua and macro level measures like phoneme segmentation and phoneme oddity tasks. It also aimed to examine the phonological proximity of the two Indian languages Malayalam (phoneme-rich) and Kannada (semi-syllabic) to English (alphabetic-which is widely used as the common language in India).

In the present study, micro level measures showed that Malayalam-English and Kannada- English bilinguals had a shift in perception towards the pattern observed in English. While the performance of Malayalam-English and Kannada-English bilinguals in the macro level measures showed that Malayalam-English bilinguals were superior to Kannada- English bilinguals in the phoneme segmentation and phoneme oddity tasks suggesting an early development of the phoneme awareness skills in Malayalam- English bilinguals when compared to Kannada-English bilinguals.

Further, from the results of the micro-level and macro-level task scores, it may be inferred that perception in Malayalam-English bilinguals (phoneme-rich) better approximates the pattern observed in English (phonemic) in comparison to Kannada-English bilinguals (semi-syllabic). This finding offers support for the speculation (Prema, 2006) that Malayalam language with its phoneme-rich characteristics appears to have better phonological proximity to English than Kannada (semi-syllabic). The results of the present study offer a quick and easy method to examine phonological processing in bilinguals with measures to evaluate the phonological distance between any two given languages. These findings are useful for clinical and research purposes.

Chapter 5

Summary and conclusions

During the developmental period, children discover the raw materials in the sounds (or gestures) of their language, learn how they are assembled into longer strings, and map these combinations onto meaning. Children integrate their capacities to crack the code of communication that surrounds them. Young children readily solve the linguistic puzzles facing them by means of speech processing at different levels.

These levels are broadly divided into two. The first one is at the level of syllables and phonemes of the language, considered as the *macro level of phonological processing.* The second is at the sub-levels of phonemes or the *micro level of phonological processing.*

Macro level phonological processing was considered as a language dependant measure while the micro level speech processing was generally treated as language independent. This view was highly debated. However, there is a dearth of studies which examined the same in the bilingual population where in there is interplay of more than one language. A study in this direction would also answer the question if micro-level processing is language dependent or not.

The objectives of the study were to examine the nature of phonological processing in Malayalam-English and Kannada- English bilinguals with the micro level measures like VOT and CD continua and Macro level measures like phoneme segmentation and phoneme oddity tasks and also to examine the phonological proximity of the two Indian languages Malayalam (phoneme-rich) and Kannada (semi-syllabic) to English (phonemic).

20 subjects were taken for the study under two groups. Group I consisted of 10 Malayalam-English bilinguals and Group II consisted of 10 Kannada- English bilinguals. Groups I & II were subjected to the micro level and macro level tasks. Phonological processing at micro and macro levels was assessed to find the phonological processing in Malayalam-English and Kannada-English bilinguals. Micro level task included the perception of VOT and CD continua, whereas, Macro level task included phoneme segmentation and phoneme oddity tasks.

The results of the study indicate that on exposure to English, there is a shift in perception of both Kannada-English bilinguals and Malayalam-English bilinguals. As observed through the micro-level processing studies, the shift is seen towards the pattern as seen in English, their common L2. At the macro-level too the development of awareness at phonemic level is seen to be attained at the level suggested in the literature for English, and the same hierarchy is followed as well.

When the Kannada-English and Malayalam-English bilinguals were compared on the tasks, the Malayalam-English bilinguals showed a shift towards English and the pattern observed suggests that, Malayalam is closer to English than Kannada. This finding offers support for the speculation (Prema, 2006) that Malayalam language with its phoneme-rich characteristics appears to have better phonological proximity to English than Kannada (semi-syllabic). This suggests that when we assess the bilinguals we should take into account the languages they are exposed to as well.

The comparison of micro and macro level assessments though not strongly, but it does suggest that they convey similar information and one of them could replace other in the test battery approach. Micro level tasks is promising as a language free and user friendly tool for the assessment as well as training in children with speech language impairment. This also is highly effective in terms of time, energy and cost. The results of the present study offer a quick and easy method to examine phonological processing in bilinguals with measures to evaluate the phonological distance between any two given languages. These findings are useful for clinical and research purposes.

However, the present study is a very preliminary study and one of its kinds in this direction, involving just the temporal parameters done on a very small population. More work in this direction needs to be done to meet the larger implications.

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Appendix A

Screening Checklist for Auditory Processing in children (SCAP)

Yathiraj and Mascarenhas (2002)

Sl No		Yes	No
1	Doesn't listen carefully and doesn't listen to instructions (requires repetition of instructions)		
2	Has short attention span for listening (approx 5-15 mins)		
3	Easily distracted by background sounds		
4	Has trouble recalling what has been heard in the correct order		
5	Forgets what is said in few minutes		
6	Has difficulty in differentiating one speech sound from the other		
7	Has difficulty following verbal instructions and tends to misunderstand what is said which other children of the same age would understand		
8	Slow or delayed response to verbal instructions or questions		
9	Has difficulty relating what is heard with what is seen		
10	Poor performance for listening but performance improves with visual cues		
11	Has pronunciation problems		
12	Performance is below average in one or more subjects, I/II language		

Appendix B

Ref: Jayashree C.S. and Prema K.S (in preparation)

TEACHER'S QUESTIONNAIRE

Dear teachers, the purpose this questionnaire is to survey the performance of children at school.

Name of child:

Code:

Age/Sex: Grade:

School:

Read each statement carefully and then answer them:

Language *use* **refers to how much the child uses each language. Circle the appropriate rank for each language for all the questions.**

0- Never uses the indicated language. Never hears it.

1- Never uses the indicated language. Hears it very little.

2- Uses the indicated language a little. Hears it sometimes.

3- Uses the indicated language sometimes. Hears it most of the time.

4- Uses the indicated language all of the time. Hears it all of the time.

DK- Don't know

Language use			
Questions	Language 1	Language 2	Language 3
1. Speaks with you in class	DK 0 1 2 3 4	DK 0 1 2 3 4	DK 0 1 2 3 4
2. Speaks with other teachers	DK 0 1 2 3 4	DK 0 1 2 3 4	DK 0 1 2 3 4
3. Speaks with other classmates	DK 0 1 2 3 4	DK 0 1 2 3 4	DK 0 1 2 3 4

Language proficiency **refers to how well the child speaks each language. Circle the appropriate rank for each language for all the questions.**

0- Cannot speak the indicated language, has a few words or phrases, cannot produce sentences, only understands a few words.
1- Cannot speak the indicated language, has a few words or phrases, cannot produce sentences, understands the general idea of what is being said.
2- Limited proficiency with grammatical errors, limited vocabulary, understands the general idea of what is being said.
3- Good proficiency with some grammatical errors, some academic vocabulary, understands most of what is said.
4- Native like proficiency with few grammatical errors, good vocabulary, understands most of what is said.
DK- Don't know

Language proficiency			
Questions	Language 1	Language 2	Language 3
1. Speaks with you in class	DK 0 1 2 3 4	DK 0 1 2 3 4	DK 0 1 2 3 4
2. Speaks with other teachers	DK 0 1 2 3 4	DK 0 1 2 3 4	DK 0 1 2 3 4
3. Speaks with other classmates	DK 0 1 2 3 4	DK 0 1 2 3 4	DK 0 1 2 3 4

- Do you think the child has language problems? Yes No
- Do you think the child has academic or learning problems? Yes No
- Do you think the child has any problem specific to a particular language use in the classroom while reading or writing? Yes No
  (Specify the language and the child's problem)
- Do you think the child has social or behavioral problem? Yes No
- Do you think the child has any motor, vision or hearing problems? Yes No

On a continuum, circle the percentage of time the child is exposed to each language at school:

Language 1: 0 %	25%	50%	75%	100%
Language 2: 0 %	25%	50%	75%	100%
Language 3: 0 %	25%	50%	75%	100%

"Thank you"

Appendix C

A. Response Sheet for Voice Onset Time

S.no	|b|	| P|	|d|	|t|	| g|	|k|
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B. Response Sheet for Closure Duration

S.no	|apa|	|aba|	|ata|	|ada|	|aka|	|aga|
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Appendix D

Reading Acquisition Profile in Kannada (Prema, 1997)

A. Phoneme Segmentation task in Kannada

ಮಾದರಿ : (Example):

b) ಸೇಡು - ಸ್ = ಏಡು
seeDu-s=eeDu

c) ನಡಿ - ನ್- ಅಡಿ
naDi-n=aDi

d) ಕನಿಷ್ಠ - ಇ = ಕನ್ಷ್ಠ
kaniSTa-i=kanSTa

e) ತಾರೆಯ - ಎ = ತಾರ್ಯ (ತಾರ್ಯ)
taareya-e=taarya

h) ಮಾರ್ಗ - ರ್ = ಮಾಗ
maarga-r=maaga

i) ಚಂದ - ನ್ =ಚದ
chanda-n=chada

g) ಮುಂಜಿ - ನ್ = ಮುಜಿ
munji-n=muji

k) ಕಂಬನಿ - ಮ್= ಕಬನಿ
kambani-m=kabani

Test Items :

1) ಪೂರೈಕೆ - ಐ = ಪೂರ್ಕೆ
puuraike-ai=puurke

2) ಸ್ವರೂಪ - ಸ್ = ವರೂಪ
svaruupa-s=varuupa

3) ಭಕ್ತ -ಕ್ = ಭತ
bhakta-k=bhata

4) ಸಪ್ತ - ತ್ = ಸಪ
sapta-t=sapa

5) ಮಧ್ಯಮ - ಧ್ = ಮಯಮ
madhyama-dh=mayama

6) ಗ್ರಾಮದ - ರ್ = ಗಾಮದ
graamada-r=gaamada

7) ಮೀನು - ಮ್= ಈನು
miinu=m=iinu

8) ನರ್ತಕಿ - ರ್ = ನತಕಿ
nartaki-r=nataki

9) ಕಲ್ಪನೆ - ಪ್ = ಕಲನೆ
kalpane-p=kalane

10) ತೀವ್ರ - ರ್ = ತೀವ್
tiivra-r=tiiva

11) ನಿಂಬೆ - ಮ್ = ನಿಬೆ
nimbe-m=nibe

12) ಕೋಳಿ - ಕ್= ಓಳಿ
kooLi-k=ooLi

B. Phoneme Oddity Task in Kannada

ಮಾದರಿ : (Example)

a) ಮೂಚ, ಮಿಟ, ಮೆಗೊ, ತಡು
muucha, miTa, mego, taDu

b) ಮಾಬು, ಕಿಜೆ, ಟಿನೊ. ಪಿಚ
maabu,kije,Tino,picha

c) ಡುಕೆ, ಬಾಳೊ, ಗುಜ, ಮುಟೆ
Duke,baaLo, guja, muTe

d) ಪೆಗಿ, ಜತ, ತರ, ಮಿಸ
pegi, jata, tara, misa

TEST ITEMS :

1) ಚೊಟಿ, ಬಿಕ. ಚೆಮ. ಚುಲಿ
coTi, bika, cema, culi

2) ಲುಟ, ಕೆಟಿ, ಬೆನು, ಸಟು
luTa, keTi, benu, saTu

3) ಕೊತ. ದಾಗೆ, ಬಾತು, ಮಾಚಿ
kota, daage, baatu, maachi

4) ಚೊತ, ನಿಕು, ಪತೆ, ಬುತಿ
chota, niku, pate, buti

5) ಸೊವ, ತುರೆ, ಡಿಕೆ, ಬಚೆ
sova, ture, Dike, bache

6) ತೊನ, ಪೊರಿ, ಲೊಣೆ, ಜಟು
tona, pori, loNe, jaTu

7) ಟುಕ, ಜಿನೆ, ಟಲೆ, ಟಿಗು
Tuka, jine, Tale, Tigu

8) ಕೆಪು, ವೆಟಿ, ಲುಮ, ಡೆಚೆ
kepu, veti, luma, Dece

9) ಲೆಗು, ಬಕೊ, ಜಿದೊ, ತುನೊ
legu, bako, jido, tuno

10) ಕಸೆ, ಕೆಟಿ, ಕುನ, ಪೊಗ
kase, keTi, kuna, poga

11) ಕನಿ, ತೊಪ, ಬೆಚಿ, ದುಲಿ
kani, topa, bechi, duli

12) ಟಬೆ, ಕೊಬು, ರಿಬ, ಜೆತ
Tabe, kobu, riba, jeta

Appendix E

Reading acquisition in Malayalam-A profile of the second graders (Sita, 2002)

A. Phoneme Segmentation Task in Malayalam

Demonstration Items

ഭംഗി /bʰaŋgi/	-	ം /ṁ/	=	ഭഗി /bʰagi/
പകൽ /pakal/	-	ൽ /l/	=	പക /paka/
കരം /karam/	-	അ /a/	=	ക്രം /kəram/
പക്ഷി /pakʃi/	-	ഷ /ʃ/	=	പകി /paki/
കുന്തം /kuntam/	-	ന /n/	=	കുതം /kutam/

Test Items

വാതിൽ /va:til/	-	ൽ /l/	=	വാതി /va:ti/
സംഭവം /sambʰavam/	-	ം /m/	=	സഭവം /sabʰavam/
മനം /manam/	-	മ /m/	=	അനം /anam/
ജലം /dʒalam/	-	അ /a/	=	ജ്ലം /dʒəlam/
സ്നേഹം /sne:ham/	-	സ /s/	=	നേഹം /ne:ham/
ത്യാഗം /tja:gam/	-	യ /j/	=	താഗം /ta:gam/
കർമ്മം /karmmam/	-	ർ /r/	=	കമ്മം /kammam/
ശക്തി /ʃakti/	-	ത /t/	=	ശകി /ʃaki/
സാമ്പാർ /sa:mba:r/	-	മ /m/	=	സാബാർ /sa:ba:r/
കാന്തി /ka:nti/	-	ദ /d/	=	കാനി /ka:ni/
മകൻ /makan/	-	ൻ /n/	=	മക /maka/
പാലം /pa:lam/	-	പ /p/	=	ആലം /a:lam/

B. Phoneme Oddity Task in Malayalam

Demonstration Items

മുട /muda/	മിത /mit̪a/	മെച്ചി /metʃi/	തടു /t̪adu/
ജുത /dʒut̪a/	കെതി /ket̪i/	ബിനു /binu/	സത /sat̪a/
മഞ്ജു /maɲdʒu/	കിട /kida/	തിജെ /t̪idʒe/	പിക /pika/
ജുകെ /dʒuke/	മസ /masa/	ശുന /ʃuna/	മുതി /mut̪i/
പഗി /pagi/	ജിത /dʒit̪a/	തുര /t̪ura/	മിസ /misa/

Test Items

ചെട്ടി /tʃeʈʈi/	ഭിക /bʰika/	ചെമ /tʃema/	ചുലി /tʃuli/
വഗെ /vage/	ഭഗി /bʰagi/	തില /t̪ila/	കഗോ /kagoː/
കൊത /kot̪a/	നാഗ /n̪aːga/	പാലി /paːli/	മാലു /maːlu/
മത /mat̪a/	നികു /n̪iku/	ബുതി /but̪i/	സിതെ /sit̪e/
നലി /n̪ali/	മികെ /mike/	കതെ /kat̪e/	പുനെ /pune/
തൊന /t̪ona/	പൊരി /pori/	മൊറെ /more/	ഇടു /idu/
തുക /t̪uka/	മന /mana/	തലി /t̪ali/	തിഗു /t̪igu/
വെചു /vetʃu/	കെട്ടി /keʈi/	മില /mila/	പെട /peda/
തപ /t̪apa/	മനോ /manoː/	കിടോ /kiɖoː/	പുകോ /pukoː/
കച /katʃa/	കെനി /keni/	കുടു /kudu/	ചൊന /tʃona/
സനി /sani/	ധുലി /dʰuli/	വൊപ /vopa/	കിരി /kiri/
ഡഭെ /dabʰe/	രിഭ /ribʰa/	കുഭു /kubʰu/	ജത /dʒat̪a/