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Non – Native Perception of the English Phonemes /w/ and /v/ by Native Sinhalese speakers: A Study Exploring Perceptual Difficulties associated with L2 Acquisition.

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ABSTRACT

The aim of this study was to test the abilities of native Sinhalese speakers to perceive and produce the English phonemes /w/ and /v/. It is well known that people who speak Sinhalese as their first language have difficulty in acquiring the English (L2) phoneme contrast [w-v]. This is commonly seen among these speakers in their L2 speech production. Experiment 1 involved native Sinhalese speakers completing language background questionnaires and carrying out an English phoneme identification task of natural speech for assessment of their L2 perception. Experiment 1 also consisted of a voice recording of the Sinhalese subjects in order to assess their L2 speech production. Experiment 2 required the native Sinhalese speakers to carry out an identification/goodness task of synthesised English phonemes and to state whether the stimuli could be assimilated to the native Sinhalese phoneme /ʋ/. Experiment 2 also involved an identification/goodness task in which native Sinhalese bilinguals and English monolinguals assessed the synthesised stimuli for assimilations to the English phonemes /w/ and /v/. Experiment 3 was carried out by both Sinhalese and English speakers and involved a discrimination task and similarity task. The results showed that the Sinhalese bilinguals generally had a low sensitivity to perception of the English phonemes. The Sinhalese Bilinguals who had more proficient use of their second language L2 showed a high sensitivity for acoustical changes in the dimension of manner of articulation wile the English speakers were sensitive to both manner and place of articulation.

INTRODUCTION

English is one of the most widely used languages in the world. For the majority of the Sinhalese speaking population, English is learnt as their second language (L2) at school. Most Sinhalese speakers have difficulty in the production of the speech sounds /v/ and /w/ that belong to the non-native English language. When speaking English, most native Sinhalese speakers produce the phoneme /v/ when the required phoneme is /w/ and vice versa. As speech production and perception are closely related, they are both required for fluent use of a language. If Sinhalese speakers have difficulty with their L2 production, is there an underlying difference in the perception of the English phonemes /v/ and /w/ between native Sinhalese speakers and native English speakers? How does the perception of non-native phonemes (L2) and native phonemes (L1) differ?

Sinhalese is a southern Indo-Aryan language which originated from Dravidian spoken in South India (Gair, 1998). A phoneme exists in the Sinhalese phoneme inventory, /ʋ/, which is similar to English /v/ and /w/ and it is investigated in this current study. /ʋ/ is classed as a bilabial semi-vowel which can be compared to a voiced /f/ without friction. This Sinhalese phoneme is produced with lips almost in complete closure and the oral cavity shaped as if the speaker was producing the phoneme /ə/. Neither /v/ nor /w/ exists in the inventory of Sinhalese phonemes (Perera, 1919).

DIFFICULTIES OF L2 ACQUISITION

All languages have a specific inventory of phonemes used that is unique for that particular language. Each phoneme set can be further divided according to regional accent variation as well. Difficulty with perception of non-native phonemes occurs in many different languages. The difficulty of Japanese speakers to perceive a contrast between English rhotic /r/ and lateral /l/ consonants has been extensively studied. The Japanese language categorises /r/ as a liquid consonant and /l/ does not exist in its inventory causing misperception of English production of /r/ and /l/ (Hallé, Best & Levitt, 1999; Miyawaki et al., 1975). This difficulty is present even in Japanese speakers who are fluent in English, as adequate phonemic production can occur with degraded phonemic perception. This is possible due to the speakers lacking the sophisticated auditory feedback required for rectifying articulation after acknowledging mispronunciation (Goto, 1971). Another such example is found by native Finnish speakers who perceive the Estonian vowel /õ/ differently as it is not a member of the existing Finnish phoneme set. It is perceived as being a combination of the two Finnish phonemes /ö/ and /o/ (Cheour et al., 1998). Studies have shown that when a common phoneme is present in the native phoneme inventories of two different languages, the acoustic cues used for the identification of that phoneme may be different for the two languages, resulting in erroneous phonemic perception. An example of this is found in the study of Flege & Port (1981). Speakers native in Arabic do not pay attention to vowel duration cues in identification of voicing of syllable-final stops and only concentrate on offset transition, whereas English speakers require duration information as well for voicing identification. Many other similar examples such as these stated exist.

Normal acquisition of L1 commences at birth provided normal learning and communicative capabilities. L2 is predominantly learnt later in life or may also be from birth. There are many factors of language acquisition that vary between a bilingual's native language (L1) and their non-native second language (L2). Some of the factors include ambient exposure, usage, proficiency and initial age of learning L2. The age of beginning acquisition effects normal development, and therefore production and perception of a second language, because the degree of plasticity of language systems in the brain decreases as a child ages. Loss in plasticity makes learning a second language more effortful. If age of acquisition is early while establishment of the native language is not yet complete, learning L2 will be easier. Age of exposure to the non-native language also affects the proficiency of use of L2 after the non-native language has been learnt. MacKay et al. (2001) investigated two groups of native Italian bilinguals whose second language was English. These two groups differed in their age of exposure to L2, i.e., one group was exposed to L2 early in life and other at a later stage. This study suggested that the late L2 exposure group were more erroneous at English phoneme identification tasks than the early exposure group indicating early exposure to be helpful for optimum L2 acquisition. Roberts et al. (2002) drew a similar conclusion about L2 proficiency and age of exposure. Exposure to a language is important because increasing experience of a language will lead to a better ability of isolating and listening to the definitive acoustic cues for phoneme identification and tuning out less informative cues (Nittrouer & Burton, 2005). Another study demonstrated that infants are able to learn phonemes by mere exposure to the language alone; this was seen to occur in the first six months of the infants studied (Kuhl et al., 1992). From the studies already mentioned, it is evident that difference in acquisition of native and non-native language result mainly from acquiring the second language at a later stage of linguistic development. The optimal way in which to acquire L2 would be at an early age as possible to minimise the difference in the quality of L1 and L2 acquisition. From the literature already discussed, it can be hypothesised that native Sinhalese speakers will have better production of English (L2) if exposed to the second language early in life and if it is spoken frequently and proficiently. This in turn may effect native Sinhalese speakers' perception of English phonemes. This is investigated in the current study.

L1 ACQUISITION

New-born infants have already been exposed to speech of their mother tongue before birth in-utero. A study by Kuhl (2000) suggests that the strategies required for perception of these sounds are innate and so making it possible for unborn infants to experience native speech sounds before birth. After birth, hearing speech in their ambient environment contributes towards the development of their auditory and cognitive skills. Auditory perception is required to hear speech sounds before they can be processed at a linguistic and phonetic level in the brain, in order for speech to be recognisable and categorical. The initial ability of an infant to perceive speech is thought to be non-selective, i.e., all auditory information of a speech signal heard is processed by the infant. This is due to lack of phonetic and lexical knowledge, which will be defined in time through experience. A recent study demonstrated that lack of selectivity is thought to dominate the first six months of an infant followed by enhanced sensitivity to perceiving acoustic properties of speech for speech processing in the second half of the first year of an infant (Jusczyk, 2002). Studies prior to that of Jusczyk (2002) suggested that speech perception took place in infants as early as one month, even before being able to reproduce the speech being heard (Eimas et al. 1971). Eimas (1975) then went on to suggest that infants aged two to three months had the ability to discriminate phonemes along an acoustic continuum with increased sensitivity for discrimination of the sounds if they originated from different categories. Kuhl (1995) however, suggested that by the age of six months, infants develop the ability to create a lexicon of representations for corresponding speech sounds heard, vowels being represented initially. After a small amount of exposure to speech, infants refine their ability to listen out for specific acoustical information about the phonemes that they hear. An increased sensitivity to discriminate between phonemes accompanied by a heightened perception of boundaries between phonemes therefore takes place. This change in perception is also present in non-human animals, which indicates that its underlying process is a basic auditory process in nature (Kuhl 1994).

Initial phoneme perception in infants later becomes more attuned to phonemes of the child's native language. The ability of infants to switch from solely hearing speech sounds to selectively perceiving and processing phonemes relevant to their native language shows a shift from language-general to language-specific form of phoneme discrimination (Bosch & Sebastiàn-Gallés, 2003; Werker & Tees, 1984). The decreased ability for discriminating non-native phonemes compared to the increased sensitivity for discriminating native phonemes is not due to sensorineural loss associated with non-native phonemes (Werker & Tees, 1984). As with Kuhl's (1995) study, this discrimination shift takes place for vowels before consonants. As infants mature, increased sensitivity resulting in newly developing perception of acoustic cues leads to an accumulation of internal representations for the set of phonemes used by their native language (MacKay et al. 2001). Best & Strange (1992) suggested that this perceptual sensitivity be not completely closed to L2 acquisition, which will over time lead to L2 phoneme representation similar to that of L1. It was also noted that the discrimination shift took place earlier for monolinguals in comparison to bilinguals due to bilinguals requiring extra time for perceptual reorganisation. The brain of a bilingual undergoes more extensive phonetic processing than a monolingual speaker (Bosch & Sebastiàn-Gallés, 2003). This theory is supported by Perani et al.'s (2003) study that demonstrated increased cerebral activity in the brain of a proficient bilingual compared to that of a monolingual speaker.

Language acquisition can be improved for phonetic perception by altering the type of phonetic exposure encountered by an infant. In a study conducted by Kuhl et al. (1997), it was shown that mothers who spoke to their baby infants with exaggerated stretching of the phonemes by increasing phoneme duration (especially vowels), caused stretching of the infants' perceptual vowel space. Vowel space stretched phonemes incorporated more linguistic information than phonemes produced by the mothers to adults, which assists in language acquisition. Phonetic learning is also improved when infants are exposed to speech sounds originating from a live person speaking directly in their physical environment than if the speech sounds were heard by the infants via an audio recording (Kuhl et al., 2003). This not only helped infant social interaction but also aided their ability to extract speech segments from running speech through refined joint visual attention leading to improvement of their phonetic perception of speech segments. Normal language acquisition as discussed so far should take place for a person's native language.

Studies investigating mismatch negativity are useful for understanding how language acquisition and storage of phonetic information of a language are related. The developing infant stores memories of acoustic information about phonemes that are heard most frequently. Stored memory traces are accessed when triggered by sensitive acoustic cues used for identification of a particular phoneme (Näätänen, 2001). Memory traces for speech sounds begin forming in the first year of life. Analyses of speech sound memory stores are carried out using mismatch negativity

(MMN) amplitudes. MMN amplitudes form by preattentive auditory processing that takes place when hearing acoustic information of a spoken phoneme. This leads to access of a memory store of its phonemic representation. The amplitude of MMN decreases if the stimulus being heard is native, as its stored representation will be well developed and easier to access eliciting a reduced brain response than if a non-native phoneme were being listened to. MMN responses of bilinguals perceiving L2 phonemes can therefore resemble the preattentive responses of native speakers of that language once they are fluent in L2 (Cheour et al., 1998). As MMN response is preattentive, it can be elicited by passive listening conditions (Diesch et al., 1998). Other studies have found that phonetic detection is quickened by lexical knowledge of the context in which the speech sound is heard (Cheour et al., 1998).

MODELS OF L2 ACQUISITION

Phonemes that are heard from speech are matched against phonemes that are stored in long term memory representatives. Two phonemes of a contrast that share the same acoustic cues are connected in perceptual space. Phonemes can be separated in perceptual space by the difference in acoustical information that can be seen to change along a continuum between two contrasting phonemes. The accuracy with which these acoustic cues of the phoneme contrast are perceived will affect the identification and discrimination of the exemplars of the contrast. Sensitivity to the acoustic information is not evenly distributed in the perceptual space of a phoneme contrast meaning that listeners will be more accurate at recognising phonemes allocated near their best corresponding exemplar and discrimination of the quality of these phonemes will be poor due to them all being perceived as good quality representatives of the best exemplar. Discrimination of two phonemes lying near the best exemplars of two different categories will however be efficient. Areas of the perceptual space that are stretched indicates the transition where recognition of one phoneme merges with another, this is called the phonemic boundary. Sensitivity is heightened at the phonemic boundary making perception of the phonemes corresponding to this area easier with poorer discrimination due to miscategorisation.

Liberman (1957) wrote about the existence of perceptual warping and the learning processes that were believed to be underlying categorical perception. Perceptual warping in such a way led to an increased sensitivity of perception when the phonemes that were categorised differently were heard repeatedly, this is called acquired distinctiveness. As mentioned above, when phonemes are labelled into the same category, discrimination within these phonemes diminishes after repetition due to a fall in sensitivity, this is called acquired similarity.

Kuhl's Native Language Model (NLM) suggests that the best exemplar of a phonemic category is considered to be a prototype for that corresponding phoneme. These prototypes that exist mentally (Kuhl, 1991), act as magnets drawing other phonemes surrounding it closer, leading to very little difference in perceived acoustic cues between phonemes near the prototype. This explains why phonemes situated near prototypic exemplars have excellent identification but poor discrimination within phoneme categories. The perceptual magnet effect is specific for humans as studies in which Rhesus monkeys were the test subjects, results showed that such an effect was not elicited (Kuhl, 1995). Perceptual magnet has a different underlying process from that producing phonemic boundaries as is seen by experiments conducted by Iverson & Kuhl (2000), in which changing the conditions of the experiment led to absence of the phonemic boundary effect whereas the perceptual magnet effect remained. This study also showed a decrease in magnitude of the perceptual magnet effect when the test subjects labelled the speech sounds heard as bad exemplars for that phoneme category. Multidimensional scaling has also been used to illustrate the perceptual warping of the perceptual magnet effect showing clustering around best exemplars of a category (Iverson & Kuhl, 1995).

Best's Perceptual Assimilation Model (PAM) is based on the theory of native speakers assimilating non-native speech to equivalent phonemes that exist in the L1 phoneme inventory. This assimilation is dependent upon the phoneme contrast being analysed and also the phonetic-articulatory similarities between the non-native phoneme being perceived and its native counterpart (Hallé et al., 1999; Best et al., 1988). Another study supporting PAM showed children's acquisition of their second language being assisted by using information they learnt from their native language (Anderson, 2004). If a listener's L1 phoneme inventory does not have a phoneme equivalent to the non-native phoneme being heard, then the listener will be highly insensitive to perception of the non-native phoneme. This is evident in Japanese speakers who have a lot of difficulty categorising all forms of English /l/ as an equivalent phoneme does not exist in their phoneme inventory (Hallé et al., 1999).

Flege's Speech Learning Model (Flege et al., 1995) suggests that non-native speech is equated by the listener to his / her own native speech. Difficulty will arise if the non-native speech is not classed as similar and if it classed as similar, the perceptual magnet effect will ensue. Flege also worked on perceived foreign accent of L2 on production. Accent can be perceived even if the speaker has an early age of learning the non-native language. From this, it can be assumed that perceived accent will be accompanied by non-native speech perception by that speaker.

Multiple cues from an individual phoneme can give different acoustic information to help the speaker's perception of the phoneme. Weighting of speech perception by non-native speakers on an acoustic cue that is used as a secondary cue to native speakers is shown in a different study. Japanese speakers attempting to identify examples of the [r-l] English contrast were concentrating their perception on changes on the F2 dimension that is a cue not used by English speakers for [r-l] identification (Iverson et al., 2003). The speech cues perceived by the listener share the same origin of articulation (Best et al., 1981).

PRESENT STUDY

The main aim of this current study was to explore why Sinhalese speakers have difficulty with the English [r-l] contrast. Native English speakers and non-native Sinhalese speakers with English as their second language were the test subjects of this study. Trained phoneticians also participated for the purpose of assessing the perceived accent of the members of the non-native group. Experiment 1 involved the bilingual group identifying natural speech (English) of /ava/ and /awa/ examples for assessing their identification in speech mode, completion of a questionnaire regarding their language background and a voice recording for assessment of their perceived accents. Experiment 2 consisted of an identification and goodness task testing the perception of all of the phonemes being investigated in this study, i.e., /v/, /w/ and /ʋ/. Native English speakers only participated in the task concerning the English phonemes and the bilingual group carried out both tasks. The purpose of this experiment was to help identify the best exemplars of the phonemes in question. Experiment 3 required all participants of this study to undertake a discrimination and similarity task in order to determine and map any perceptual warping that may take place and to learn more about the way in which the acoustic cues being varied (independent variable) affect phoneme perception.

EXPERIMENT 1

The main aim of Experiment 1 was to assess the speech production and speech perception capabilities of the Sinhala/English bilinguals when using their second language English (L2). This was carried out by the subjects taking part in a natural speech identification task of medial English phonemes /v/ and /w/, assessment of the subject's accent through recordings of their English speech production and using information from questionnaires completed by the subjects regarding their language background.

METHODS

PARTICIPANTS

A group of twenty Sinhala/English bilinguals, aged between 21 and 71 years participated in Experiment 1. The bilinguals all spoke English as their second language (L2) having acquired Sinhalese from birth. The native Sinhalese group of subjects had a varied range of age of exposure to English. Most of these subjects started learning English during their primary education (age at which they began to learn English ranges from 2.5 to 18 years). Their age of arrival to England ranged from 14 to 39.5 years. None of the participants had a hearing impairment or have lived in any other English speaking country.

STIMULI AND APPARATUS

NATURAL IDENTIFICATION TASK

The natural speech identification task consisted of 46 trials of natural speech produced by voice recordings of two male and two female speakers. Each speaker was recorded in a quiet environment. The stimuli used in the natural identification task were medial English consonants /v/ and /w/ with initial and end vowels /a/, /i/ and /u/, i.e., the stimuli were /ava/, /awa/, /ivi/, /iwi/, /uvu/ and /uwu/, which were recorded twice by each speaker.

VOICE RECORDINGS

The stimuli used for the voice recordings of the test subjects was the following L2 phrase clearly printed in block capitals on a sheet of A4 card, "THE HEAVY WIND SWEPT AWAY VALERIE'S VELVET SCARF". Recording of good quality audio files was achieved by using a quiet environment.

APPARATUS

The apparatus required for the natural identification task were a set of headphones and a PDA. This equipment was used by all of the bilingual subjects in this experiment for uniformity. Recording of the non-native speech produced by the Sinhalese bilinguals was directly saved on the PDA. These voice recordings were then played back to the three trained phoneticians for accent rating.

PROCEDURE

All subjects were asked to complete a printed questionnaire regarding their personal details and language background (see Appendix 1).

NATURAL IDENTIFICATION TASK

The natural identification task involved the subject listening to 46 trials of natural speech. Their task was to identify whether the medial consonant speech sound they perceived of the VCV trial corresponded to the letter V or W. The order of the trials was randomised for each test subject. All subjects were given a practise test to help familiarise them with the stimuli and feel at ease. Trials could not be repeated.

VOICE RECORDINGS

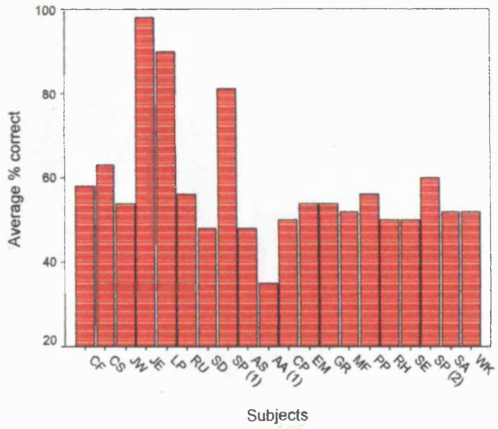
Voice recordings required the subject to repeat, in spoken form, the following phrase that was presented to them in written form, "THE HEAVY WIND SWEPT AWAY VALERIE'S VELVET SCARF". A quiet environment was used to ensure that all voice recordings were of equally good sound quality in order to aid the accent rating task of the trained phoneticians.

Three trained phoneticians rated the accents of the voice recordings of the native Sinhalese test subjects. The scale used was 1 – 10 according to how native-like (English) the accent of the subject was. A low score represented a strong foreign (Sinhalese) accent and 10 represented a native-like (English) accent.

RESULTS

NATURAL IDENTIFICATION TASK

The results from the natural identification task show significant inter-subject variability for percentage of correct identification of the stimuli overall (Figure 1). The average percentage correct scored by the listeners varied from 35.4% to 97.9% (mean – 58.1%, standard deviation – 14.9%) showing a varying range of ability of sufficient perception of English phonemes /v/ and /w/. The majority of test subjects scored an average percentage correct in the region of 50% indicating that responses are more close to chance. Only three individuals had a score that was significantly above chance (% correct scores were 97, 90 and 81 for those three subjects).



<u>Figure 1: Bar chart natural identification: Overall % correct for individual subjects.</u>
Showing varying abilities of English phoneme identification by the Sinhalese bilinguals. The majority of the test subjects have positive identification at approximately 50% indicating that identification may be due to chance. There are three listeners who are significantly better at English phoneme identification than the remaining test subjects.

In the natural identification results, identification of the medial consonant was heavily dependent on vowel context (Figure 2). When listeners heard the vowel context /i/, there was more bias to identifying the medial consonant as /v/. This is supported by the percentage identification of the consonant as /w/ in the vowel context /i/ being lower than chance. It was also noted that when the subjects heard the vowel context /u/, there was a strong bias for identification of the medial consonant as /w/ (Figure 2). This vowel driven effect is more strongly seen with the results of the strong L2 group of bilinguals than the weak L2 group. For both contextual effects stated, on average the strong L2 group's identification of /ivi/ and /uwu/ was 9.4% and 6.8% respectively higher than the weak L2 group's identification. The strong L2 group of bilinguals therefore had a better overall perception of English consonants /v/ and /w/. There was no significant improvement in correct identification of the consonants due to an individual speaker being heard. Stimuli from all four of the speakers were perceived equally by the test subjects.

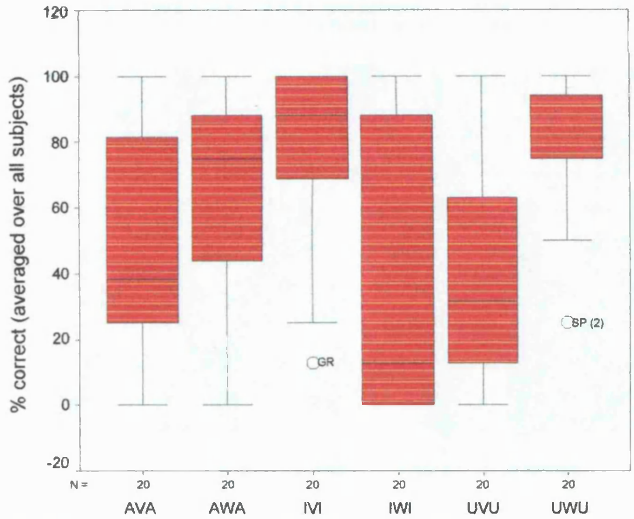


Figure 2: Box plot showing vowel context effect: Natural identification. Increase in accuracy of positive identification of the phonemes /v/ when in the vowel context /i/ and the phoneme /w/ in the vowel context /u/.

NATURAL IDENTIFICATION TASK AND ACCENT RATING

Accent rating carried out by the trained phoneticians then gave insight into the bilinguals' non-native speech production by quantifying how English-like their accents were. This involved rating their accent on a scale of one (non-native accent) to 10 (native English accent). As with results from natural identification, the range of average rating was considerable (2.33 – 8.00) indicating significant variation in accent amongst the bilingual group. Comparison of accent rating (speech production of L2) and natural identification (speech perception of L2) in Figure 3 showed a positive correlation, $r = 0.484$, $p = 0.03$. This indicated that as the test subjects achieved higher average percentage correct scores for natural identification of English phonemes, their speech production was perceived as being a better representation of a native English accent (Figure 3).

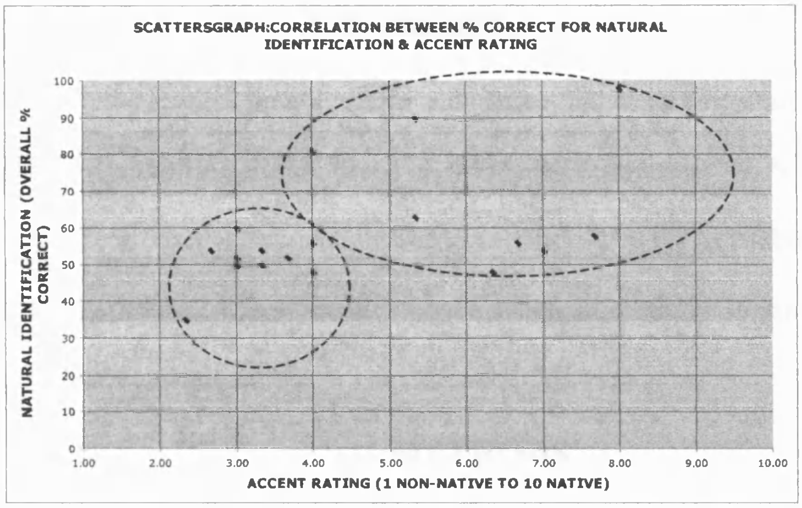


Figure 3: Accent rate – natural identification scatter graph. A positive correlation between the natural identification task's results and the average accent rating given to the test subjects by the trained phoneticians. This indicates that there is a relationship present connecting L2 speech production and perception. From this, the subjects were further sub-categorised into two groups according to their proficiency of L 2 (the groups are identified by circles).

For analysis of test results in further experiments, the Sinhalese bilingual test subjects were divided into two groups. This grouping was carried out using information from the natural identification task and accent rating given to the subjects by the trained phoneticians (Figure 3). The first group consisted of subjects with strong use of L2 that scored greater than 80% correct in the identification task and was rated highly on the English accent scale (scoring above 5). The first group was therefore called the strong L2 bilingual group. The second group of test subjects were grouped together as their use of L2 was weak, therefore called the weak L2 bilingual group. This group included subjects scoring less than 80% correct for natural identification and receiving a low rating on the English accent scale (less than 5).

EXPERIMENT 2

Both native English monolinguals and Native Sinhalese bilinguals took part in Experiment 2. Synthesised stimuli based on the medial consonants /v/, /w/ and /ʋ/ were used in identification and goodness tasks carried out by the test subjects. The purpose of Experiment 2 was to identify what acoustic information forms the best exemplars of /v/, /w/ and /ʋ/.

METHODS

PARTICIPANTS

The same twenty Sinhala/English bilinguals subjects, described in Experiment 1, participated in the English /v/ and /w/ identification/goodness task and also the Sinhalese /ʋ/ phoneme identification/goodness task. Ten native English monolinguals took part in the English /v/ and /w/ identification/goodness task. These native English monolinguals were aged between 20 and 60 years. They did not suffer from any known hearing impairment and none have lived in another English speaking country.

STIMULI AND APPARATUS

SINHALESE PHONEME IDENTIFICATION / GOODNESS TASK

The stimuli were medial consonants in the VCV format and all synthesised stimuli had the initial and end vowel /a/. They were synthesised using a Klatt synthesiser (Klatt, 1980). The original utterance on which the stimuli were based was /ava/ produced by a female speaker. This original recording's consonant component was then modified on two dimensions (independent variables). The first varying dimension was place of articulation, which was produced by increasing the F2 formant frequency of the stimulus in four steps using the ERB scale (Glasberg & Moore, 1990). The F2 frequencies used were 680Hz, 875Hz, 1112Hz and 1400Hz.

This continuum produced a change in place of articulation from bilabial (at the 680Hz extreme) to labiodental (at the 1400Hz extreme). The second dimension along which the stimuli varied was that of manner of articulation. The manner of articulation shifted from an approximant to a fricative along the second continuum. This dimension was varied by changing the amplitude of frication, F1 formant frequency and transition duration. Amplitude of frication increased in equal linear steps from 31dB, 34dB, 37dB to finally 40dB. The F1 formant frequency was decreased in equal steps using the ERB scale as before; the F1 frequencies were 316Hz, 267Hz, 223Hz and 182Hz. The transition duration was altered by changing the time of closure and the transition time out of closure while the transition time into the closure remained constant at 80milliseconds (ms). As the manner of articulation changed from approximant to fricative, the values of closure duration were (in ms) 60, 73, 87 and 100. From approximant to fricative, the values of the transition time out of closure decreased (in ms) were 80, 67, 53 and 40. The total duration of closure and transition time out of closure remained at 140ms (See summary Table 1).

Figure 4: Synthesised /VCV/ stimuli

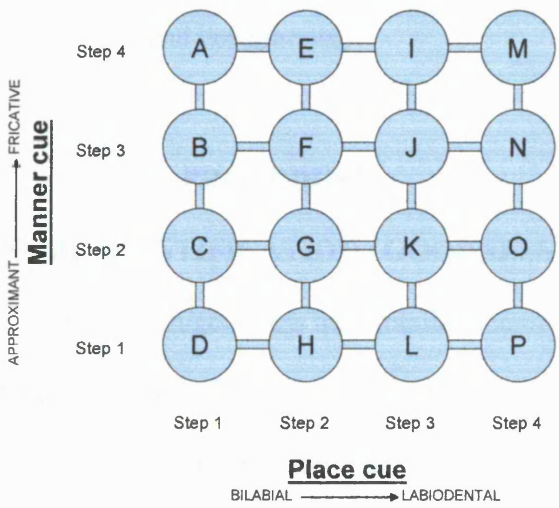


Table 1: Summary of values of the independent variables, place and manner of articulation.

STEP	PLACE	MANNER		
	F2 (Hz)	Amplitude of frication (dB)	F1 (Hz)	Closure: transition out (ms)
1	680	31	316	60:80
2	875	34	267	73:67
3	1112	37	223	87:53
4	1400	40	182	100:40

In this way, the stimulus was varied in four steps in the dimensions described forming a matrix of 16 stimuli varying in both four levels of place and manner of articulation.

ENGLISH PHONEME IDENTIFICATION / GOODNESS TASK

The 16 stimuli synthesised used for the Sinhalese identification/goodness task (as described above) were the stimuli used for the English phoneme identification/goodness task in Experiment 2.

APPARATUS

The apparatus used for both tasks of Experiment 2 were the same as those used in Experiment 1, i.e., PDA and headphones.

PROCEDURE

SINHALESE PHONEME IDENTIFICATION / GOODNESS TASK

The Sinhalese identification/goodness task entailed members of the English/Sinhala bilingual group listening to the stimuli which they then had to identify as either a good or bad exemplar of the Sinhalese /ʋ/ phoneme being investigated in this study. If the stimulus was classed a good exemplar of the

Sinhalese /ʋ/ phoneme, the subject was then required to rate the quality of the stimulus as a representation of their best perceived exemplar of this phoneme. The goodness rating assigned to each stimulus by the listener was along a scale from poor exemplar of /ʋ/ to good exemplar of /ʋ/. Each trial could only be heard once for the identification component of this task. However, the trial could then be repeated for purpose of goodness scaling. The order of the trials was randomised differently for each test subject.

ENGLISH PHONEME IDENTIFICATION / GOODNESS TASK

The English identification/goodness task followed a very similar formula. This task was completed by both native English monolinguals and native Sinhalese bilinguals. The participants listened to each trial and were asked to identify whether they perceived the English phoneme /v/ or /w/. After identification, that stimulus was rated on a goodness scale requiring the subject to judge how good an exemplar of the identified phoneme the trial actually was. The extremes of the scale were good exemplar of /v/ to good exemplar of /w/. As with the Sinhalese identification/goodness task, the subjects could listen to the trial only once for identification, but then was allowed to repeat the stimulus if necessary to rate it on the goodness scale. The order of the trials was randomised differently for each test subject.

Both tasks were preceded by a practise test in order to familiarise the test subjects with the synthesised speech sounds and procedure of the tasks. The practise test for both the Sinhalese identification/goodness task and English identification/goodness task consisted of 16 practise trials. The stimuli used in both the Sinhalese and English identification/goodness task were a total of 64 trials that can be broken down into four repeats of 16 different stimuli (A – P, see Figure 4) of the synthesised stimuli matrix.

RESULTS

SINHALESE PHONEME IDENTIFICATION / GOODNESS TASK

The Sinhalese identification/goodness task was carried out by the Sinhalese bilingual subjects. Their data was analysed following the sub-grouping of the subjects into the strong L2 bilingual group and weak L2 bilingual group as discussed in the results section of Experiment 1. There was considerable variation between subjects in the identification results in the Sinhalese /ʋ/ task (Figure 5). All of the synthesised stimuli were significantly (more than at chance) assimilated to /ʋ/ by the listeners (Figure 5). The average identification of the synthesised stimuli as /ʋ/ ranged from 64.6% - 79.2% for the strong L2 group and from 53.1% - 90.6% for the weak L2 group. Identification results showed that some subjects uniformly perceived all the stimuli to be good representatives of /ʋ/ and some subjects showed the opposite pattern. The listeners did not class any of the stimuli as good exemplars of the Sinhalese phoneme /ʋ/, which is indicated by the goodness ratings of the stimuli being approximately 0.5, especially for the strong L2 bilingual group (Figures 6 & 7). In general, there was a not a specific synthetic phoneme classed as the definitive representation of Sinhalese phoneme /ʋ/. This observation is supported by the lack of specific synthesised stimuli rated with a significantly high goodness rating, seen in Figure 6 and Figure 7, in comparison to other stimuli.

Figure 5: Bar graph: Group average % of stimuli identified as a Sinhalese phoneme /ʋ/.
All of the synthesised stimuli were significantly identified as the Sinhalese phoneme /ʋ/, i.e., higher than at chance. There is significant variation between the test subjects in both groups.

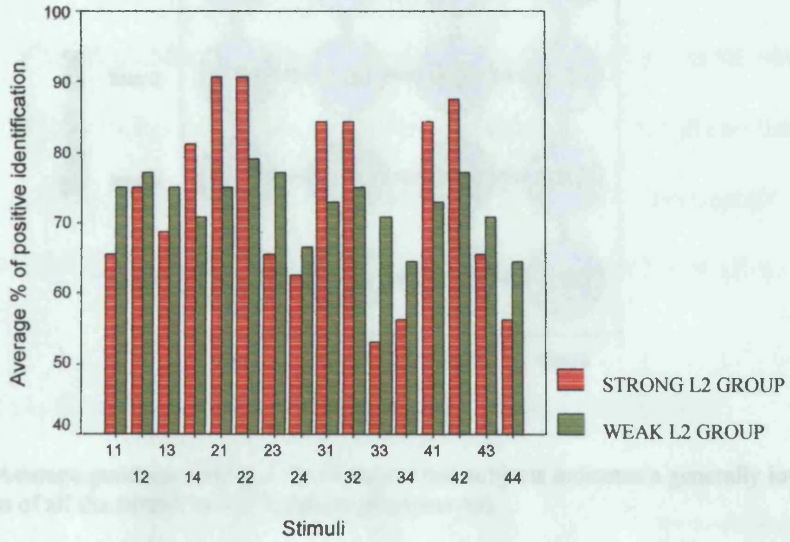


Figure 6: Sinhalese goodness task: Average goodness Strong L2 bilingual group

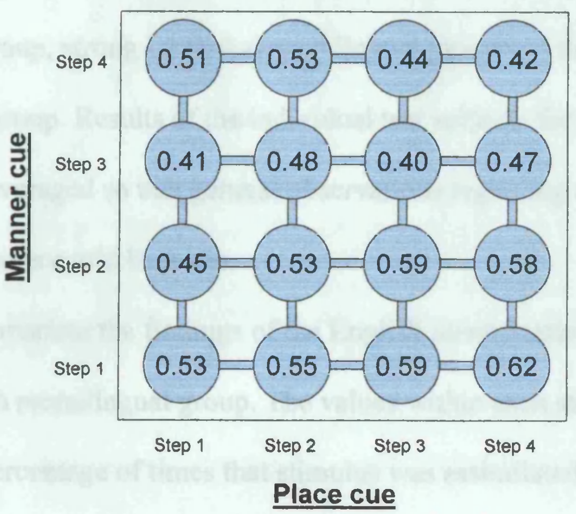


Figure 6: Average goodness rating of the Sinhalese test subjects indicates a generally low assimilation of all the stimuli to the Sinhalese phoneme /ʋ/.

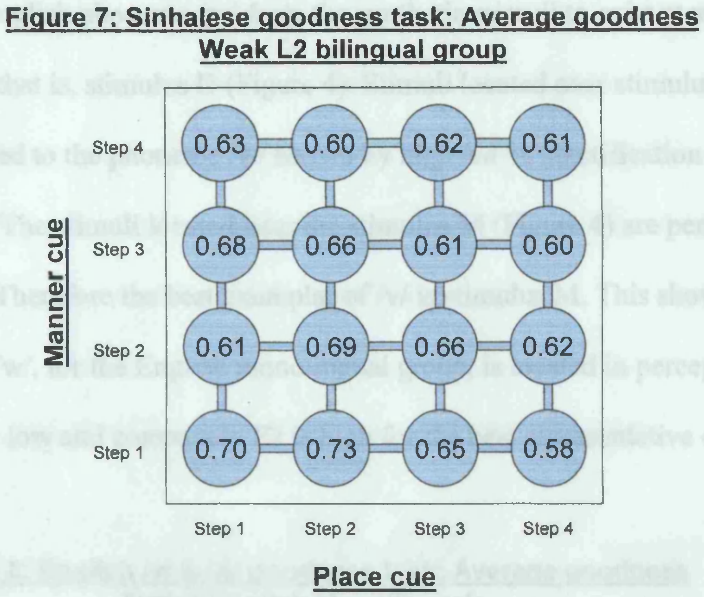


Figure 7: Average goodness rating of the Sinhalese test subjects indicates a generally low assimilation of all the stimuli to the Sinhalese phoneme /ʋ/.

ENGLISH PHONEME IDENTIFICATION / GOODNESS TASK

The English identification task was carried out by the native English monolinguals and by the Sinhala/English bilinguals. The results were separated into the native English group, strong L2 Sinhalese bilingual group and the weak L2 Sinhalese bilingual group. Results of the individual test subjects for the three separate groups were firstly averaged so that general observations regarding any patterns forming from the results could be made.

Figure 8 summarises the findings of the English identification/goodness task for the native English monolingual group. The values within each stimulus space corresponds to the percentage of times that stimulus was assimilated to /w/ and the average goodness rating of the predominant phoneme to which it was mostly assimilated to. Therefore, it is possible to locate the best exemplars of /w/ and /v/ using information from the goodness ratings of the stimuli and percentage of assimilations for the stimulus to /w/. Overall, the monolingual group showed the best exemplar of the English phoneme /w/ from the synthetic stimuli to exist at step 1 in both dimensions, that is, stimulus D (Figure 4). Stimuli located near stimulus D were strongly assimilated to the phoneme /w/ shown by high /w/ % identification and high goodness ratings. The stimuli located near the stimulus M (Figure 4) are perceived as the phoneme /v/. Therefore the best exemplar of /v/ is stimulus M. This shows that the best exemplar of /w/, for the English monolingual group, is located in perceptual space where F2 is low and conversely F2 is high for the best representative of /v/.

Figure 8: English /v/ & /w/ goodness task: Average goodness Native English Monolinguals

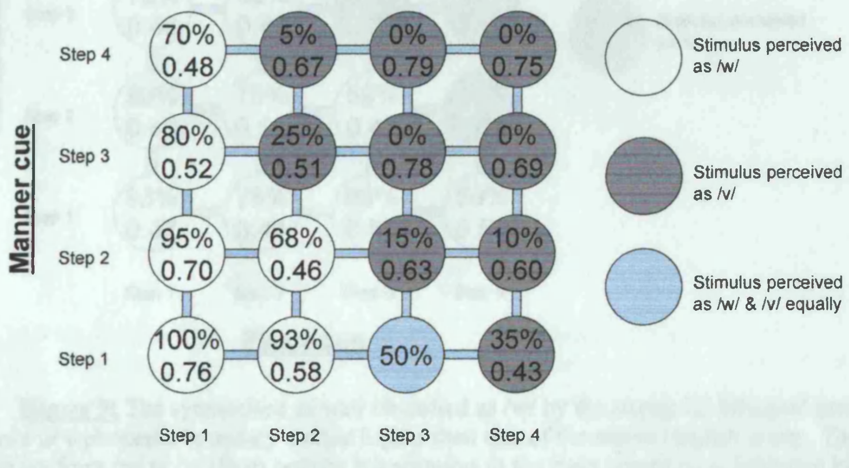


Figure 8: The synthesised stimuli identified as /w/ by the English monolingual group shows the presence of a phoneme boundary. The change of perception from /w/ to /v/ (from bottom left stimulus to top right stimulus) is indicated by the percentage of /w/ identification decreasing from the bottom right stimulus to the top right stimulus. The average goodness rating, of the predominant phoneme that the stimulus was identified as, is shown in a scale from 0 to 1.

Figure 9 shows the results the strong L2 group of Sinhalese bilinguals indicating the average percentage identification of the stimuli as /w/ and the average goodness rating given to each stimulus for the predominant phoneme category to which the stimulus was assimilated. As with the native English monolingual group, Figure 9 shows the strong L2 group had its best exemplar of /w/ at stimulus D and its best exemplar of /v/ at stimulus M (Figure 4). The phoneme boundary for the strong bilingual group, indicated by the change of assimilations from /w/ to /v/ on the stimuli grid, was shifted along both dimensions of place and manner of articulation when compared to the phoneme boundary of the English monolingual group. When the stimulus resembled a labiodental and fricative, it was more likely to be identified as /w/ by the strong L2 group than the English monolingual group.

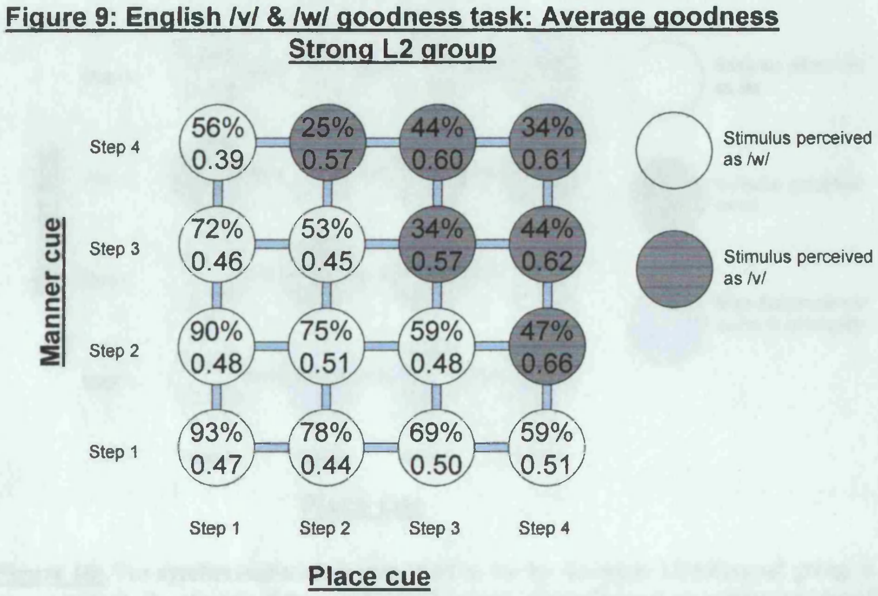


Figure 9: The synthesised stimuli identified as /w/ by the strong L2 bilingual group shows the presence of a phoneme boundary shifted higher than that of the native English group. The change of perception from /w/ to /v/ (from bottom left stimulus to top right stimulus) is indicated by the percentage of /w/ identification decreasing from the bottom right stimulus to the top right stimulus. The average goodness rating, of the predominant phoneme that the stimulus was identified as, is shown in a scale from 0 to 1.

Figure 10 summarises the averaged results of the English identification/goodness task for the weak L2 Sinhalese bilingual group. From Figure 10, the best exemplar of /w/ appears to be stimulus I and the best exemplar of /v/ is stimulus K (Figure 4). In general there is not a particular synthesised stimulus that was strongly representative of the English phoneme /v/ or /w/. With the English monolingual and the strong L2 Sinhalese group there is a clear pattern of increasing percentage identification and goodness rating as the stimuli are located closer to the best exemplars of /v/ and /w/. This pattern is not present for the weak L2 bilingual group showing that members of this group may be categorising the stimuli as either /v/ or /w/ by chance. This is supported by the percentage of identification being in the region of 50% for the stimuli and the moderate goodness ratings given to the stimuli.

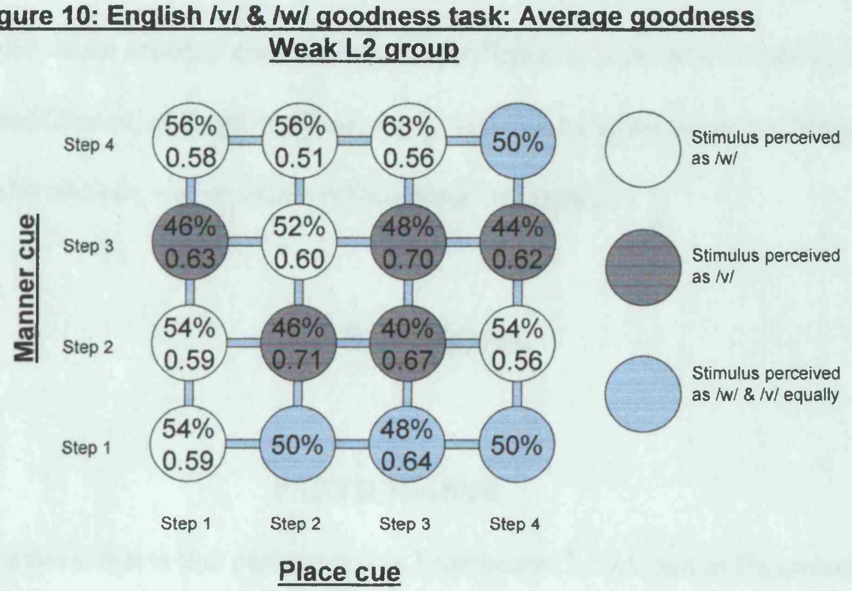


Figure 10: The synthesised stimuli identified as /w/ by the weak L2 bilingual group is distributed unevenly in the stimuli of the synthesised matrix. There is no clear pattern of identification in the results showing that the stimuli were perceived with low sensitivity. The percentage of /w/ identification is varied for the stimuli around 50% indicating identification of the synthesised phonemes that may have involved guessing. No clear pattern is available in the goodness ratings of the stimuli.

EXPERIMENT 3

The aim of Experiment 3 was to map out the perceptual spaces for the English phoneme contrast [w-v], for all of the test subjects participating in this study, using discrimination and similarity tasks. The acoustic cues used for phoneme identification were the cues that the listeners are most sensitive to. The purpose of Experiment 3 was to identify these acoustic cues and note any differences seen between the cues used for identification, of English phonemes /v/ and /w/, by native speakers (English monolinguals) and non-native speakers (Sinhalese bilinguals)

METHODS

PARTICIPANTS

The same subjects that participated in Experiment 2 took part in Experiment 3. (See Experiment 2, methods section for details).

STIMULI AND APPARATUS

The stimuli and apparatus used in Experiment 3 were the same as those used in Experiment 2. (See Experiment 2, methods section for details).

PROCEDURE

DISCRIMINATION TASK

The discrimination task involved the subject listening to paired stimuli. With reference to Figure 4, the stimuli used in the discrimination task were the stimuli D, G, J and M. Each of the four stimuli chosen were then paired with itself and the other remaining three stimuli forming ten pairs of stimuli which was then repeated five times in the task in a random order. There were a total of 50 trials for the discrimination task.

After listening to each pair, the participant was asked to identify whether the two stimuli of the pair were acoustically the same stimulus or two different stimuli.

SIMILARITY TASK

For the similarity task, the stimuli were again taken from the synthesised matrix described in Figure 4. Each stimulus (A – P) was paired with the other 15 stimuli of the matrix. There were 240 trials of paired stimuli presented to the subject in a randomised order.

The similarity task of this experiment involved listening to pairs of stimuli as with the discrimination task, listening for any acoustic differences between the two stimuli of the pair. However, in this task, subjects were asked to rate on a similarity scale how acoustically similar or different the stimuli of each pair are perceived when comparing stimuli within each pair. The extremes of the similarity scale were classed as similar (i.e., the two stimuli for that pair are the same stimulus) and dissimilar (i.e., the two stimuli for that pair are different stimulus).

Both tasks followed a practise test and the order of the trials was randomised for each subject.

RESULTS

DISCRIMINATION TASK

The discrimination task was carried out in order to assess the sensitivities of the subjects to acoustic differences in the synthesised stimuli. The stimuli changed in a continuum from a stimulus that was calculated as bring a very good exemplar of /w/

(stimulus D, Figure 4) to a good exemplar of the phoneme /v/ (stimulus M, Figure 4). Because of this, the discrimination results can also indicate any signs of categorical perception that may have taken place.

From Experiment 2, the results of the English identification/goodness task show that the phoneme boundary of the native English monolingual group includes the stimuli G and J (Figure 8). This group has a heightened sensitivity for accurately discriminating stimuli pairs located at the phoneme boundary that was defined in Experiment 2. The monolingual group also had poor sensitivity for discrimination between stimuli near the best exemplars of /w/ and /v/ as seen in Experiment 2 (Figure 8). This pattern seen with the English monolingual group shows categorical perception of the English phonemes.

In general, the strong L2 bilingual group had a better sensitivity for hearing acoustical changes between stimuli pairs than the weak L2 group. The strong bilingual group's line graph in Figure 11 follows the shape of the native English monolinguals line graph, although it is less prominent, with a lower overall sensitivity for discrimination. Neither of the two Sinhalese bilingual groups showed signs of categorical perception.

Looking at the individual groups, it is evident that the native monolingual group had the most native form of categorical perception and the weak L2 bilingual group showed the least native-like perception. The results were analysed with repeated measures of ANOVA. There was a significant effect of group in the discrimination task, $F(2, 27) = 6.9$, $p = 0.004$. When considering the stimuli pairs separately, the subject groups in general scored a lower average percentage correct for the pair J – M in comparison to the other two pairs. There was a significant effect of pair, $F(2, 54) = 3.68$, $p = 0.03$. Assessing any interaction between the groups and pairs from the discrimination results for helped to clarify whether the different subject groups had the same discrimination patterns. The monolingual English group and the strong L2 bilingual group had slightly similar patterns, but both differed from that of the weak L2 bilingual group. The repeated measures ANOVA revealed that there was a significant group * pair interaction, $F(4, 54) = 3.37$, $p = 0.02$.

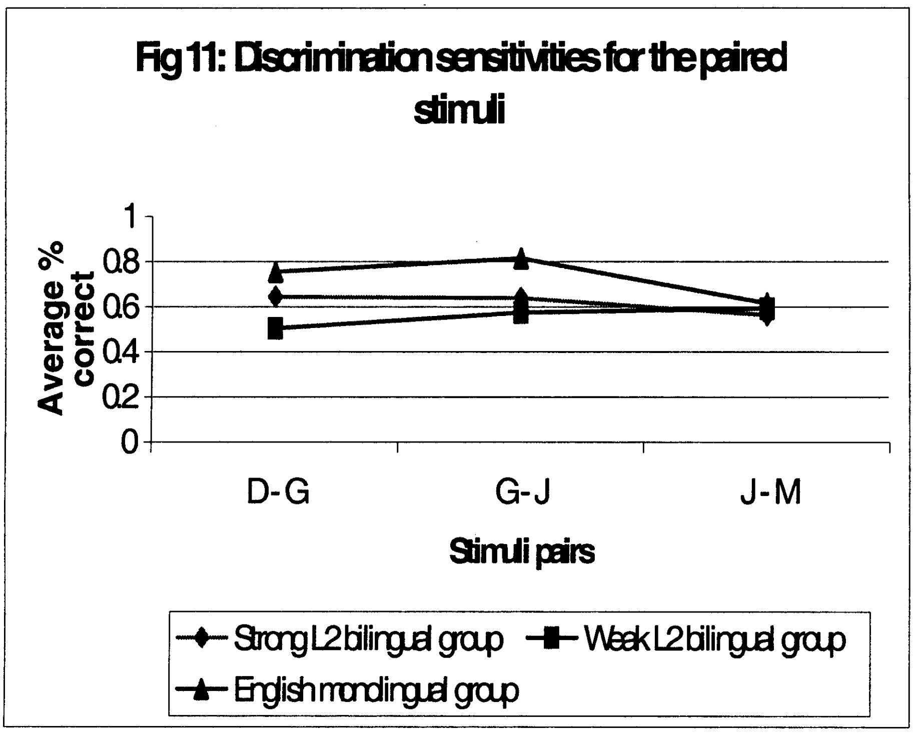


Figure 11: The line graph showing the accuracy of positive identification of acoustic differences between the diagonally paired synthesised stimuli indicates categorical perception occurring for the English monolingual group. The strong L2 bilingual group is generally better at perceiving acoustic differences in comparison to the weak L2 bilingual group. Neither Sinhalese bilingual group shows categorical perception.

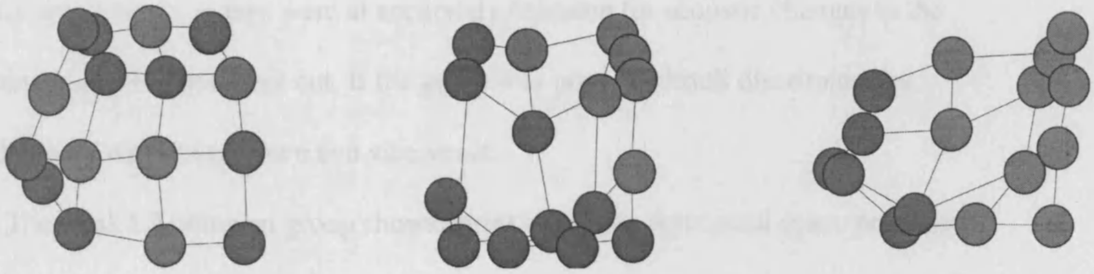
SIMILARITY TASK

The results of the similarity task were analysed using multidimensional scaling (MDS) to reveal the presence of any stretching or shrinking of the perceptual space within the [w-v] phoneme contrast (Figure 12).

From the MDS spaces that were calculated, the weak L2 bilingual group appears to show little significant warping of their perceptual space for the [w-v] contrast. This indicates that all of the stimuli sounded similar as the members of this group had difficulty in hearing the acoustic differences between the stimuli.

The MDS space of the strong L2 bilingual group shows significant stretching between the stimuli in the middle and shrinking of the space at the extremes in the dimension of manner of articulation. This shows that the strong L2 bilingual group is sensitive to acoustic changes that occur in the dimension of the manner of articulation, the changes include amplitude of frication, F1 formant frequency and the duration of the phonemes' closure and transition time out of closure.

The native English monolingual group's MDS space shows stretching in a diagonal dimension, which implies that this group's sensitivity to acoustic change is based on the dimensions place and manner of articulation simultaneously. Members of this group are perceptive to both cues. Clustering seen at the top right corner of the MDS space indicates a decrease in perception of acoustic differences near the best exemplar of the English phoneme /v/.



(A) (B) (C)

Figure 12: Unscaled MDS solutions showing the perceptual spaces of the phoneme contrast [w-v]. A) MDS space of the weak L2 bilingual group is indicating little stretching or shrinking of stimuli in the perceptual space. B) MDS space of the strong L2 bilingual group is showing stretching of the perceptual space in the dimension of manner of articulation. C) MDS space of the native English monolingual group shows diagonal stretching indicating the use of both acoustic cues, place and manner of articulation.

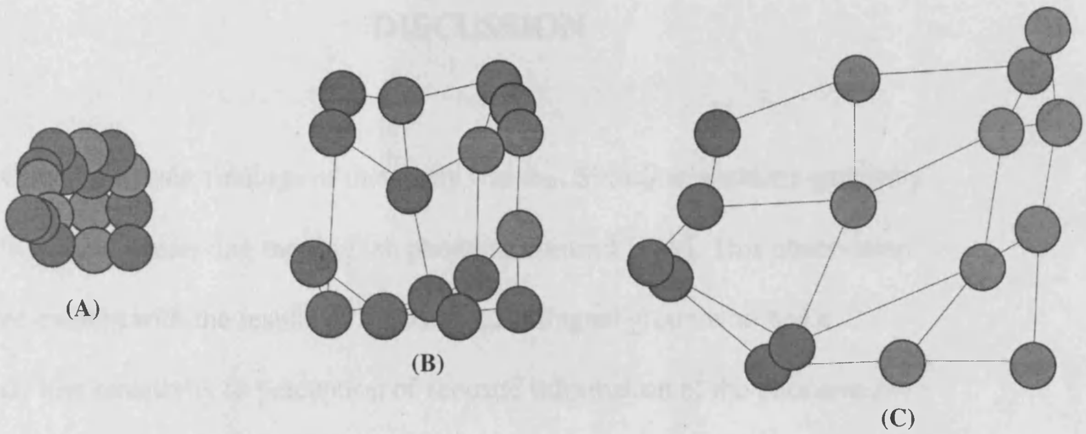


Figure 13: The MDS solutions from the similarity task incorporated the accuracy of discrimination for each group seen in the discrimination task forming the SCALED MDS solutions showing the perceptual spaces of the phoneme contrast [w-v]. A) MDS space of the weak L2 bilingual group is indicating little stretching or shrinking of stimuli in the perceptual space. Enhanced by scaling down of the space due to discrimination sensitivity showing poor overall perception of the stimuli. B) MDS space of the strong L2 bilingual group is showing stretching of the perceptual space in the dimension of manner of articulation. C) MDS space of the native English monolingual group shows diagonal stretching indicating the use of both acoustic cues, place and manner of articulation. Enhanced by the scaling up of the space due to discrimination sensitivity indicating very good perception of the stimuli by this group.

Figure 13 gives a better illustration of the perceptual warping that is present in the three groups of listeners as it takes into account the discrimination sensitivity of the groups for the stimuli. Scaling the calculated MDS spaces in relation to how generally sensitive the groups were at accurately listening for acoustic changes in the discrimination task carried this out. If the group was poor at stimuli discrimination, the MDS space was scaled down and vice versa.

The weak L2 bilingual group shows shrinking of the perceptual space between all of the stimuli. Therefore, this group had very poor perception of all the stimuli that was heard. As with the un-scaled MDS space for the strong L2 bilingual group (Figure 12), this group's perception is sensitive to the acoustic cue manner of articulation. The native English monolingual group's sensitivity to both dimensions of acoustic cues investigated is emphasised in Figure 13 by the space being up-scaled to show the accurate sensitivity of this group to discriminating acoustic differences between the stimuli.

DISCUSSION

One of the main findings of this study was that Sinhalese speakers generally have difficulty in perceiving the English phoneme contrast [w-v]. This observation was more evident with the results of the weak L2 bilingual group who had a uniformly low sensitivity to perception of acoustic information of the phoneme /w/ and /v/. Another finding of this study was that when the strong L2 bilingual group, who were more proficient in their speech production and perception of English, was more sensitive to acoustic changes along the manner of articulation dimension than the place of articulation dimension. This was evident from the discrimination task.

The Sinhalese speakers' generally low sensitivity to perception of the English phonemes /w/ and /v/ was firstly noted from Experiment 1 due to the predominantly inaccurate identification of the phonemes spoken by natural speakers. The poor identification for the natural identification task was more evident in the weak L2 bilingual group than the strong bilingual group. This non-native perception of English phonemes by the Sinhalese speakers is again seen in Experiment 2 in the English phoneme identification/goodness task. For this experiment, the native English monolingual group's average scoring for percentage of stimuli identification as /w/ ranged from 100% (best exemplar of /w/) to 0% (best exemplar of /v/). The results of the English identification/goodness task for the strong and weak L2 bilingual group ranged from 93% - 34% and 63% - 40% respectively. These results show a general low sensitivity to perception of English phonemes in comparison to that of native English speakers. In Experiment 2, the strong L2 bilingual group had more accurate identification than the weak L2 bilingual group; this pattern is also seen in Experiment 1. The higher accuracy of English phoneme identification by the strong

L2 bilingual Sinhalese speakers in comparison to the weak L2 bilingual group is supported by the Speech Learning Model (Flege et al., 1995). The L2 speech production of the members of the strong L2 bilingual group were assessed by the trained phoneticians stated that their accents are similar to a native English accent. The accents rated from the L2 speech production of the weak L2 bilingual group were comparatively more foreign than the more English-like accents of the strong L2 bilingual group. The Speech Learning Model posits the idea of native-like speech production of L2 being necessary for skilful native-like L2 categorical perception.

The generally low sensitivity of the Sinhalese speakers' perception of English phonemes /v/ and /w/ can be explained using the Perceptual Assimilation Model, PAM (Hallé et al., 1999; Best et al., 1988). As seen in some cross language studies, in some cases only the first phoneme of a non-native phoneme contrast exists in the native phoneme inventory of a listener. When this occurs, the second phoneme of the non-native contrast that does not exist in the native inventory is assimilated to the L1 phoneme to which the first non-native phoneme is assimilated. Therefore, both of the non-native phonemes of the contrast are perceived as being the same. Japanese native speakers do not have the phoneme /l/ in their native phoneme inventory (Hallé, Best & Levitt, 1999; Miyawaki et al., 1975) and native Finnish speakers do not have a categorical representation of the Estonian vowel /õ/ in their native phoneme set (Cheour et al., 1998). Similarly, Sinhalese natives are missing the English phoneme /w/ from their own native inventory (Perera, 1919). PAM can therefore be used to explain the importance of a similar phoneme, to the L2 phoneme being perceived, existing in the speaker's native language to which he/she can assimilate the non-native phoneme for recognition.

The native English monolingual group produced results that were consistent with the use of their native language. The results of the English identification/goodness task showed a clear trend. Identification percentage was highest near the best exemplars of the phonemes /w/ and /v/ and it was lowest for the stimuli located near the phoneme boundary for the phoneme contrast. Goodness ratings of the stimuli support the identification of the phonemes by the native monolingual group. Categorical perception was seen in the discrimination results, which is usually seen in native language perception. The MDS space of the similarity task showed that the native listeners use acoustic information about both the place and manner of articulation. The stretching of the MDS space matched the phoneme boundary that occurred in the English identification task. The native English group's perceptual space stretching showed sensitivity at the phoneme category boundary and clustering of stimuli around good exemplars of the phoneme /v/ supports the idea of a perceptual warping due to distinctiveness and acquired similarity (Liberman, 1957) as well as the perceptual magnet effect (Kuhl, 1991).

The weak L2 bilingual group also produced characteristic results that were fitting for that language group, that is, their results were consistent with the patterns that would be expected in the perception of a non-native language. Their general insensitivity to perception of the stimuli, that has already been discussed with respect to the natural and synthesised speech identification tasks of the English phonemes, is also present in the discrimination and similarity tasks. The percentage of correct identification of the discrimination pairs is uniformly low for this group in comparison to the other two groups. When the discrimination results were used to form the scaled MDS space, it was clear that the weak L2 bilingual group is fairly insensitive to any acoustic changes of the stimuli as they are all perceived as being of the same quality.

An intermediate pattern was found in the strong L2 group that combines aspects of the results of both the weak L2 bilingual group and the native English group. Their accuracy of natural phoneme identification was better than that of the weak L2 bilingual group and worse than that of the native English group. The results from the English phoneme identification/goodness task of Experiment 2, it is evident that this group has developed a more native English-like perception than the weak L2 bilingual group as this group's results showed the presence of a phoneme boundary. This phoneme boundary is an intermediate between native and non-native perception as the boundary has a different location, along the stimuli matrix, from that of the native English group. The strong L2 group's non-native perception is again different to that of other two groups when looking at their results of Experiment 3. This is because both the weak L2 group and the native English group show consistency between the findings of the English identification/goodness task and the MDS space. The weak L2 group has uniformly poor sensitivity to perception of the phonemes and the native English group's phoneme boundary is present in both sets of results. The MDS space of the strong L2 bilingual group does not match the findings of the English phoneme identification/goodness task. The identification results of Experiment 2 indicate that the strong L2 bilingual group is sensitive to acoustic changes along both dimensions of place and manner of articulation. The MDS analysis of this group however indicates that the listeners are only sensitive to acoustic information in the manner of articulation cue, which is a secondary cue, used by native English listeners for discrimination of the [w-v] phoneme contrast. It has already been discovered that native Japanese listeners are more sensitive to changes in

F2 formant frequency when discriminating the non-native English phoneme contrast [r-l] (Iverson et al., 2003). The F3 cue is not the predominating cue used by native listeners of English when discriminating the [r-l] contrast, this native group is more attuned to differences in F3 formant frequency. The current study is therefore another example of how non-native listeners weight their perception on acoustic cues that are secondary to the natives of that particular language.

The differences seen between the results of the weak and strong L2 bilingual group leads to the questioning of what factors that caused this shift in perceptual pattern from being typically non-native to one that resembles native use of language more closely. From the language background information that was collected via the questionnaires (Appendix 1), there does not appear to be a clear pattern occurring with the age of exposure of the two groups to their non-native language. Instead the difference between the two bilingual groups may be due to frequent use of L2 in everyday life. Investigating further into the language background of the Sinhalese test subjects will give more insight into what factors of the non-native language causes the shift in perception that has been discovered by the this current study. It would also be helpful in future studies to test the native Sinhalese participants, before any of the subjects have been exposed to English (L2), as have been carried out in this study. After initial testing of all of the Sinhalese participants, the group could be divided into one group that remains as Sinhalese monolingual speakers and a second group that acquires English becoming bilingual speakers. Following L2 acquisition by the second group, follow up with a second set of similar tasks on all of the participants (Sinhalese monolingual and bilingual speakers). If detailed information can be obtained regarding the exposure, proficiency and frequent use of L2 by the group that was exposed to English, it would be possible to explore what caused the shift in perception seen between the two bilingual groups of this current study.

Speech perception of a bilingual's non-native language can be optimised by manipulating the conditions under which L2 is acquired. Optimising speech perception is done mainly through perceptual training of the non-native speaker, even though this may be "slow and effortful" to do (Strange & Dittmann, 1984), adequate perception is achievable. A study carried out by Guenther et al. (1999) showed reduced discrimination by test subjects for new phonemes following training indicating an adoption of a native-like status in categorisation by the new phonemes. Another such example showed improved phoneme identification after subjects were trained and MMN responses supported the nativisation of the novel phonemes (Trembley et al., 1997). Improving perception of phonemes that are already difficult for the listener to perceive may take longer than training of other phonemes that are perceived more easily. This will require more exposure to the difficult phonemes (Logan et al., 1991). As seen in Kuhl's (1997) study, exaggerated speech production helped infants to acquire language as a part of normal development. This idea is used to successfully train Japanese listeners to perceive the [r-l] contrast through use of exaggerated stimuli (McCandliss et al., 2002).

Using the information that has gathered from the previous studies already mentioned regarding non-native phoneme training, with the main findings of this current study, it is possible to direct future research in this area. The shift in perception from the weak L2 bilingual group to the strong L2 bilingual group involves an increased sensitivity for acoustical changes in the dimension of the manner of articulation. This includes amplitude of frication, F1 formant frequency and duration of the closure and transition out of the closure. Training of members of the weak L2 bilingual group to achieve strong L2 bilingual group-like perception of the phoneme contrast [w-v] could therefore involve significant and repeated exposure to stimuli that have exaggerated acoustic information with regards to the three factors form the manner of articulation. Another training programme could be aiming to improve the perception of the strong L2 group to closely resemble native English-like perception of the phoneme contrast [w-v]. The listeners of the strong L2 bilingual group could be trained using repeated exposure to stimuli with acoustical information that is exaggerated in the dimension of place of articulation, i.e., the F2 formant frequency. Future training techniques could include use of live socially interactive contact with native English speakers to enhance the perception (Kuhl et al., 2003).

From this study, native Sinhalese speakers who use their second language less frequently and proficiently had difficulty in perceiving the English phoneme contrast [w-v]. All of the English phoneme stimuli that were test were classed as poor quality assimilations to their native /ʋ/ phoneme. The native Sinhalese speakers who had more proficient usage of their second language English (L2), also called the strong L2 bilingual group, also had difficulty in perception of the English contrast [w-v] in comparison to the native English monolingual speakers but their perception was better than that of the weak L2 bilingual group. The strong L2 bilingual group showed an enhanced perception of acoustic changes along the manner of articulation dimension while the native English monolingual speakers were sensitive to both place and manner of articulation.

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APPENDIX 1 - LANGUAGE BACKGROUND INFORMATION FROM QUESTIONNAIRES

SINHALESE SPEAKERS (non-native)

Name	Gender	Age	Country of birth	First language	Other languages	Age (years) started speaking english	Years lived in england	Lived in other english speaking countries	Hearing problems
CA	male	71	Sri Lanka	Sinhala	English	18	41	no	no
SA	female	67	Sri Lanka	Sinhala	English	9	41	no	no
AA (1)	female	47	Sri Lanka	Sinhala	English	17	30	no	no
SS	male	26	Sri Lanka	Sinhala	English	4	2	no	no
JE	female	50	Sri Lanka	Sinhala	English	5	29	no	no
SE	male	54	Sri Lanka	Sinhala	English	5	30	no	no
CF	female	55	Sri Lanka	Sinhala	English	4	28	no	no
MF	female	41	Sri Lanka	Sinhala	English	8	1.5	no	no
RH	male	21	Sri Lanka	Sinhala	English	8	0.5	no	no
WK	female	26	Sri Lanka	Sinhala	English	18	8	no	no
EM	male	26	Sri Lanka	Sinhala	English, Russian	4	3	no	no
LK	male	55	Sri Lanka	Sinhala	English	5	35	no	no
PP	male	57	Sri Lanka	Sinhala	English	4	26	no	no
SP (1)	female	47	Sri Lanka	Sinhala	English	5	33	no	no
SP (2)	female	58	Sri Lanka	Sinhala	English	4	26	no	no
GR	female	60	Sri Lanka	Sinhala	English	7	36	no	no
AS	female	51	Sri Lanka	Sinhala	English	2.5	30	no	no
CS	male	60	Sri Lanka	Sinhala	English	8	36	no	no
RU	male	31	Sri Lanka	Sinhala	English	5	9	no	no
JW	female	57	Sri Lanka	Sinhala	English	13	27	no	no

APPENDIX 1 - LANGUAGE BACKGROUND INFORMATION FROM QUESTIONNAIRESECT DETAILS									
ENGLISH SPEAKERS (native)									
								Lived in other	
Name	**Gender**	**Age**	**Country of birth**	**First language**	**Other languages**	**speaking english**	**england**	**countries**	**problems**
AA (1)	male	21	Great Britian	English	no	From birth	From birth	no	no
JB	female	23	Great Britian	English	no	From birth	From birth	South Africa (7months)	no
CB	female	20	Great Britian	English	no	From birth	From birth	no	no
HC	female	22	Great Britian	English	French, German	From birth	From birth	no	no
AJ	female	34	Great Britian	English	no	From birth	From birth	no	no
PJ	female	60	Great Britian	English	no	From birth	From birth	no	no
VM	female	26	Great Britian	English	no	From birth	From birth	no	no
CM	female	27	Great Britian	English	no	From birth	From birth	no	no
KO	female	21	Great Britian	English	no	From birth	16	no	no
NW	female	40	Great Britian	English	no	From birth	From birth	no	no