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ACOUSTIC ANALYSIS OF VOICING CONTRAST ON MALAY WORD-INITIAL PLOSIVES PRODUCED BY TAMIL-SPEAKING CHILDREN

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ABSTRACT

The primary objective of this study was to investigate the acquisition of voicing contrast in Malay word-initial plosives produced by Tamil-speaking children. This study's contribution to the existing literature lies in adding information on Malay word-initial plosives produced by Tamil-speaking children which can be instrumental in developing objective speech evaluation and designing effective intervention plans in the speech-language pathology practice. A total of 15 subjects aged between 3;00 to 7;11 years old were included in the present study. The participants underwent a picture naming task, and their speech samples were recorded and acoustically analysed using PRAAT. Descriptive data were presented, and a non-parametric Mann-Whitney U test was conducted to examine gender effects on voice onset time (VOT) of Malay word-initial plosives produced by Tamil-speaking children. The results indicated that at the age of 3;00, children produced only short lag VOT values. By the age of 5 years old, Tamil-speaking children acquired the expected voicing contrast in Malay word-initial plosives (pre-voiced vs. short lag). Full acquisition of voicing contrast for Malay plosives (pre-voiced vs. short lag) was observed at the age of 7. The later acquisition of voicing contrast and pre-voicing was further discussed. VOT distributions aligned with the developmental path proposed by Macken & Barton (1980) and Zlatin & Koenigsknecht (1976). Notably, place of articulation effects on the duration of VOTs were not observed in Tamil-speaking children. This finding prompted considerations of perceptual, social, and environmental factors, as well as Cross-Linguistic Influence, as plausible reasons for this phenomenon. Furthermore, with increasing age, the VOT values tended to approach adult-like VOT patterns. Regarding gender effects, no significant gender differences in VOT of Malay word-initial plosives were found in Tamil-speaking children, except for the phoneme /d/. Possible explanations for this were discussed in detail.

Keywords: Voice onset time, voicing contrast, pre-voiced, voicing lag, bilingual

ABSTRAK

Kajian ini bertujuan untuk meneliti pemerolehan dan penguasaan kontras penyuaraan dalam plosif awal perkataan Melayu yang dihasilkan oleh kanak-kanak penutur Tamil. Sumbangan kajian ini kepada literatur sedia ada adalah dengan menambah maklumat tentang plosif awal Bahasa Melayu yang dihasilkan oleh kanak-kanak penutur Tamil yang boleh digunakan untuk merancang dan mereka cipta bahan-bahan ujian dan penilaian serta pelan intervensi yang berkesan dalam patologi pertuturan dan bahasa. Dalam kajian ini, penelitian masa mula suara atau dikenali sebagai voice onset time (VOT) yang dihasilkan oleh 15 subjek yang berusia antara 3;00-7;11 tahun telah dijalankan. Kanakkanak dikehendaki menamakan gambar stimulus, sampel pertuturan direkodkan dan dianalisis secara akustik dengan menggunakan PRAAT. Data deskriptif telah dikemukakan dan ujian non-parametrik Mann-Whitney U dijalankan untuk mengkaji kesan jantina terhadap VOT plosif awal perkataan Melayu. Hasil kajian menunjukkan bahawa kanak-kanak berumur 3; 00 hanya menghasilkan tundaan suara pendek (short lag). Pada usia 5 tahun, kanak-kanak penutur Tamil mula menguasai kontras penyuraan yang dijangka dalam plosif awal Bahasa Melayu (duluan suara-tundaan suara pendek). Penguasaan penuh kontras penyuaraan dalam plosif Bahasa Melayu telah diperhatikan pada usia 7 tahun. Perkembangan VOT adalah selari dengan model yang dicadangkan oleh Macken & Barton (1980) dan Zlatin & Koenigsknecht (1976). Selain itu, kesan tempat artikulasi terhadap durasi VOT tidak diperhatikan dalam kanak-kanak penutur Tamil. Pertimbangan faktor perseptual, sosial, dan persekitaran, serta Cross-Linguistic Influence (CLI) telah dibincangkan sebagai punca fenomena ini. Nilai VOT cenderung mendekati corak VOT orang dewasa dengan peningkatan usia. Tiada kesan jantina yang signifikan terhadap VOT plosif awal perkataan Melayu ditemui dalam kalangan kanak- kanak penutur Tamil, kecuali dalam fonem /d/. Penjelasan mungkin untuk ini telah dibincangkan secara terperinci.

Kata kunci: Masa mula suara (mms), kontras penyuaraan, duluan suara, tundaan suara, dwibahasa

INTRODUCTION

Malaysia is known as a “melting pot” that arises from its multi ethnic and multilingual composition. This blend of cultures, languages, and traditions forms the diversity of Malaysian society, epitomizing harmonious coexistence. Such harmony resonates throughout the nation's demographics, which encompass a rich array of ethnicities - Malays, Chinese, Indians, and various other ethnicities. This diversity imbues Malaysia's linguistic landscape with a rich tapestry of languages and dialects, creating a fascinating interplay.

In the diverse language landscape of Malaysia, the Indian community holds a special place, adding dynamic language variations to the overall mix. However, it's important to note that the Indian community isn't one single group, but a collection of smaller groups, each with their own language history. While several Indian languages like Malayalam, Telugu, Punjabi, and Hindi are present in different Indian subgroups, Tamil stands out as the primary language among Malaysians of Indian descent. Despite the variety of languages, Tamil serves as a unifying factor that brings these subgroups together. It acts as a common thread that enables communication between Indians of different backgrounds. The fact that Tamil is used widely, even among various Indian subgroups, emphasizes its crucial role as a language that connects and unifies. Hence, our research focuses on the Tamil-speaking population within the Indian community of Malaysia.

Malay, the national language of Malaysia, assumes a critical role in the country's linguistic mosaic. All preschoolers are required to learn Malay, according to the Ministry of Education

(2015). Since 1983, it has been used as a medium of instruction in all national primary and secondary schools. In addition, despite the existence of Tamil-medium primary schools in Malaysia, many parents prefer to enroll their children in national schools where Malay is the major language of instruction (Ibrahim 2018). The ability of these children to speak Malay is therefore essential for a variety of reasons, including academic and social purposes. However, Jamian et al. (2018) reported that children who use Malay are influenced by their mother tongues (e.g Tamil). It has been discovered that Tamil-speaking children frequently face quite distinct challenges in using Malay due to differences in both language systems, causing them to be less familiar with or fluent in the Malay language (Winskel 2020) particularly the pronunciation of certain Malay words.

Noteworthy is the fact that substantial investigation on voicing contrasts in plosives has been conducted by examining voice onset time (VOT) as plosive sounds are a universal feature found in all languages (Henton,et al. 1992). However, this study attempted to fill the gap by adding fresh evidence to the body of knowledge on this subject due to the lack of studies on Tamil speaking children and the Malay language. This study also aimed to provide information on the acquisition of Malay word initial plosives by Tamil-speaking children between the ages of 3;00 and 7;11. Since voicing errors are a common speech defect in children with hearing loss, childhood apraxia of speech, and phonological disorders (Umat et al. 2015), it is beneficial to look into the developmental patterns of voicing contrast acquisition in typically developing children. Consequently, the likelihood of mistaking developmental errors for delayed or disordered errors can be minimized. Also, understanding the age of acquisition for voicing contrast could aid the teaching and learning process of Malay pronunciation in academic settings and/or therapeutic settings (Shahidi et al. 2012).

Acoustic Analysis of Plosives

Acoustic analysis has become an increasingly vital tool in linguistics, extending beyond its traditional domain of phonetics (Boersma, Podesva, Robert, Sharma 2014). Initially, acoustic analysis of speech focused on the acoustical properties of both normal and abnormal speech, involving waveform analysis, voice onset time (VOT) measurements, and formant frequency measurements (Lisker & Abramson 1964). Graphical software like Praat (Boersma & van Heuven 2001) facilitates acoustic analysis by visually inspecting speech.

Stops, or plosives, are consonants formed by briefly stopping the airflow with the articulators, leading to a sudden release of the air (Shimizu 2011). VOICED plosives occur when the vocal folds vibrate, while VOICELESS plosives occur when the vocal folds remain open and stationary. The production of these plosives involves adjustments in vocal fold state, air stream, and articulatory timing relative to glottal closure and opening (Shimizu 2011).

Earlier studies proposed three phases for the formation of stops: the onset of closure, the closure itself, and the offset of the closure (Henton, et al. 1992). However, more recent research expanded this model to include four phases: Closure, Hold, Release, and Post-release (Jehma & Phoocharoensil 2014).

Stops are a universal consonant class present in all languages (Henton, et al. 1992). Acoustically, various measurements, such as consonant duration, spectral moments, and formant transitions, can describe plosives. Among them, voice onset time (VOT) is widely used and extensively studied in normal healthy speakers.

In the previous years, several studies have utilized acoustic analysis to investigate plosive consonants in different languages and populations. Kang and Guion (2006) conducted a comparative study on stop contrast in Korean and English, examining VOT and formant transitions. Chang et al. (2011) investigated the acoustic characteristics of Mandarin plosives produced by English-speaking learners of Mandarin. Birkholz (2013) utilized articulatory-acoustic mapping to analyze German VCV utterances with plosives. Kim & Stoel-Gammon (2009) examined the acoustic characteristics of word-initial plosive voicing contrasts in Korean children. Tanaka (2018) explored the VOT patterns of Mandarin initial stops in English and Japanese learners of Mandarin.

Furthermore, acoustic analysis has been used to investigate plosive production in bilingual populations. A study by Kang and Guion (2006) compared the stop contrasts in Korean and English, providing insights into cross-linguistic differences in plosive characteristics. Similarly, Kim and Stoel Gammon (2009) examined the development of word-initial plosive voicing contrasts in Korean children, shedding light on how children's plosive production patterns evolve in the early stages of language acquisition. Badrulzaman Abdul Hamid, et al.., (2022) examined the Acoustic Analysis of Voicing Contrast in Malay Word-Initial plosives produced by Mandarin-Speaking Children. Another study by Badrulzaman Abdul Hamid, et al. (2020) analysing of voice onset time pattern in Malay plosives produced by adult Mandarin speakers.

These studies showcase the significance of acoustic analysis in exploring the production and perception of plosive consonants across different languages, age groups, and language backgrounds. Therefore, stop plosives are considered suitable for acoustic investigation due to the abundance of data available on VOT.

Voice Onset time (VOT)

The term "VOT" was first used by Lisker and Abramson (1964) in their pioneering study that examined voicing in onset stops in 11 different languages. It is used to refer to the time interval from the release of a stop until voicing for vowel production begins (Byers & Yavas 2017). Voice Onset Time (VOT) is the duration of time between the release of a plosive and the beginning of vocal fold vibration which is typically measured in milliseconds (ms). As a realistic approximation of possible precision, each measurement was rounded to the closest five milliseconds. It is discovered that the VOT measure is an incredibly useful tool in dividing phonemic categories such as voiced and voiceless or aspirated and unaspirated across multiple languages (Lisker & Abramson 1964). In a recent study, Arthur Abramson and D. H. Whalen has provided a retrospective reflection which further proves that Voice Onset Time (VOT) is indeed a robust measure of the acoustic realisation of consonantal voicing distinctions in most languages (Abramson & Whalen 2017).

Based on the typical VOT value conditions, plosives were divided into three ranges, as shown in Figure 1.1. When voicing begins after the release of the stop (i.e., after the burst), causing "voice lag," VOT is referred to as "positive." Depending on whether the stop is made with aspiration or without aspiration, the voice lag may be short or long. If voicing occurs immediately before or simultaneously with the burst, the short lag is referred to as zero. This yields a VOT value that is 20 milliseconds or less away from zero or slightly positive. In English, these are typically voiceless unaspirated stops that are made with a very brief voice onset time at or close to zero (voicing is simultaneous with the stop release). According to Auzou et al. (2000), an offset of 15 ms or less for [t] and 30 ms or less for [k] qualifies as unaspirated and is inaudible. However, aspirated stops occur after a significant delay. Nonetheless, they tend to have a longer VOT when followed by sonorants. In this situation, the length of the VOT typically serves as a gauge of aspiration; the longer the VOT, the greater the aspiration.

In the first, voicing starts before the stop is released; in the second, it starts right after the release; and in the third, it starts much later than the stop is released. The first stop is voiced and aspirated, the second is voiceless and aspirated, and the third stop is voiceless and aspirated, according to their typical phonetic descriptions. As a result, measurements of voice onset time before the release are conveyed as negative numbers and are referred to as "voicing lead," or "pre-voicing" while measurements of voice onset time after the release are conveyed as positive numbers and are referred to as "voicing lag." We have adopted the convention of assigning zero-time to our reference point, the instant of release.

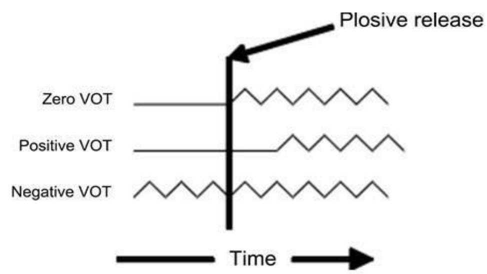

Figure 1.1. Types of VOT

Burst release indicates stop release, and the first periodic waveform indicates the onset of voicing (Lisker & Abramson, 1964). Figure 1.2 and Figure 1.3 are examples of spectrograms of VOT (the highlighted region).

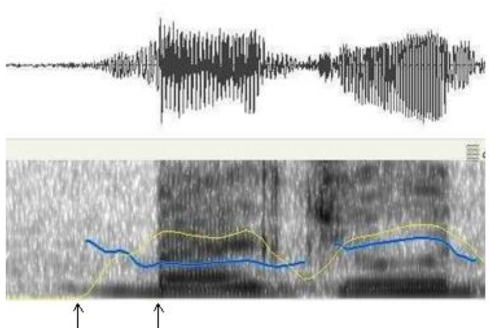
FIGURE 1.2. Spectrogram of pre-voicing

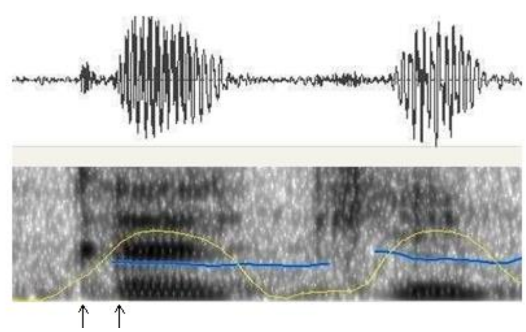
FIGURE 1.3. Spectrogram of voicing lag

VOT development in second language (L2)

According to Edwards and Zampini (2008) who focused on one acoustic cue namely the voice onset time, the stop consonants are one of the most extensively researched classes of sounds in second language acquisition research. Many examples of L1 VOT values being transferred to L2 aspiration patterns of stops can be found in the SLA literature, particularly at lower levels of L2 proficiency (e.g. (Flege & Eeftink,1987). Meanwhile, Shimizu (2011) found that L1 stop categories were used to learn L2 stop categories because VOT values were nearby. The primary cue for learning new L2 speech sounds has been identified in several models, including the speech learning model (SLM) and perceptual assimilation model (PAM), as the phonetic distance between

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plosives in L1 and L2. Bilinguals build L2 voicing categories by looking for L1 sounds whose VOT values are similar to those of L2 sounds.

The majority of L2 studies on the acquisition of VOT demonstrate that learners almost never manage to attain native-like VOT values in their second language (Caramazza et al. 1973), regardless of whether they are attempting to learn a language that implements stops with a longer or shorter lag than in their L1. This does not imply that learners produce the L2 and L1 stops with the same values, but rather that their L2 values are different from both monolingual native speakers of that L2 and monolingual speakers of their own L1. The majority of L2 learners are able to create a new category for the L2 sound, but this category differs from that of native speakers of the two languages involved, according to other research on the acquisition of VOT in a second language. It is common to come across L2 proficient speakers who produce stops with VOT values that fall somewhere between those of monolingual speakers of their L1 and those of monolingual speakers of their L2 (Flege & Eeftink,1987).

Factors affecting VOT

The extensive literature on English VOT has demonstrated that VOT differs depending on a variety of factors, including linguistic factors (place of articulation) and non-linguistic factors (age, gender and other physiological characteristics of the speaker). Whereas the effects of some factors on VOT are well studied i.e., place of articulation; (T. Cho & Ladefoged 1999; Yava & Wildermuth 2006), gender; (Ryalls et al. 1997), and age; (Zlatin & Koenigsknecht 1976), research on the effects of other factors remains limited.

Place of articulation

The place of articulation has received the most research attention when it comes to VOT variation. Numerous studies have demonstrated that VOT rises when the point of constriction shifts from the lips to the velum, both in read speech and isolated word reading (Crystal & House 1988) this pattern is not limited to the English language (T. Cho & Ladefoged 1999). According to a study done by Kaur and Rao (2015) on the three places of articulation of stops, the tongue's dorsum separates from the velum for the stop /k/ more gradually than the tip separates from the alveolar ridge for the stop /t/ or the lips for the stop /p/. Their findings imply that as the place of articulation shifts from the front to the back, voice onset time increases.

Gender difference

According to earlier research, male and female speakers' articulators differ. Many studies showed that females have VOICELESS consonant VOTs that are significantly longer than those of males (Li 2013; Whiteside & Marshall 2001). While male adults produced VOICED plosives with a longer VOT interval than female adults, Whiteside and Marshall's study from 2001 found the opposite. In terms of VOT values in VOICELESS plosives, no significant gender differences have been reported, according to Bijankhan and Nourbakhsh (2009). Although there have been many studies looking into how gender affects VOTs in adults, there hasn't been as much research on how gender affects VOTs in children. No all-encompassing conclusion has been made in light of the contradictory results found for the gender effect on VOT.

Age

Additionally, it has been suggested that age influences VOT. Typical children reach VOTs similar to adults by around age 11 and continue to hone their motor skills throughout adolescence (Bae 2020). However, the descriptions of age-related VOT changes in earlier studies have been a little erratic. According to Zlatin and Koenigsknecht (1976), when compared to 2-year-old or 6-year-old children, adults have longer VOTs, whereas Macken & Barton (1980) found the opposite pattern, with 4-year old children having longer VOTs than the reported adult data from Lisker and Abramson (1964). A recent cross-sectional VOT study, which compared mean VOTs of voiceless stops across eight different age groups ranging from 4 years to young adults, supports the pattern discovered by Macken and Barton (1980). According to the study's findings, VOT declines significantly with age. A robust relationship between VOT variability and age in voiceless stop production has been discovered; overall VOT variability decreases from childhood to adulthood, in contrast to the ambiguous relationship between the VOT direction and age that has produced mixed results.

MALAY AND TAMIL POSIVES

Malay is an Austronesian language and Malayo Polynesian language that was used for over 10,000 years which was widely spoken in Brunei, Indonesia, Malaysia, East Timor, Singapore and parts of Thailand (M. Cho 2020). Malay has 27 consonants (see TABLE 1.1), including 6 plosives which are divided into VOICELESS plosives /p, t, k/ and VOICED plosives /b, d, g/ (Badrulzaman 2016). Malay plosives can be found in initial, medial and final word positions. Malay voiceless plosives are always unaspirated, but they can sometimes be aspirated in the case of Malays from northern Malaysia (Noor et al. 2021).

TABLE 1.1. Phonemic inventory of Malay language

Place / Manner	Bilabial	Dental	Labio-Dental	Alveolar-Dental	Palato-Alveolar	Palatal	Velar	Glottal
Plosives	p b			t d			k g	
Nasal	m			n		ɲ	ŋ	
Affricates					ʧ ʤ			
Fricatives		θ ð	f v	s z	ʃ ʒ		x ɣ	h
Lateral				l				
Trill				r				
Semivowels	w					j		

Source: Shahidi (2010)

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Tamil belongs to the southern branch of the Dravidian language. It is the official language of the Indian state of Tamil Nadu, the sovereign nations of Sri Lanka and Singapore. It is also spoken by the Tamil diaspora in Malaysia where it is called the Malaysian Tamil or Malaya Tamil. The dialect between Malayan Tamil and Indian Tamil, however, may vary due to environmental variables such as L2 impacts on L1.

There are 18 consonants in Tamil, including 5 stops /p/, /t/, /k/, /tʃ/, /ʈ/ (Harold F 1971). The sixth stop, alveolar retroflex /t:r/ is an underlying segment, which does not surface in rapid speech; hence, this segment is written either as /r/ intervocalically or as /tt/ when doubled, claims Schiffman. Most Indian languages including Tamil treat the voicing of plosives at an allophonic level (Bhaskararao & Ray 2017). Unlike Malay, plosives are unvoiced if they occur word-initially or doubled. Elsewhere they are voiced, with a few becoming fricatives intervocalically. Consonants in brackets are voiced equivalents where both voiceless and voiced forms are represented by the same character in Tamil (see Table 1.2), and voicing is determined by context (Kanapathy 2015).

TABLE 1.2. Phonemic Inventory of Tamil language

Place / Manner	Labial	Dental	Alveolar	Retrofle x	Alveolo - palatal	Velar	Glottal
Nasal	m ம்	(n̪) ந்	n ன்	ɳ ண்	ɲ ஞ்	(ŋ) ங்	
Stop/Affricate	p ப்	t̪ த்	t:r ற்ற	ʈ ட்	t͡ɕ ~ t͡ʃ ச்	k க்	
Fricative	(f)		s5 ஸ◌்◌் (z)	(ʂ) ஷ்	(ɕ) ஶ்	(x)	(h) ஹ்
Tap			ɾ ர்				
Trill			r ற்				
Approximant	ʋ வ்			ɻ ழ்	j ய்		
Lateral approximant			l ல்	ɭ ள்			

Source: Keane (2004)

Phonology development and acquisition of plosives

The plosive consonants, the class of sounds that is investigated in this study, are typically acquired in the phonological system before the third year of life; more specifically, /p/ and /b/. Acoustic analysis of plosives /t/ and /d/ are acquired around the first and a half year of life, /k/ around one year and seven months, and, finally, /g/ around one year and eight months (Crowe & McLeod 2020). Lim et al. (2015) conducted a study that focused on the rate of multilingual phonological acquisition of English–Mandarin–Malay languages by multilingual children. It's noteworthy that the present study shares a commonality with this prior research, as both investigations revolve around bilingual or multilingual subjects. According to Lim et al. (2015), by the ages of 2;06 to 2;11, multilingual children had effectively acquired all plosive sounds in both Malay and English.

Based on a study on Tamil language, all the stop consonants are acquired by the age of 2;5 years except retroflex /ʈ/, [ɖ] and velar stops /k/ and [g] which are acquired between 3;0 and 3;6 years (Venkatesh et al. 2010). This is in concurrence with the findings of Indian studies like Kochetov and Sreedevi (2016) which reported that majority of consonants including stops are acquired by the age of 3 to 4 years.

One of the studies that have been done on phonological acquisition in Malay children who used Malay as their first or dominant language (Phoon et al. 2014) have shown that stop consonants are acquired around the age range of 4;00 to 4;05, which is relatively later compared to the acquisition of stop consonants in Tamil which less likely to develop later than 3;6 years of age (Venkatesh et al. 2010).

VOT development in Malay and Tamil monolingual

According to Shahidi et al. (2012), the realization pattern for the Malay plosive word initial voicing contrast is pre-voiced for VOICED plosives and short lag for VOICELESS plosives. VOICED and VOICELESS plosives in beginning position produced by Malay children ages 3; 00 - 6;11 were compared in (Shahidi et al. 2016)'s study. The results showed that children under three years old produced voicing lag for all plosives, indicating that they had not yet acquired voicing contrast in Malay plosives. Children who were 4 years old and older produced pre-voiced VOT for VOICED plosives. This demonstrates that they have grasped the distinction between voiced and voiceless Malay word- initial plosives. The resulting VOT values got closer to adult-like VOT as the age grew.

According to a study by Badrulzaman (2016), children between the ages of two and three did not produce the voicing lead for VOICED plosives (see TABLE 1.3). This was consistent with the conclusions reached by Shahidi et al. (2016). Children four years of age and older produced prevoiced VOT for VOICED plosives, except for the velar plosive /g/.

TABLE 1.3. Mean VOT values for Malay word-initial plosives for children aged 2;006;11

Mean VOT (ms)	2;00	3;00	4;00	5;00	6;00	Adult
/b/	11	10.65	-50.1	-59.4	-61.8	-87.4
/d/	13.3	13.25	-38	-49.9	-53.6	-75.5
/g/	18.1	20.25	9.83	12	12	-54.3
/p/	8.3	7.9	6.7	8.5	7.9	11.8
/t/	14.2	13.2	14.3	13.1	14.1	14.3
/k/	23.6	24.7	30.4	29.6	34	31.6

Source: Badrulzaman 2016

According to some recent studies, among Dravidian languages, Tamil treats voicing partially at allophonic level (Bhaskararao & Ray 2017). This is in line with an earlier study which found that Tamil does not distinguish aspiration or even voicing; stops are voiceless and weakly aspirated in initial position and voiced after nasals (Balasubramanian 1975).

In Tamil, among the words from native vocabulary (vocabulary that is not borrowed from other sources such as Indo-Aryan languages or English), voiced and voiceless plosives behave as allophones, i.e., sounds that are decided by the context of their occurrence in a word. A phoneme such as /p/ is realised as its voiced allophone [b] when it occurs between two voiced sounds (such as vowels, nasals, etc.). In other contexts (such as in word initial position, or when it is doubled), /p/ is realised as its voiceless allophone [p]. In borrowed words such as /bassu/ for English ‘bus’, the initial /b/ is realized as [b] (Bhaskararao 2011). In this case, literate speakers of Tamil do use a voicing contrast such as [p] vs. [b] word-initially, due to a large number of borrowed words with initial voiced stops (such as [b]) in common use (Wiltshire 2015), and even voiced aspirates may appear in learned contexts or for borrowed words.

Many Indian languages which have contrastive aspiration among their plosives, do not have much of aspiration in the plosion that occurs in utterance final position. In careful speech, they are released with an extra ‘puff of air’ (which has the acoustic correlation of voiceless glottal friction). Thus, the quantity of VOT lag has to be finely tuned to get the appropriate result depending upon the position of the voiceless aspirated plosive in an utterance (Bhaskararao 2011).

Lisker and Abramson (1964) measure the Voice Onset Time (VOT) of Tamil voiced and voiceless stops, and find the voiced stops have a long lead time: -62ms for /g/, -78ms for /d/, and 74ms for /b/; the voiceless have little aspiration and short VOTs: 24ms for /k/, 8ms for /t/, and 12ms for /p/, consistent also with Balasubramanian (1975) who reports short VOTs for the voiceless stops. In contrast, some other studies on Dravidian languages like Kannada, Malayalam, and Tamil have revealed that voiceless plosives have longer VOT compared to voiced plosives (Klatt 1975; Lisker & Abramson 1964). This is supported by a later study which found that Tamil exhibits shortlag VOT voiceless word- initial plosives (Keane 2004).

However, due to the lack of investigations that involve the analysis of the voicing contrast of plosive phones and VOT development in Tamil, there is little to no evidence-based data that shows the patterns of VOT development across different age ranges among Tamil-speaking children.

While the results of VOTs in Tamil plosives vary in these studies, one thing that must be made clear is that phonetic voicing differences that are not phonologically contrastive are not necessarily accompanied by onset f0 differences. For example, Kingston & Diehl (2019) reported that in Tamil, where stop voicing is allophonic, onset f0 does not correlate with voicing differences in stop consonants. This finding can be explained in a very straightforward manner: If onset f0 functions primarily as a cue to a phonological distinction, then it need not vary with VOT when that variation is simply phonetically conditioned.

<u>Tamil plosives</u>

b d g p t k

\- +

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pre-voiced 0 short lag long lag

Malay plosives

b d g p t k

\- +

pre-voiced 0 short lag long lag

FIGURE 1.4. Schematic representation of the VOT continuum which shows the relationship between Tamil and Malay plosives.

Voicing Contrast of Plosives

Voicing contrast of plosives requires complex coordination between the auditory and articulatory systems. Acoustic cues like voice bar, voicing during closure, closure duration, vowel duration, and VOT can be used to study the voicing contrast in plosives. To investigate voicing contrast in word-initial plosives, however, VOT is the only acoustic cue that could be used (Shahidi 2010).

In many languages, including English (Kewley-port et al. 1974; Macken & Barton 1979), Korean (Jun 2007), Thai and Hindi (Shimuzu 1989), the acquisition of voicing contrast in young children has been extensively investigated (Macken & Barton 1980). Generally, monolingual children learn to differentiate between short and long lag VOT by the ages of 2; 00–2; 06 (Kehoe et al. 2004; Kewley-port et al. 1974; Macken & Barton 1980). However, it takes till after age 3; 00 to develop the distinction between pre-voiced and short lag VOT (for example, in Spanish, French, and Italian). This is because lead voicing is challenging to produce, especially for beginners like children (Macken & Barton 1980).

Purpose of Study

The primary purpose of the present study was to investigate the VOT pattern of Malay word-initial plosives produced by Tamil-speaking children. Along with measuring the VOT values, we estimated that as age increases, the VOT values approach adult-like VOT values (Kewley-port et al. 1974; Macken & Barton 1980; Shahidi et al. 2012). The study also hypothesized that the voicing contrast between pre-voiced and short lag VOT in Malay word initial plosives is acquired after age 3;00 (Badrulzaman 2016; Badrulzaman et al. 2022,). Besides, the study also aimed to determine whether gender would influence the VOT values produced by the children.

Objectives

1. To measure the VOT values of Malay word-initial plosives produced by Tamil speaking children.
2. To determine the age of acquisition of voicing contrast in Malay word-initial plosives by Tamil- speaking children.
3. To determine the gender effect on VOT values of Malay word initial plosives produced by Tamil- speaking children.

METHODS

Participants

This study involved two main groups: (1) Tamil-Malay bilingual children aged 3;00 to 7;11 years old, and (2) control groups. The control groups comprised of three categories: (1) Malay monolingual children, (2) Malay monolingual adults, and (3) Tamil-Malay bilingual adults. Data from past research and findings were utilized for the Malay monolingual children group.

A total of 15 children residing in the Klang Valley area were selected. The subjects were categorized into five age groups: 3 years (hereafter denoted as 3;00) to 3 years and 11 months (hereafter denoted as 3;11), 4;00–4;11, 5;00–5;11, 6;00–6;11, and 7;00–7;11.

There were five inclusion criteria in sample selection as follows: (1) Malaysian (2) native speakers of Tamil (3) simultaneous or sequential bilinguals who are able to understand and use Malay (4) no reported speech and language delay or other disabilities (5) given consent by parents/caregiver to participate in the study.

TABLE 2.1. Demographic Data of Participants (Tamil-Malay Bilingual Children)

Participants	Gender	Age
1.	Male	3;02
2.	Male	3;04
3.	Male	3;05
4.	Male	4;02
5.	Male	4;08
6.	Male	4;11
7.	Female	5;05
8.	Female	5;06
9.	Female	5;08
10.	Female	6;01
11.	Female	6;05
12.	Male	6;09
13.	Female	7;03
14.	Female	7;03
15.	Female	7;05

TABLE 2.2. Demographic Data of Participants (Malay Monolingual Adults)

Participants	Gender	Age
1.	Male	65;08
2.	Female	68;05
3.	Female	72;02

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TABLE 2.3 Demographic Data of Tamil-Malay Bilingual

Participants (Adults)

Participants	Gender	Age
1.	Female	28;03
2.	Male	33;11
3.	Female	51;02

Material and Procedure

The study began with the application and approval of research from the Research Ethics Committee of Universiti Kebangsaan Malaysia .The Upon approval, consent and some background information were obtained from the parents of the participants. Consent was also obtained from the study site where the recording took place, i.e., kindergarten, tuition center. Then, the data collection process began. During testing, a digital audio recorder (Sony IC recorder ICD-SX850) was placed close to the participants. Stimuli pictures (refer Appendix I) were used to elicit words with targeted wordinitial plosives /p, b, t, d, k, g/. A Malay picture-naming task was conducted. Each time, one picture was shown, the child was requested to produce the words with targeted plosives spontaneously. Cues were given if the child had difficulties naming the pictures. Cues were given in the following order: (1) Semantic cue (e.g., Monyet suka makan buah apa?); (2) False choice (e.g., Ini pokok, payung atau pisang?); (3) Delayed imitation (e.g., Monyet suka makan pisang. Monyet suka makan apa?). However, direct imitation from the tester was not considered as the target response.

TABLE 2.4 List of stimulus words

/p/	/t/	/k/	/b/	/d/	/g/
Pisang	Tandas	Kaki	Bola	Datuk	Gajah
Pokok	Tangan	Kakak	Baju	Duduk	Gigi
Pensel	Tiga	Kasut	Buku	Dua	Gula

Source: Badrulzaman 2016

Recordings and VOT measurements

The recording took place in a quiet room that could have been in the child's house, kindergarten, or tuition center. Speech samples of the children (3 subjects x 5 age groups x 6 consonants x 3 words x 3 repetitions = 810 tokens) and control groups (3 subjects x 2 groups x 6 consonants x 3 words x 3 repetitions = 324 tokens) were audio recorded using Sony IC recorder ICD-SX850 and transferred into a computer. The PRAAT software version 5.3.56 was used to analyze the collected samples. Speech samples were displayed as spectrograms in the software. VOT, the period between the release of the consonant stop and the onset of voicing, was measured.

DISCUSSION AND RESULTS

The Cronbach's alpha (α) coefficient was used to measure the internal consistency. Results revealed good internal consistency (α= 0.894). A clinical linguist trained in the use of the PRAAT software determined the inter-rater reliability via the analysis of VOTs of the audio samples independently. The intraclass correlation coefficient (ICC) is 0.942 indicating excellent inter-rater reliability.

VOT values of Malay word-initial plosives produced by Tamil-speaking children

For VOICED plosives, the age group of 3 and 4 years old obtained mean VOT values that fell within the short lag region (0-30ms) for phonemes /d/ and /g/. For phoneme /b/, children aged 3;00 and 4;00 obtained mean VOT values of M=34 (SD=4.041) and M=34 (SD=2.646) respectively, with both mean VOT values falling within the long lag VOT range. Children aged 5;00 and 6; 00 produced voicing lead for phonemes /d/ and /g/, voicing lag for phoneme /b/. However, children aged 5;00 obtained mean VOT values of M=42 (SD=1.732) that fell within the long lag region whereas children aged 6;00 obtained mean VOT values of M=26 (SD=1.000) falling within the short lag region. Results revealed that children aged 7; 00 obtained mean VOT values for all three phonemes that fell within the pre-voiced VOT region.

For VOICELESS plosives, children from all age groups produced short-lag VOT for all phonemes similar to the VOT range of Tamil-Malay bilingual adults and Malay monolingual adults.

TABLE 3.1. VOT for VOICED and VOICELESS plosives (mean VOT (M) in milliseconds (ms) and standard deviation (SD)) by age

Phoneme			3;00	4;00	5;00	6;00	7;00	Tamil-Malay bilingual adults	Malay monolingual adults
VOICED	/b/	M	34	34	42	26	-46	-93	-90
			(4.041)	(2.646)	(1.732)	(1.000)	(32.192)	(2.082)	(2.000)
	/d/		21	22	-45	-39	-32	-76	-77
		SD	(6.807)	(3.215)	(3.000)	(1.528)	(2.646)	(0.577)	(4.583)
		SD							
		M							
	/g/	M	26	30	-40	-54	-45	-63	-56

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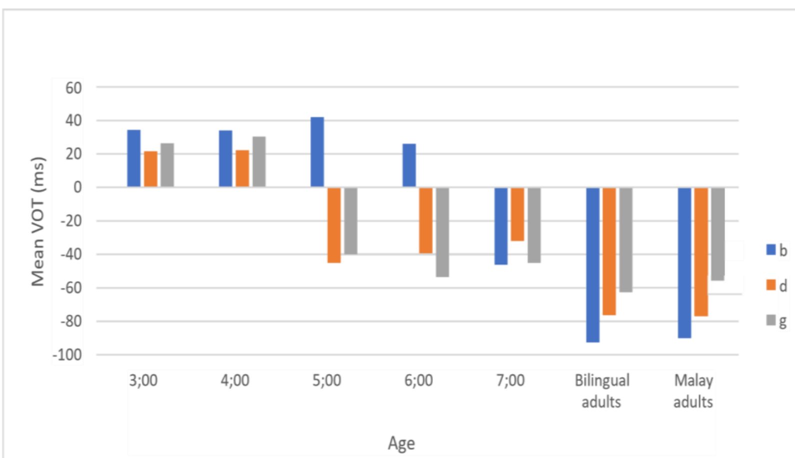
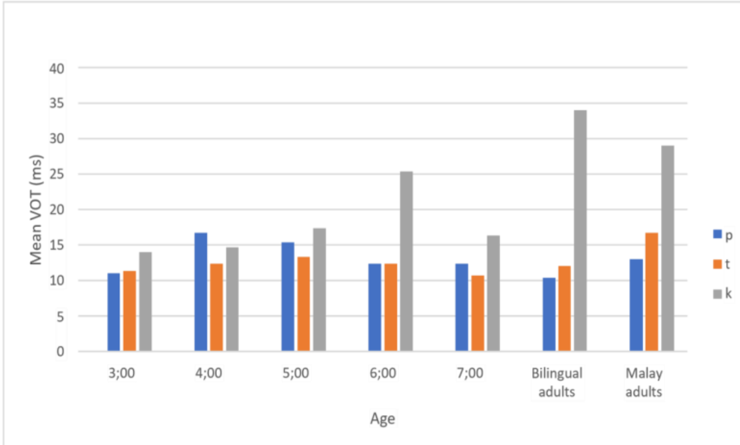
			(5.508)	(2.082)	(17.088)	(3.055)	(9.000)	(0.577)	
VOICELESS	/p/		(0.000)	(1.528)	(0.577)	(2.517)	(4.726)	(0.577)	
	/t/		(4.933)	(1.528)	(8.622)	(4.509)	(3.786)	(0.000)	
		SD							(2.517)
		M	11	17	15	12	12	10	13
		SD							(1.000)
		M	11	12	13	12	11	12	17
		SD							(1.155)
	/k/	M	14	15	17	25	16	34	29
		SD	(4.593)	(3.055)	(2.082)	(1.155)	(2.517)	(4.000)	(1.000)

Based on GRAPH 3.1, the duration of voicing lag, regardless of short or long lag, did not show a fixed pattern in relation to the place of articulation. There is an increasing pattern of the mean VOT values as the place of articulation moved further back from alveolar plosive /d/ to velar plosive /g/ as noticed in children aged 3;00 and 4;00. However, the bilabial plosive /b/ had longer VOT compared to alveolar plosive /d/ and velar plosive /g/. Children aged 5;00 and 6;00 produced pre-voicing for all phonemes except for phoneme /b/ meanwhile children aged 7;00 produced pre-voiced VOT for all phonemes. Unlike the high variability in the VOT pattern of children, it was noted that the further back the place of articulation, the shorter the duration of pre-voiced VOTs among Tamil Malay bilingual adults similar to Malay monolingual adults.



GRAPH 3.1. Mean VOT values for VOICED plosives across age groups

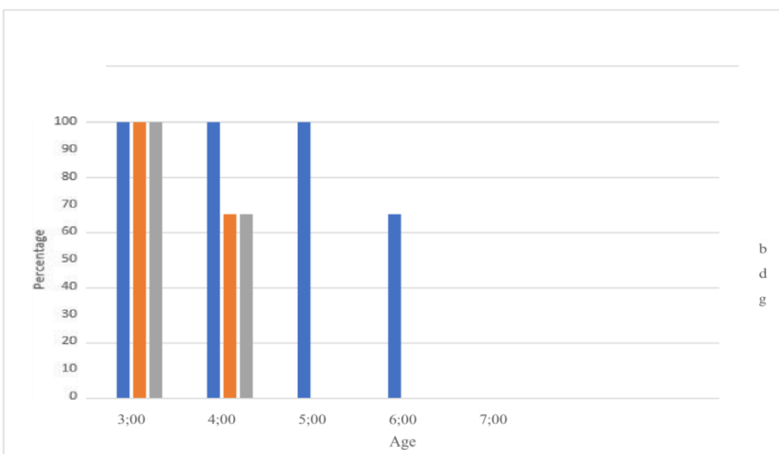
Based on GRAPH 3.2, as the place of articulation moved further back, the mean VOT values of Tamil- Malay bilingual adults and Malay monolingual adults increased. However, the mean VOT values of children of all ages did not follow the same pattern.



GRAPH 3.2. Mean VOT values for VOICELESS plosives across age group

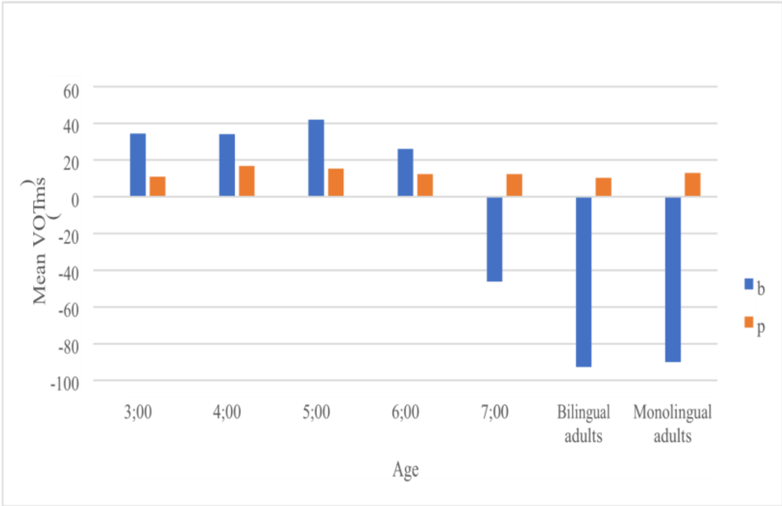
Acquisition of voicing contrast

According to graph 3.3, all children aged 3; 00 did not produce a pre-voiced VOT pattern for VOICED plosives /b, d, g/. All children aged 4;00 and 5;00 did not produce pre-voiced VOT for phoneme /b/ meanwhile 2 children (66.67%) aged 4;00 did not produce pre-voiced VOT for phoneme /d/ and /g/. In the age group of 6;00, 2 children (66.67%) did not produce pre-voiced VOT for phoneme /b/. All children aged 7;00 (n=3) produced pre-voiced VOT for all VOICED plosives. It was noted that voicing contrast in plosives was fully established by the age of 7 years old.



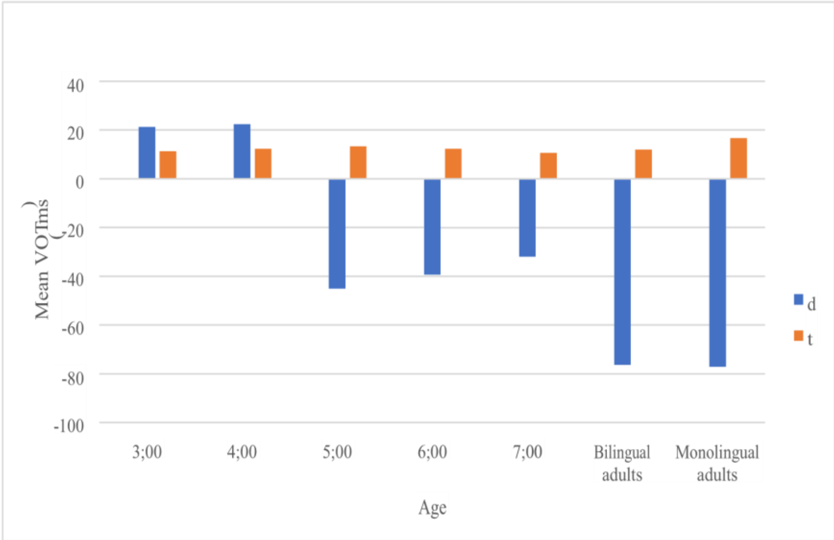
GRAPH 3.3. Percentage of subjects who did not produce pre-voiced (-) VOT for VOICED plosives according to age groups

Graph 3.4 revealed that the mean VOT values for phoneme /b/ and /p/ at the age of 3;00 are similar to the mean VOT values for phoneme /b/ and /p/ of children aged 4;00. It could be seen that the mean VOT values for both phoneme /b/ and /p/ decreased from age 5; 00 to 7; 00. Children aged 7; 00 produced pre-voiced VOT for the phoneme /b/, according to the negative mean VOT value. The mean VOT value for phoneme /p/ obtained by children aged 7;00 is similar to bilingual and monolingual adults but was yet to achieve a closer VOT range to adults for phoneme /b/.



GRAPH 3.4. Mean VOT values for bilabial plosives /p/ and /b/ across age groups

Based on GRAPH 3.5, children aged 3; 00 and 4; 00 obtained positive and similar mean VOT values for both phonemes/d/ and /t/. The mean VOT values for phoneme /t/ are positive and similar across all age groups. For phoneme /d/, children aged 5;00 to 7; 00 obtained a negative VOT value which indicates that they produced a pre-voiced VOT pattern for this phoneme similar to adults.



GRAPH 3.5. Mean VOT values for alveolar plosives /d/ and /t/ across age groups

Based on GRAPH 3.6, children aged 3;00 and 4;00 produced voicing lag (positive VOT) for both phonemes /k/ and /g/. Similar to Tamil-Malay bilingual adults and Malay monolingual adults, children aged 5;00 to 7;00 produced negative mean VOT values (pre-voiced) for phoneme /g/ and positive mean VOT values for phoneme /k/.

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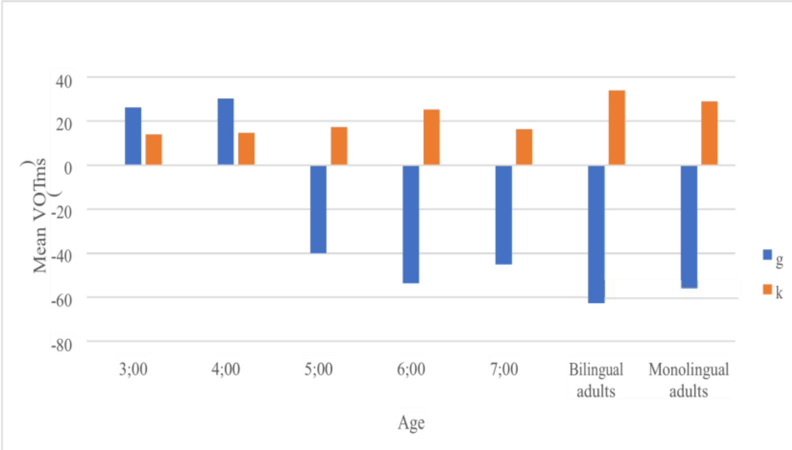

GRAPH 3.6 Mean VOT values for velar plosives /g/ and /k/ across age groups

Gender effect on VOT values

Based on TABLE 3.2, males produced longer VOT compared to females, for both VOICED and VOICELESS plosives except for velar plosive /k/ where females produced longer VOT than males. The Mann-Whitney U test, a non-parametric test, was used to investigate the impact of gender on the VOT values of plosives. Mann-Whitney U analysis revealed that there was no significant gender effect on VOT values for VOICED phonemes (U=41.000, p=0.355 for /b/; U=27.000, p=0.055 for /g/) except for phoneme /d/ (U=25.500, p=0.043 <0.05). There were also no significant gender effects on VOT values for VOICELESS phonemes (U=47.500, p=0.641 for /p/; U=51.000, p=0.830 for /t/; U=33.500, p=0.144 for /k/).

TABLE 3.2.. Mann-Whitney U Test Results for Mean VOT of plosives by gender

Phoneme	Gender	Mean	U	p
b	Male (n=7) Female (n=8)	12.44 9.92	41.000	0.355
d	Male (n=7) Female (n=8)	14.17 8.63	25.5000	0.043
g	Male (n=7) Female (n=8)	14.00 8.75	27.000	0.055
p	Male (n=7) Female (n=8)	11.72 10.46	47.500	0.641
t	Male (n=7) Female (n=8)	11.33 10.75	51.000	0.830

k	Male (n=7) Female (n=8)	8.72 12.71	33.500	0.144

DISCUSSION

The main purpose of the present study was to examine the VOT pattern of Malay word-initial plosives produced by Tamil-speaking children, by measuring the VOT values and determining the age of acquisition of voicing contrast. This study also aimed to determine whether gender has a significant impact on VOT values.

VOT of Malay word-initial plosives produced by Tamil speaking children

The table below compares three models suggested by Macken and Burton (1980) to the findings of this present study.

TABLE 4.1. Model of Initial Plosives

	Three-stage model (Macken & Barton 1980)	Present study
STAGE I	Children produced a fairly short VOT, showing nearly no distinction in VOT values between voiced and voiceless plosives	Children aged 3; 00 and 4;00 produced short lag VOT patterns for both VOICED (except for phoneme /b/) and VOICELESS plosives, showing no contrast in VOT production. No prevoiced VOT produced.
STAGE II	A distinction starts to develop; however, did not conform to the adult perceptual boundaries of VOICED and VOICELESS categories	The VOICED and VOICELESS plosives produced by children aged 5; 00 to 7; 00 showed distinct differences in mean VOT. The VOT means for VOICED plosives mostly fell within the pre-voiced VOT range meanwhile the VOT means for VOICELESS plosives fell within the short lag VOT range. However, the VOT means for VOICED plosives are yet to achieve a closer VOT range to adults.
STAGE III	With further development, children produce considerably longer voiceless stops that fell within the expected VOT pattern for plosives resembling the adult contrast	Children aged 7; 00 produced prevoiced VOT for all VOICED phonemes similar to the bilingual and monolingual adults' VOT means. All children produced VOT pattern that was similar to adults for VOICELESS plosives.

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Stage I

Results from the present study found that, Tamil-speaking children aged 3; 00 and 4;00 produced only short lag for both VOICED (except for phoneme /b/) and VOICELESS plosives. This finding aligns with previous research on word-initial stops in various languages, as demonstrated by Shahidi et al. (2016) in Malay monolingual children, Yang et al. (2018) in Mandarin monolingual children, and Shahidi & Aman (2011) in Malay English bilinguals. It is typical for children to produce only a short lag in the early stage of acquiring voicing contrast (Badrulzaman 2016; Badrulzaman et al. 2022). In accordance with the mentalist theory of language learning, an individual has an innate predisposition towards language acquisition, and it is universal in nature. Based on articulatory and aerodynamic considerations, Kewley-port et al. (1974) hypothesised that short lag VOT is acquired first because it is easier to produce short lag VOT than long lag VOT or pre-voiced VOT. This is due to the fact that the immature motor system of young children restricts the production of long-lag VOT, as indicated by Green et al.
(2000).

Based on a past study on phonetics and phonology of the Tamil language (Bhaskararao 2005), the ability of Tamil-speaking children aged 5 and 6 to produce prevoiced VOT for plosives /d/ and /g/ while not exhibiting pre-voiced VOT for phoneme /b/ can be attributed to the allophonic nature of voiced and voiceless plosives in Tamil. In the Indian linguistic context, the phonemes /p/ and /b/ are sometimes used interchangeably due to their allophonic nature in Indian languages, including Tamil. The presence of borrowed words from other languages, such as English, in Tamil has influenced the use of a voicing contrast between [p] and [b] in word-initial positions, especially among literate Tamil speakers (Wiltshire 2015).

As Tamil-speaking children grow and are exposed to a second language, such as when they attend preschool or school, they encounter more borrowed words, leading to increased exposure to the word-initial voicing contrast which explains why children aged 5 and 6 did not produce pre-voiced VOT for phoneme /b/ yet as compared to children aged 7;00 who produced pre-voiced VOT for all phonemes, including /b/.

Stage II

Children aged 5;00 to 7;00 exhibited distinct mean VOT values between VOICED and VOICELESS plosives, with pre-voiced characteristics for voiced plosives and short lag for voiceless plosives. This pattern resembles the realization of the Malay initial plosive voicing contrast in the speech of native Malay speakers with English as their second language, as suggested by Shahidi et al. (2012). According to Macken & Barton (1980), in the second stage, children begin to develop differentiation between the VOT values of VOICED and VOICELESS stops. However, they do not adhere to the adult perceptual boundaries of these categories, making the distinction presumably imperceptible to adults. A similar phenomenon can be observed in the VOT means produced by Tamilspeaking children in the present study.

Stage III

In a study conducted by Badrulzaman (2016), using a similar procedure to the present study, it was reported that Malay monolingual children acquired voicing contrast (prevoiced vs. short lag) at the age of 4 years old. However, in the present study, the emergence of pre-voiced VOT in VOICED plosives occurred later, around the age of 5;00 for phonemes /d/ and /g/. The delayed emergence may be influenced by various perceptual, social, and environmental factors, which will be discussed later.

In comparison to a previous study by Hamid et al. (2022), which focused on voicing contrast in Malay word-initial plosives produced by Mandarin-speaking children, it was hypothesized that voicing contrast emerges when children are around 7;00 years old. The results of the present study suggest that the acquisition of voicing contrast in Malay is relatively early among Tamil-speaking children. This could be attributed to the relatively similar property pattern of VOTs between Tamil (a Dravidian language) and Malay plosives.

Several studies on voice onset time in Kannada (another Dravidian language) have shown that voiced plosives (/b/, /d/, /g/) have negative VOTs in the initial position of stops in both children and adults (Athaide & Kumudavalli 2017; Shetty et al. 2010). Similarly, Lisker & Abramson (1964) examined VOT values in Tamil spoken by a native Tamil speaker and found that voiceless plosives (/p/, /t/, and /k/) had VOT values close to zero or small positive values. This is comparable to the realization of the Malay initial plosive voicing contrast in native Malay speakers, where short lag is produced for voiceless plosives, and voicing-lead is produced for voiced plosives (Shahidi et al. 2012). Hence, the similarity in VOT patterns between Tamil and Malay among native speakers may facilitate the relatively early acquisition of voicing contrast in Malay among Tamil speaking children compared to Mandarin speakers of Malay.

As children age, their VOT values are expected to approach adult-like VOT patterns. In the present study, all children exhibited VOT patterns for VOICELESS plosives that resembled those of adults. However, for VOICED plosives, the VOT means of children aged 5;00 to 7;00 did not resemble the adult-like VOT range. Despite having acquired the voicing contrast of their second language (L2), it was observed that the fine-tuning process continued and extended into school-age years. This phenomenon is particularly evident in languages with pre-voiced and short-lag VOT contrasts, as discussed by MacLeod (2016).

Additionally, Zlatin and Koenigsknecht (1976) proposed a developmental shift in the acquisition of voicing contrast among English-speaking children, transitioning from a unimodal pattern (favouring short lag VOT) to an emerging bimodal pattern, and eventually to a typical bimodal pattern. A similar developmental trajectory was observed in the present study. Specifically, the VOT distribution demonstrated a unimodal pattern (short lag VOT) in the three-year-olds and four-year-olds, gradually approximating the bimodal distribution observed in adult speakers (prevoiced - short lag VOT) starting at the age of 5;00.

Moreover, the duration of pre-voicing and voicing lag varies based on the place of articulation, with the duration of pre-voiced VOT being shorter and voicing lag (short or long) being longer as the place of articulation moves further back. However, the VOICED and VOICELESS plosives produced by Tamil-speaking children for Malay did not conform to this general agreement. Notably, a diverse range of mean VOT values patterns can be observed in each place of articulation across different age groups in children (refer GRAPH 3.1 AND GRAPH 3.2). In contrast, the VOT pattern produced by Tamil-Malay bilingual adults adheres to the expected general statement.

This difference in VOT patterns between children and bilingual adults can be attributed to two potential factors. Firstly, the extent of establishment of phonemic categories is influenced by the exposure to the second language (L2) and the usage of both the first language (L1) and L2 (Aoyama et al. 2004). The bilingual adult participants in this study regularly use Malay in social and occupational settings since their early years, leading to higher exposure and usage of the

Malay language compared to the children who have been exposed to Malay only within the past three to seven years.

Secondly, another possible explanation lies in the language-specific nature of the place effect. A previous study on a Tamil-speaking individual conducted by Lisker & Abramson (1964) revealed that the VOT value for /t/ was shorter than /p/ and /k/ in Tamil. This finding suggests that the place effects may not be as robust in Tamil as in other languages. Consequently, this may indicate the influence of the first language (Tamil) in the realization of the second language (Malay) VOT pattern in the present study, suggesting Cross-Linguistic Influence (CLI) as a plausible explanation which is also known as language transfer, by which someone's knowledge of one language influences how they learn and use another language (Serratrice 2013).

Acquisition of voicing contrast

MacLeod (2016) suggested that a child's ability to manipulate acoustic phonetic cues might be influenced by the demands of the task they are engaged in. Previous studies investigating languages with a pre-voiced Voice Onset Time (VOT) contrast have focused on three types of tasks: repetition (Eilers et al. 1984), picture naming (MacLeod 2016), and spontaneous speech (Bóna & Auszmann 2014). The variability in the age of acquisition of voicing contrast observed in these studies could be partly attributed to the different tasks utilized and the languages under investigation.

In this study, it was observed that Tamil-speaking children acquire the voicing contrast in Malay word-initial plosives at the age of 5 years old, which is later compared to the acquisition age of 4 years old for Malay monolingual children (Badrulzaman 2016). This delay in acquisition may be influenced by various factors such as perception, social interactions, and the environment.

Based on the typical VOT production development pattern, all plosives are initially produced with short lag VOT (Zlatin & Koenigsknecht 1976). Khattab (2022) proposed that a bilingual's preference for short lag over pre-voiced VOT might be a developmental characteristic rather than a result of Cross-Linguistic Influence (CLI). Nevertheless, it is acknowledged that bilingualism could potentially impede the acquisition of certain features that require early and extensive exposure if adequate input is lacking. In Khattab (2022) study on English-Arabic children, it was revealed that sufficient exposure to Arabic pre-voiced at an early age was crucial for mastering the complex articulatory features necessary for pre-voiced production.

In the present study, the acquisition of voicing contrast by Tamil-speaking children at the age of 5;00 may be attributed to insufficient exposure to the Malay language during their early years. As children typically commence attending preschool at the age of 5, the increased exposure to Malay in their environment could have made pre-voiced more salient, leading to the acquisition of pre-voiced VOT at the age of 5. It is hypothesized that children who have access to Malay speaking individuals such as maids, friends, or neighbours may acquire the voiced contrast of Malay at an earlier age (Khattab 2022).

Gender effect on VOT values

Given that the allocation of male and female subjects was not equal in each age group, the overall gender effects on the distribution of VOT were examined instead. Consistent with a previous study by Whiteside and Irving (1998), females in the present study produced longer VOT values than males, except for phoneme /k/. However, no significant gender effects were found between the VOT means produced by males and females, except for phoneme /d/ in the present study. This finding aligns with a few earlier studies (Koenig 2000; Morris et al. 2008) that also reported no significant gender effect on VOT values for both VOICED and VOICELESS plosives.

On the other hand, Li (2013) reported significant gender effects in VOT values produced by individuals aged 18-30 years old. The observed gender effects were attributed to physiological and anatomical differences between females and males. The contrasting findings between the present study and Li (2013) could be explained by the age of the subjects involved. Yang et al. (2018) suggested that apparent articulatory structure differences between males and females are not evident until around the age of seven. Considering that all children in the present study were around the age of 7 or below, this may be a reason why no significant gender effects on VOT were found.

To gain a better understanding of gender effects on VOT values of Malay word-initial plosives produced by Tamil-speaking children, further studies should aim to recruit a larger sample with an even distribution of genders in each age group and investigate gender effects within specific age groups. This approach would minimize biases and provide more robust insights into the potential impact of gender on VOT patterns in this population.

Conclusion and Clinical Implication

The main objective of this study was to investigate the age at which Tamil-speaking children acquire voicing contrast (pre-voiced vs. short lag) in Malay word-initial plosives, using acoustic analysis of Voice Onset Time (VOT). Although the study's findings were limited in scope, they indicated that Tamil-speaking children begin to acquire voicing contrast in Malay word-initial plosives at the age of 5;00. The VOT distributions followed the developmental trajectory proposed by Macken & Barton (1980) and Zlatin & Koenigsknecht (1976). Interestingly, place effects on the duration of VOTs were observed only in adults, likely influenced by their exposure to the second language (L2) and cross- linguistic influence.

As children age, their VOT values tend to approach adult-like VOT values, reflecting a developmental trend in phonetic categories. Notably, no significant gender effect was observed on the VOT values of Malay word-initial plosives produced by Tamil speakers. These findings shed light on the developmental acquisition of voicing contrast in children and provide insights into the influence of perceptual, social, and environmental factors in this process. The present study had a relatively small sample size; therefore, future studies are recommended to target a larger sample to obtain more representative data. Such data could then be compared with the VOT of children suspected of phonological disorders, childhood apraxia of speech, or hearing impairment, who demonstrate voicing errors. This evidence-based approach can be instrumental in speech-language pathology practice, as suggested by Hattori et al. (2005), where objective speech evaluation using acoustic measurements can assist in designing effective intervention plans. VOT can be used as a diagnostic tool to assess speech disorders, especially those related to the production of stop consonants. Deviations from the typical VOT patterns can indicate speech sound disorders, such as articulation disorders or phonological disorders. The study of VOT helps in differentiating between voiced and voiceless sounds. This can be particularly relevant in cases where individuals have difficulty distinguishing between sounds, which may contribute to speech and language difficulties. Understanding VOT patterns can assist speech-language pathologists in making accurate diagnoses of speech disorders. It also provides valuable information for planning appropriate interventions and treatments tailored to an individual's specific speech production patterns.

In summary, the study of Voice Onset Time has several clinical implications, ranging from the assessment and diagnosis of speech disorders to the development of tailored therapeutic interventions. It plays a crucial role in understanding speech production and can contribute to improving communication outcomes for individuals with speech and language difficulties.

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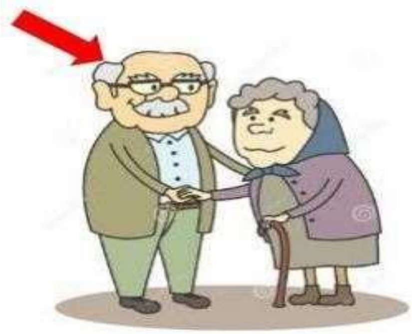
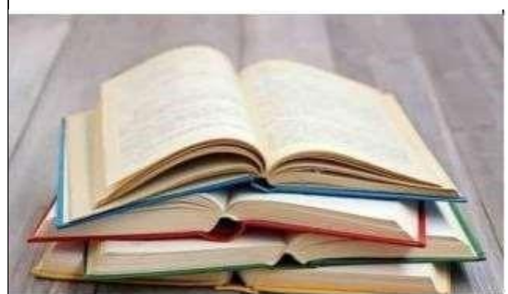
Appendix 1- Stimulus picture

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	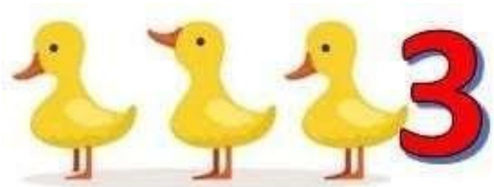
	
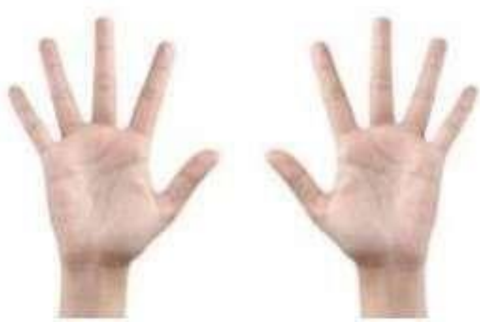	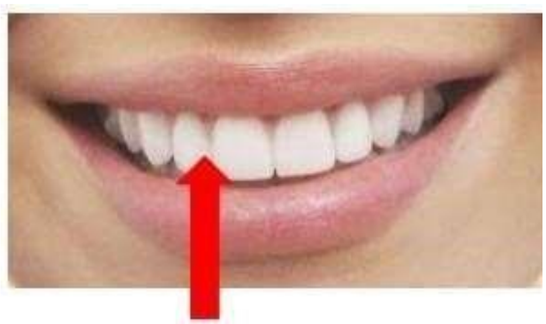

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Biodata Penulis:

Preeta a/p Rajandran merupakan seorang graduan dalam bidang Sains Pertuturan dan kini berkhidmat sebagai ahli terapi pertuturan. Beliau memegang Ijazah Sarjana Muda dalam Sains Pertuturan dari Universiti Kebangsaan Malaysia.

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