DEVELOPMENT AND VALIDATION OF RETROFLEX LOADED PICTURE STIMULI FOR TAMIL-SPEAKING CHILDREN WITH SPEECH SOUND DISORDERS

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CERTIFICATE

This is to certify that this dissertation entitled **"Development and Validation of Retroflex Loaded Picture Stimuli for Tamil- Speaking Children with Speech Sound Disorders"** is a bonafide work submitted as part of fulfilment of the degree of Master of Science (Speech-Language Pathology) of the student with Registration Number P01II24S123001. This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other university for the award of any other Diploma or Degree.

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This is to certify that this dissertation, entitled **"Development and Validation of Retroflex Loaded Picture Stimuli for Tamil- Speaking Children with Speech Sound Disorders "**, has been prepared under my supervision and guidance. It is also being certified that this dissertation has not been submitted earlier to any other university for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled **"Development and Validation of Retroflex Loaded Picture Stimuli for Tamil- Speaking Children with Speech Sound Disorders "** is the result of my own study under the guidance of Dr. Amulya P Rao, Assistant Professor in Language Pathology Centre for Augmentative and Alternative Communication & Sign Language (CAAC-SL), All India Institute of Speech and Hearing, Mysuru and has not been submitted earlier to any other university for the award of any other Diploma or Degree.

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CHAPTER I

Introduction

Promotion of clear and intelligible speech production is among the most important objectives in speech and language pathology. Improved clarity in speech production makes it easier for native and non-native listeners to understand the speech and similar proportional enhancement occurs across different listener populations, suggesting similar processing routines (Smiljanic & Bradlow, 2007). In children speech intelligibility develops slowly over time. It continues through childhood until the child produces utterances comparable to the ones produced by adults. Majority of English speech sounds are established by the age of 4 years and consonant clusters by 4.5 to 5.5 years (Priester et al., 2011). Of the Indian languages, Dravidian languages such as Tulu, children achieve majority consonants by 3.0 to 3.12 years and the rest retroflex /l/ and trill /r/ by later ages (Shetty & Prabhu, 2015). In Tamil-speaking children, most consonants were acquired by 3 to 5 years, except flap trill and palatal lateral at the single-word level, and all consonants were acquired by 4 to 5 years in sentence level (Perumal et al., 2019). In Kannada, typically developing children acquire most pressure consonants by the age of 3 to 4 years, achieving a criterion level of 90% to 100% accuracy (Muralikrishna, 2019). According to Neenu and Sreedevi (2011), Malayalam-speaking children acquire all the consonants except for fricatives, laterals and aspirants by 4 years of age. In the Indo-Aryan languages, such as Hindi, by the age of 6 years, most children complete their phonological repertoire, except for a few sounds like voiced alveolar fricatives, voiced velar fricatives, velar nasals, and certain liquids (Kaur, 2015). So, there are differences in the age at which the speech sounds are acquired across various languages due to presence of phonetic and phonotactic variations between the languages and even within the languages across different dialects (Tucker, 2020).

Phonetic and Phonotactic Variations across Indian Languages

India has two major language groups, Indo-Aryan (Hindi) and Dravidian Languages (Kannada, Tamil, Malayalam and Telugu). Across these languages, there are both similarities as well as differences in phonetics and phonotactic characteristics. For example, the aspirated sounds are not common and non-phonemic in the Tamil language, but they are phonemic in nature in Hindi, Kannada, and Telugu. Further, voicing is context-dependent in Tamil, whereas in Kannada, Telugu, Malayalam and Hindi it is not. This explains the diversity of the language, culture, and communication in different geographical locations. Further, a particular sound acquisition varies across these languages depending upon the frequency of occurrence of speech sounds in a particular language, as well as the phonetics and the phonotactics of that language. If there is a delay or deviation in the acquisition of speech sounds, it will lead to Speech Sound Disorders (SSD).

Speech Sound Disorders (SSD)

Speech sound disorder (SSD) is described as 'persistent difficulty with speech sound production that interferes with speech intelligibility or prevents verbal communication' (APA, DSM-5, 2013). SSD is a common communication disorder characterized by persistent phoneme deletion or distortion errors in speech production (Cabbage, 2019). In the United Kingdom, 3.6% of 8-year-old children were estimated to have persistent SSDs (Wren et al., 2018). In young adults, 1%–2% have been reported to exhibit residual or persistent speech errors (Flipsen, 2015). The prevalence of communication disorder in a part of rural Indian population was found to be 6.07% (Konadath et al.,2013). Further, in a recent epidemiology study of communication disorders, the prevalence of speech sound disorder was 14% (Jijo et al., 2020). All these Indian epidemiological studies indicate the need for early identification, assessment and intervention of children with SSD across various languages in India.

Tamil is one of the Dravidian languages spoken predominantly in the Indian state of Tamil Nadu. It is one of the world's oldest and most widely spoken languages. According to Ethnologue (2025 data), Tamil is spoken by approximately 79 million native (L1) speakers and 8 million second-language (L2) speakers, totaling to 86 million speakers worldwide. Globally, over 80-85 million people speak Tamil language, like in India, Sri Lanka, Singapore, Malaysia, and the modern diaspora of migrant workers in the UAE, France, the UK, Canada, the USA, Germany, and other countries. Hence, considering the number of Tamil-speaking individuals across the world necessitates the importance of early identification and intervention of Tamil-speaking children with SSD.

Assessment of SSD in Children

Assessment of speech sound production is generally carried out at various levels, such as isolation, word, sentence, and spontaneous speech. The spontaneous speech sample helps to determine the errors in normal conversation and also gives the status of speech intelligibility, which is the ultimate goal of speech therapy.

The available diagnostic tests of articulation in various Indian languages test the target speech sounds generally at the word level. Sometimes children have difficulty producing sounds at the sentence level or spontaneous speech level due to the presence of more coarticulatory effects at these levels, which the available Indian diagnostic tests fail to administer.

In Tamil, the Tamil Articulation Test (TAT) (Usha, 1986), the Consonant and Phonological Process Test in Tamil (Perumal et al., 2019), and the Deep Test of Articulation in Tamil Picture Form (Sangeetha, 1995) are the currently available tests which are in clinical use. TAT tests the sounds at the word level only; the Consonant and Phonological Process Test in Tamil tests the sounds at both the word and sentence levels, and the Deep test of articulation in Tamil – Picture form tests the target sounds in various vowel contexts and phoneme positions at the word level only. Based on the results of these assessments, the articulation intervention plan is made for Tamil-speaking children with SSD.

Intervention for Children with SSD

In most SSD therapy programs, the process is predictable: start with isolated sounds, then move to words, and eventually to conversation. Use of appropriate picture stimuli at all these levels is very important. Picture stimuli are available for word-level intervention, either in the form of flash cards of various lexical categories or those that are available from the diagnostic tests. However, there are no readily available picture stimuli to either assess or carry out intervention at the spontaneous speech level.

Need for the study

In spite of many children with SSD attending articulation therapy, they fail to fully bridge the gap between practicing a sound in isolation and using it correctly in daily conversation. That is, generalization of the learnt sound in daily routine is a difficult task. A key reason for this is the absence of culturally familiar, linguistically precise picturable materials that are intentionally loaded with the target sounds into engaging sentence contexts in a particular language. Petinou (2025) achieved positive intervention results through pictorial production probes among preschool children who communicate in Greek and registered effect sizes of 1.2-2.7 on measures of phonology. Such picture and picture model therapy has a greater effect on the development of speaking skills than the conventional therapies. Applying new image media to learning could be regarded as an influential method to improve early childhood speaking capacity and make learning a delightful and interactive process (Prima et al., 2025).

Current resources often consist of word lists or generic illustrations, many of which lack cultural relevance. Standardized tools that are evidence-based and specifically designed for treating speech sound disorders at the connected speech level in different languages are scarce. Connected speech, which simulates a child's everyday speaking situations, should be assessed and used to correct errors as it allows for targeted intervention within naturalistic contexts. Creating and utilizing such materials is essential for improving intervention by guaranteeing that treatments are closely aligned with real-life communication scenarios.

Pascoe & Norman (2011) have made a strong plea for locally appropriate resources being developed by speech-language therapists rather than translations, while keeping in view variables other than language, such as test familiarity, population norms, and level of education. In Tamil language, there are no culturally and linguistically appropriate picture stimuli available for frequently erred sounds at the spontaneous speech level. Further, generally, such picture stimuli are not available for the target sounds in various vowel contexts and phoneme positions. Considering Tamil as one of the most commonly used languages in various geographical areas, as per the literature, and retroflex being one of the commonly erred speech sounds in Tamil (Clinical Observation), it is necessary to develop and validate picture stimuli (spontaneous speech level) for the same. Hence, the current study was planned.

Aim

This study aimed to develop and validate retroflex-loaded picture stimuli for Tamil-speaking children with SSD, specifically targeting the retroflex sounds /ʈ/ and /ɖ/.

Objectives

1. To design and develop culturally and linguistically suitable picture stimuli that incorporate Tamil retroflex sounds.

2. Utilization of picture stimuli in speech assessment and therapy sessions (Pilot study).

Chapter II

REVIEW OF LITERATURE

Speech is the result of integrated actions of the respiratory, phonatory, resonatory, and articulatory systems, which work together to generate and shape the sound stream used for communication (Freed, 2020). A breakdown in any subsystem can impact the accuracy and quality of speech output. Articulation is one of the major components of speech, significantly affecting its intelligibility. Intelligibility refers to the extent to which a speaker is understood by an interlocutor (Derwing et al., 2022).

In children, speech intelligibility develops slowly over time. It continues through childhood until the child produces utterances comparable to those produced by adults. The age at which children achieve speech intelligibility varies across languages, and this variability can be attributed, in part, to differences in phonetic inventories and phonotactic constraints inherent to individual languages (Tucker, 2020). Cross-linguistic research has demonstrated that the acquisition of speech sounds does not follow a universal timeline; rather, it is shaped by language-specific phonological structures, such as the presence of complex consonant inventories, syllable structures, and permissible sound combinations (McLeod & Crowe, 2018a; Stoel-Gammon, 1994).

There are several Western and Indian studies reporting on the age at which speech intelligibility is acquired in typically developing children across various languages. Table 2.1 provides information on the same.

Table 2.1

Speech Intelligibility Development Across Language in Typically Developing Children.

S. No	Author and year	language	Percentage of intelligibility achieved	Age
1	Hustad et al., 2021	English (American)	90%	6.9 years
2	Schölderle et al., 2021	German	100%	5years
3	Baudonck et al., 2009	Flemish Dutch	90%	4.6 - 5.0 years
4	Zheng et al., 2009	Mandarin	90%	3-6years
5	Le, McLeod & Pham et al., 2022	Vietnamese	99%	5-6 years
6	Jumiarti et al., 2024	Indonesian	95%	6 years
7	Bharadwaj et al., 2010	Kannada	100%	4 years
8	Shetty & Prabhu., 2015	Tulu	98%	3 years
9	Catherine & Abirami et al., 2023	Tamil	95%	6 years
10	Kumar et al., 2023	Hindi	94%	4-5 years

The world is home to over 7,000 languages (Eberhard et al., 2025), and each language exhibits distinct phonetic and phonotactic characteristics that shape its sound system Phonetic variation across languages is reflected in differences in phoneme inventories, articulatory features, and suprasegment properties (Anderson, 2012). Languages vary considerably in the number and types of consonants and vowels they employ; for instance, some languages possess large and complex consonant inventories, while others rely on relatively small and simple sound systems (Maddieson, 1984). For instance, languages such as English (approximately 24 consonants and 20 vowels) (Kusuma & Kurniati, 2020) and Russian (around 35–37 consonants and 5–6 vowels) have relatively large consonant inventories with multiple contrasts and complex syllable structures (Yanushevskaya & Bunčić, 2015) , while languages like Hawaiian (about 8 consonants and 5 vowels) (Parker Jones, 2018)and Japanese (approximately 15 consonants and 5 vowels) exhibit smaller and more restricted phonological systems(Nakai, 2014). At the extreme ends, Taa language possesses an exceptionally large consonant inventory of over 80 consonants (Wikipedia Contributors, n.d.), whereas Rotokas has one of the smallest inventories, with about 6 consonants and a total of approximately 11 phonemes (Robinson, 2006). Similar variation is observed within Indian languages, where Hindi has around 30–35 consonants (Hayes-Harb & Barrios, 2022), while Tamil has a comparatively smaller inventory of about 18 consonants (Keane, 2004). Additionally, languages differ in the use of contrastive phonetic features such as voicing, aspiration, place and manner of articulation, and tone. For example, Indo-Aryan languages like Hindi, contrast aspirated and unaspirated stops phonetically, whereas this contrast is absent in many other languages including Tamil, Japanese, and English (Venkateswaran & Wayland, 2026a). Suprasegmental features such as lexical tone, stress, and rhythm also vary widely, with tonal languages like

Mandarin using pitch variations to distinguish lexical meaning, unlike stress-timed languages such as English (Yip, 2002), and even the acquisition of speech sounds differs among them.

In addition to phonetic differences, languages also vary in their phonotactic constraints, Phonotactic constraints are defined as "restrictions on the types of sounds that are allowed to occur next to each other or in particular positions in the word" (Zsiga, 2000). Languages differ in permissible syllable structures, ranging from simple consonant–vowel (CV) patterns, as seen in Hawaiian, to highly complex consonant clusters permitted in Georgian (Goldsmith, 2006). Phonotactic rules further restrict the positions in which specific sounds may occur, as well as the types of consonant clusters allowed in word-initial, medial, or final positions. For example, many Indian languages such as Tamil, Tulu and Telugu impose restrictions on consonant clusters and often employ vowel epenthesis to resolve phonotactic violations (Pandey, 2014). These language-specific phonotactic patterns influence how speech sounds are learned, produced, and perceived.

Phonetic and Phonotactic Structure of the Tamil Language

Tamil, a major Dravidian language, is spoken predominantly in Tamil Nadu and across global Tamil-speaking communities. According to Ethnologue (2025), the language has approximately 86 million speakers worldwide, including both native (L1) and non-native (L2) speakers covering countries like India, Sri Lanka, Singapore, Malaysia, and the modern diaspora of migrant workers in the UAE, France, the UK, Canada, the USA, Germany, and other countries.

Keane (2004) describes Tamil's diglossic nature, in which the formal literary variety, conforming to standards set as early as the thirteenth century by the grammarian Pavanandi, is used in formal written contexts, while everyday communication relies on colloquial Tamil with considerable regional and social variation. Tamil contains five short vowels, their corresponding long vowels, and two diphthongs. Vowel length is phonemic in nature and influences meaning. The vowels of Tamil language with examples are listed in table 2.2

Table 2.2.

Tamil Vowel Inventory with Examples

Vowel	Tamil Script	Transliteration	Gloss
A	பல்	Pal	teeth
E	எரி	Eri	burn
I	நிலம்	Nilam	earth
O	ஒட்டு	oṭṭu	stick
U	உறு	Uru	shape
Ai	பை	Pai	bag
Ā	பால்	Pāl	milk
Ē	ஏறு	Ēru	climb
Ī	நீலம்	Nīlam	blue
Ō	ஓட்டு	ōṭṭu	drive
Ū	ஊர்	Ūr	village
Au	வௌவால்	Vauvāl	bat

Note. Adapted from *Tamil* by E. Keane, 2004, *Journal of the International Phonetic Association, 34*(1), p. 111–116 (https://doi.org/10.1017/S0025100304001549).

Tamil exhibits a relatively small consonant inventory compared to many other Dravidian languages. Stops occur at four places of articulation: bilabial, dental, retroflex, and velar, and maintain a crucial dental–velar contrast, which is central to meaning. Voicing in stops is contextually driven, with intervocalic voicing and the absence of voiced stop contrasts in word-initial positions. Nasals occur at six major places of articulation, reflecting the distinctiveness of Tamil phonology, as shown in table 2.3.

Table 2.3

Tamil Consonant Inventory by Place and Manner of Articulation

Manner/ Place	Bilabial	Labio dental	Dental	Alveolar	Post-alveolar	Retrof lex	Palatal	Velar
Plosive	p (b)	—	t̪ (d̪)	—	—	ʈ (ɖ)	—	k (g)
Affricate	—	—	—	—	t͡ʃ (d͡ʒ)	—	—	—
Nasal	M	—	n̪	n	—	ɳ	ɲ	ŋ
Fricative	—	—	—	s	—	—	—	—
Tap/Flap	—	—	—	r	—	—	—	—
Approximant	ʋ	—	—	—	—	—	j	—
Lateral Approximant	—	—	—	l	—	ɭ	—	—

Note. Adapted from *Tamil* by E. Keane, 2004, *Journal of the International Phonetic Association, 34*(1), p. 111–116 (https://doi.org/10.1017/S0025100304001549).

Evidence from Indian studies indicates that Tamil-speaking children show a progressive reduction in phonological processes with increasing age, reflecting gradual mastery of consonants and permissible sound sequences. Studies examining typically developing Tamil-speaking children between approximately 2 and 6 years of age have reported that younger children exhibit a higher frequency of phonological processes such as stopping, fronting, cluster reduction, and syllable structure simplification, while older children demonstrate more adult-like productions (Perumal et al., 2017). This developmental trend suggests that early-acquired sounds and structures are mastered first, followed by more complex consonants and phonotactic patterns.

In Tamil, simple syllable structures, particularly CV and CVC patterns, are acquired early and dominate children's early speech output. As children grow older, they gradually acquire longer words, geminated consonants, and morphologically derived consonant sequences, which are characteristic of Tamil phonotactics. Complex articulatory gestures, including those required for retroflex consonants, typically stabilise later in development due to increased motor and coordinative demands (Maassen & Terband, 2024). The persistence of syllable structure simplification beyond the expected age range may therefore indicate immature phonological development.

When speech sound acquisition does not align with expected developmental patterns, the distinction between delay and deviance becomes clinically relevant. A speech sound delay is characterized by the continued use of developmentally earlier patterns beyond the expected age, whereas a speech sound disorder with deviant patterns involves atypical error types that are not observed in typical Tamil development (Bernthal et al., 2022). Indian studies on Tamil-speaking children have highlighted that the persistence of phonological processes beyond the preschool years can significantly lead to SSD, affecting speech intelligibility and communicative effectiveness (Perumal et al., 2017).

Speech Sound Disorders (SSD)

A significant delay or deviation in the typical acquisition of speech sounds is referred to as a Speech Sound Disorder (SSD) (Lewis et al., 2011) SSD is defined as a Persistent difficulty with speech sound production that interferes with speech intelligibility or prevents verbal communication of messages (American Psychiatric Association, 2022). American Speech-Language-Hearing Association (American Speech-Language-Hearing Association, n.d.)stated that Speech sound disorders (SSDs) refer to any difficulty or a combination of difficulties with perception, motor production, or phonological representation of speech sounds and speech segments, including phonotactic rules governing permissible speech sound sequences in a language. Children with SSD often produce speech that is difficult for listeners to understand, resulting in reduced intelligibility. Poor intelligibility can lead to communication breakdowns, reduced self-confidence, social withdrawal, academic challenges, and increased stress for parents (Hustad, 2012; Lewis et al., 2011; Raitano et al., 2004; van Doornik et al., 2025).

SSD is one of the most common communication disorders associated with speech impairment worldwide. Epidemiological studies indicate that the prevalence of SSDs in children aged 4–6 years ranges widely from 2.1% to 23% (Eadie et al., 2015; Jessup et al., 2008; McKinnon et al., 2007). Among 8-year-olds, approximately 3.6% continue to present with persistent SSDs (Wren et al., 2016). In contrast, 1%–2% of young adults demonstrate residual articulation difficulties that persist beyond childhood (Flipsen, 2015). Sex differences have also been reported, with SSDs occurring more frequently in boys than girls, at an estimated ratio of 2:1 in school-aged populations (McKinnon et al., 2007).

Clinical evidence from India indicates that speech sound disorders are commonly observed in pediatric populations attending tertiary care facilities (Kumar et al., 2022). In a retrospective hospital-based study from eastern India, articulation-related speech sound disorders formed a notable proportion of pediatric speech disorder cases, with a higher prevalence reported among male children (Swain et al., 2018). Large school screening programs also report that 6.0% of children are at risk of speech-language disorders, including articulation and phonological disorders (AIISH Mysore School Screening Report, 2015–2020). These prevalence findings establish the public health relevance of speech sound disorders in Indian contexts and underscore the need for early detection and intervention.

Several factors may contribute to articulation difficulties, including structural anomalies (e.g., cleft lip and palate), ankyloglossia, hearing loss, dysarthria, apraxia of speech, and phonological processing deficits, or it can be idiopathic. Predominantly errored speech sound category, both in typically developing children as well as in those with SSD, is retroflex (Bathina et al., 2022). These sounds require precise tongue movements that develop relatively late in speech acquisition. When these sounds are not produced correctly, clarity drops, and communication can become frustrating for both children as well as listener. Understanding the characteristics and prevalence of speech-sound disorders underscores the need for reliable, linguistically appropriate assessment tools to accurately identify speech-sound errors and inform clinical decision-making. Further, the usage of linguistically and culturally appropriate stimuli in the assessment and management of children with SSD is very important.

Assessment of Speech Sound Disorders

A comprehensive assessment of SSD must include oral peripheral mechanism examination, single-word elicitation, spontaneous speech sampling, stimulability testing, hearing screening and so on. Language-specific assessment tools are required as phonetic inventory and phonotactic rules are language-dependent. There are several screening, diagnostic and deep tests available in various languages. Table 2.4 lists various available test materials across different languages along with their stimuli.

Table 2.4

Commonly using standardized articulation tests in English and Indian languages.

S. No	Test	Author	Section/Domains	Type of Stimuli	Age Range
1.	Diagnostic Evaluation of Articulation and Phonology (DEAP)	Barbara Dodd et al., 2002	Articulation, Phonology, Inconsistency, Oral motor	Picture naming, imitation tasks	3-8 years
2.	Photo Articulation Test–3 (PAT-3)	Stephen Pendergast et al., 2013	Articulation screening	Photo-based naming	3–8 years
3.	Goldman–Fristoe Test of Articulation–3 (GFTA-3)	Ronald Goldman & Macalyne Fristoe, 2015	Sounds in words, sounds in sentences, and consonant blends; stimulability testing	Picture naming, sentence repetition	2- 21 years
4.	Arizona Articulation and Phonology Scale–4	Elaine Fudala, 2017	Articulation & phonology	Picture naming	1.5–21 years
5.	Test of Articulation and Discrimination in Telugu	Padmaja, 1988	Vowels, consonants and word pairs.	Picture naming	2.6 – 4.5 years
6.	Tamil articulation test (TAT)	Usha, 1986	Vowels and consonants in different contexts	Picture naming	3-8 years

7.	Deep test of articulation in Kannada-sentence form	Rohini, 1989	Commonly misarticulated sounds are assessed.	Sentence repetition	Not specified
8.	Articulation test battery in Malayalam.	Maya. S, 1989	Checklist, picture naming, deep test of articulation-sentence repetition, predictive screening test.	Single word repetition, picture naming, and sentence repetition.	3-7 years
9.	Revision and Re-Standarization of the Test of Articulation in Odia	(Behera, 2013)	Vowels, consonants and clusters	Picture naming	2 – 5 years
10.	Deep test of articulation in Tamil picture form.	Sangeetha, 1995	Commonly misarticulated sounds are assessed	Picture naming	3-7 years
11.	Deep Test of Articulation In Nepali Picture Form	Bhavani, 1995	Commonly misarticulated sounds are assessed	Picture naming	3 -7 years
12.	Deep test of articulation in Hindi	Deepa Shankar, 1998	Phonemes at possible context	picture naming	3-7 years
13.	CAPP-M (Computerised Assessment of Phonological Processes in Malayalam)	Sreedevi, John & Chandran, 2013	Phonological processes	Computer-based stimuli	2 – 3.6 years

14.	Picture Articulation Test – Tulu	Shetty & Prabhu, 2015	Consonant production	Picture naming	3-8 years
15.	Screening Articulation Test (Multi-language - Hindi, Malayalam, Kannada, Sanskrit)	Prabhu, Subhash & Subba Rao, 2015	Articulation screening	Picture naming (common lexical items)	3 – 8 years
16.	A Screening Test of Articulation in Kannada Using Dynamic Time Warping (Dtw): A Prototype	Mendhakar, 2017	Commonly misarticulated sounds are assessed.	Computerized pictures	Not specified
17.	Consonant and Phonological Process Analysis in Tamil	Perumal et al., 2019	Word level and sentence level	Picture naming and sentence repetition.	Not specified
18.	Intelligibility in Context Scale – Tamil (ICS-Tamil)	Bathina, Garibaldi & Venkatesh, 2022	Speech intelligibility	Parent-report questionnaire	3 – 6 years
19.	RBSK Developmental Screening Tool (Part of the Government of India's Rashtriya Bal Swasthya Karyakram (RBSK) program)	(Chandrasekar et al., 2023)	Developmental screening (speech-language)	Checklist, mobile-based screening	Birth – 6 years

20.	Language-Free Stimuli for Evaluating Speech Intelligibility (Dravidian Languages)	Madhusudhanan, Shabnam & Bhat, 2025	Speech intelligibility	Word list (trisyllabic stimuli)	Not specified

For Tamil-speaking population, the commonly used standardised test materials are the Tamil Articulation Test (TAT) (Usha, 1986) and the Deep Test of Articulation in Tamil – Picture Form (Sangeetha, 1995). These tests only allow for testing articulation at the single-word level, but do not provide the opportunity to assess it in connected speech or at the sentence level. The other available test materials, such as the Consonant and Phonological Process Test in Tamil (Perumal et al., 2019), provide sentence-level stimulation for testing articulation, along with single-word repetition and picture-naming tasks at the word level.

Recent evidence suggests that meaningful sentences may offer improved measures of intelligibility and better clinical insights compared to isolated word lists (Xue et al., 2023). Merely, the available test materials in the Tamil language assess speech sounds in spontaneous speech. Spontaneous speech can be elicited through conversation task, picture description, story narration and so on. Toby Macrae et al. (2016) noted that picture-based tasks can complement standardised testing by providing additional contexts for speech production analysis. It has been found that the use of pictures will effortlessly stimulate the targeted speech sounds, especially in pre-schoolers. Patel et al. (2014) developed the "Park Play" picture description task to assess childhood motor speech disorders in English-speaking children. This picture-based approach was effective in eliciting desired speech targets in connected speech samples, providing additional diagnostic information beyond the syllables, words, and sentences typically obtained through imitation during traditional motor speech examinations.

However, despite the availability of assessment tools in various languages, there is a significant gap in standardised treatment using picture-level stimuli in Tamil, especially for specific sound classes, such as retroflexes. A detailed assessment of speech-sound disorders across contexts and complexities lays the groundwork for successful treatment. The main focus of treatment should not stop till the acquisition of speech sounds at isolation or only at the word level, but at the connected speech level, so it is important to assess the baseline at isolation, word level and even at the connected speech level to complete the assessment along with its stimulability before starting therapy.

Intervention for Speech Sound Disorders

The treatment methods for speech sound disorders are numerous. Intervention methods can be broadly categorised into motor-based and linguistic-based approaches. Even though there are a huge number of approaches, some of them are used more widely than others and have shown significant improvement. Wren et al. (2018) found that interventions for preschoolers with speech sound disorders (SSD) predominantly fall into cognitive-linguistic and production categories, with the highest level of evidence in auditory-perceptual and integrated intervention approaches. Techniques such as the Cycles Phonological Remediation Approach (Hodson & Paden, 1991; (Rudolph & Wendt, 2014) and the PhonoSens program have demonstrated strong empirical support. The PhonoSens program, for instance, showed large treatment effects (Cohen's d = 0.89–1.04) over 28 sessions (Siemons-Lühring et al., 2021).

Speech sound disorder (SSD) intervention practices vary considerably across countries, reflecting differences in clinical training, service delivery models, and contextual factors influencing clinical decision-making. International evidence indicates that speech-language pathologists (SLPs) commonly employ individualized and context-specific treatment approaches, often combining multiple intervention methods to address the diverse needs of children with SSD. For instance, survey-based studies conducted in Australia, the United States, and the Netherlands have shown that clinicians frequently integrate more than one treatment approach rather than relying on a single method (Furlong et al., 2021). In the United States, school-based SLPs predominantly reported the use of traditional articulation therapy, the cycles approach, and minimal pairs therapy, with findings further indicating a negative association between years of clinical experience and the diversity of treatment approaches used, suggesting that more experienced clinicians tend to adopt fewer intervention approaches (Cabbage et al., 2022). Furthermore, children often struggle to generalise corrected sounds into connected speech, emphasising the need for materials that integrate therapy into naturalistic language contexts (Park & Kim, 2015). The efficacy of most treatments is based on the acquisition of the particular target sounds, and not based on the generalization of those acquired targets in connected speech.

The current approaches which facilitate generalisation include a multisensory approach, a process-oriented dimensional framework, the Motor Speech Treatment Protocol (MSTP) and so on.

Square et al. (2014) evaluated a multisensory treatment approach for children with developmental motor speech disorders, including presentations similar to speech-sound disorders. The intervention integrated auditory, visual, and tactile–kinesthetic cues during treatment to support the planning and execution of speech movement sequences, aiming to improve both accuracy and functional speech production (Square et al., 2014). Importantly, positive outcomes were observed not only on trained (practised) words but also on untrained (test) words, indicating that children were able to generalise learned speech patterns beyond the specific items used in therapy. This finding suggests that multi-sensory input may facilitate broader transfer of motor speech skills to novel word contexts, thereby enhancing the likelihood that therapeutic gains extend into everyday speech. The authors infer that such integration of sensory modalities contributes to normalising speech movement parameters and supports generalisation of target features to untrained contexts (Square et al., 2014).

Maassen and Terband (2024) present a process-oriented, dimensional framework for diagnosing and treating speech sound disorders (SSD) in children, emphasizing the need to understand underlying speech mechanisms and individual processing profiles rather than relying solely on categorical diagnostic labels (e.g., articulation vs. phonological disorders). They argue that a process-oriented approach can better inform treatment target selection and the connection between underlying deficits and intervention strategies (Maassen & Terband, 2024). This approach focuses on conceptualising how understanding underlying processes can inform treatment planning, including the choice of targets and strategies that could support generalisation over time. A theoretically grounded approach to treatment planning that may enhance the potential for generalization by aligning therapeutic targets with underlying speech processes, it stops short of providing direct data or specific treatment protocols that demonstrate generalization of speech sounds to untrained tasks or contexts. This means that the work is conceptual and diagnostic in nature, providing a framework for intervention decisions rather than an empirical demonstration of generalization outcomes following specific speech therapy methods.

Namasivayam et al (2015) investigated the effects of a Motor Speech Treatment Protocol (MSTP) — a multi-sensory, motor-based intervention — in young children with severe developmental motor speech disorders, a subgroup of speech sound disorders characterized by impaired speech motor control. The MSTP integrates auditory, visual, and tactile-kinesthetic cues and employs hierarchical goal selection to systematically guide speech motor control (Namasivayam et al., 2015). Importantly, the study found that improvements occurred not only on trained items (words practiced during treatment) but also on untrained test words, indicating generalization of target speech features beyond the specific stimuli used in therapy (Namasivayam et al., 2015). This pattern suggests that the MSTP may enhance transfer of learned motor speech skills to novel word contexts, a key clinical objective in effective intervention. However, despite this evidence of word-level generalization, the protocol does not explicitly measure or target broader generalization outcomes such as performance in connected speech, spontaneous conversation, or across varied linguistic contexts, which are critically important for functional communication. Additionally, the study's small sample size and focus on motor speech disorders limit the generalizability of findings to children with more typical phonological speech sound disorders. Consequently, while the MSTP approach shows preliminary evidence of facilitating generalization to untrained words, it does not provide comprehensive evidence of systematic generalization across untrained contexts and communicative levels beyond word-level tasks, underscoring the need for intervention protocols that explicitly incorporate and measure broader generalization strategies (Namasivayam et al., 2015).

These findings highlight that while some treatment approaches yield incidental generalization, generalization is not always an explicitly engineered outcome, underscoring the need for intervention materials and strategies that directly promote transfer across contexts.

Lack of Generalisation

Speech-language pathologists aim to help children and adults communicate more effectively in their daily lives. However, most of the time, the transition of targets from one context to the next does not happen. Preston et al. (2016) specifically observed that children with speech sound errors showed no generalisation of learned speech sounds to untreated words. For generalisation of speech sounds from one context to another, the clinician should use stimuli with different contexts in therapy as the child progresses. Elbert et al. (1985) discovered generalisation was typically limited to specific sound classes, while Gierut et al. (1987) suggested that a child's existing phonological knowledge significantly influences their ability to generalise speech learning. These findings consistently indicate that speech sound generalisation is complex, context-dependent, and not automatically achieved through initial learning. This emphasises the need for standardised stimuli, providing the opportunity to produce the target sounds in different contexts specific to particular languages. Further, in children, intervention approaches that incorporate visual stimuli have been shown to enhance engagement and facilitate the acquisition of speech sounds (Pedro et al.,2018).

Need for Retroflex-loaded Picture Stimuli in Tamil

Currently available materials for the assessment of speech sound disorders are primarily designed to facilitate systematic elicitation and analysis of speech sounds rather than to support active learning or generalization during intervention at connected speech level. Standardized articulation and phonological assessments typically employ controlled, single-word picture-naming stimuli with limited linguistic variability, enabling accurate identification of error patterns, sound inventories, and phonological processes (Bernthal et al., 2022; McLeod & Baker, 2017). These assessment stimuli are carefully selected to minimize semantic ambiguity, restrict phonetic context, and ensure consistency across administrations, which is essential for diagnostic reliability but limits their functional richness.

In contrast, intervention materials require stimuli that promote motor practice, phonological contrast, and generalization across contexts, often involving multiple examples, varied syllable structures, and meaningful communicative settings (Williams et al., 2010; Baker & McLeod, 2011). Assessment stimuli typically lack these features, as they are not designed to be repeatedly manipulated, hierarchically graded, or embedded within naturalistic interaction. Moreover, the static and repetitive nature of assessment pictures may reduce motivation and engagement during therapy, particularly for young children, thereby limiting their effectiveness as intervention tools (McCauley & Strand, 2008).

Thus, while assessment materials play a critical role in identifying and classifying speech sound errors, their restricted phonetic variability, limited contextual flexibility, and absence of learning scaffolds make them largely unsuitable for intervention purposes. This mismatch underscores the need for purpose-built, contextually rich picture stimuli that can bridge assessment findings with intervention goals, supporting both accurate diagnosis and effective remediation of speech sound disorders.

Retroflex sounds are among the most frequently misarticulated phonemes in Tamil-speaking children with SSDs. These errors significantly reduce intelligibility and hinder academic and social communication. Although Tamil-specific articulation tests exist, there is a critical gap in: Treatment-oriented picture stimuli, Retroflex-loaded word lists, validated materials designed for therapy, not merely assessment, Stimuli targeting generalisation into continuous speech. Currently, clinicians rely on ad hoc or self-made stimuli, which lack standardisation, familiarity validation, and phonetic balance. Without validated picture stimuli, it becomes challenging to deliver systematic, evidence-based therapy for retroflex production. This gap underscores the urgent need for the development and validation of retroflex-loaded picture stimuli specifically tailored for Tamil-speaking children with SSDs.

While developing picture stimuli for articulation assessment, several empirically supported criteria must be followed to ensure clinical validity and reliability. First, the pictures should elicit target speech sounds across all word positions (initial, medial, and final) and in varied phonetic contexts, as coarticulatory influences significantly affect speech sound production (Bernthal et al., 2022; McLeod & Baker, 2017). Second, the lexical items represented must be age-appropriate, familiar, and culturally relevant, as unfamiliar vocabulary can negatively influence naming accuracy and intelligibility, thereby confounding speech sound analysis (Smit et al., 1990; McLeod, 2012).

Additionally, picture stimuli should be designed to minimize semantic ambiguity and maximize name agreement, ensuring that children consistently label the image with the intended target word (Snodgrass & Vanderwart, 1980; Bates et al., 2003). Visual characteristics such as clarity, simplicity, and salience are essential, particularly for young children, as complex or cluttered images may increase cognitive load and reduce elicitation accuracy (Dockrell et al., 2006). For comprehensive articulation analysis, stimuli should include words of varying syllable lengths and phonotactic complexity, enabling assessment of both segmental accuracy and syllable structure acquisition (Stoel-Gammon, 2011; Vihman, 2014).

Finally, articulation picture stimuli must undergo systematic validation, including expert review, pilot testing, and normative data collection, to establish content validity, reliability, and diagnostic sensitivity for identifying speech sound disorders (Bernthal et al., 2022; McCauley &

Strand, 2008). Without such validation, picture-based tools risk limited clinical applicability despite their face validity.

Therefore, the current study aims to develop and validate retroflex-loaded picture stimuli for Tamil-speaking children with SSDs, addressing a critical clinical and research gap in speech-language intervention

Chapter III

METHOD

The current study involved the development of the retroflex-loaded picture stimuli for Tamil-speaking children. The study was carried out in two phases:

Phase 1: Development of the retroflex-loaded picture stimuli

Phase 2: Utilization of picture stimuli in speech assessment and therapy sessions (Pilot study)

Phase 1: Development of the retroflex-loaded picture stimuli

This phase of the study was carried out in the following steps:

Step 1: Selection of Target Sounds

A total of 6 case files of Tamil-speaking children aged 3 to 6 years diagnosed with Speech Sound Disorders were reviewed from the Department of Clinical Services at the All India Institute of Speech and Hearing (AIISH), Mysuru, Karnataka, India. The case files that were reviewed were from 2017 to 2024. Retroflex sounds were found to be the most commonly erred speech sounds across all the reviewed case files in the decreasing order of /ɭ/, /ɖ/, /ʈ/, and /ɳ/. Out of these four retroflex sounds, the use of retroflex /ɭ/ in the Tamil language is less common in daily use; it is mostly substituted with non-retroflexed /l/and the meaning will be contextually correlated even if it is produced without retroflexion. Further, the nasal retroflex /ɳ/is the least erred retroflex sound; hence, in the current study, the picture stimuli were developed for the unvoiced retroflex /ʈ/ and the voiced retroflex /ɖ/.

Step 2: Development of retroflex Tamil wordlist

Wordlists for each of these two target phonemes were compiled from commonly used Tamil and English loanwords found in Tamil textbooks for primary grades, dictionaries, and daily conversations. These wordlists consisted of bisyllabic and/or trisyllabic words. Words contained the target phonemes in the initial, medial, or final positions, following short or long vowels /a, i, e, u, o/ (e.g., /CVCVC/ and /CVCVC/).

Step 3: Familiarity rating of the wordlist

The developed wordlists were given to three special educators, two speech–language pathologists, and three regular teachers whose native language is Tamil to conduct a familiarity rating of the words for children in the 3- to 6-year age range. A 3-point rating scale in the form of a Google form was provided to them to rate the words as either 'least familiar/familiar/highly familiar'. The words which received the rating of either familiar or highly familiar were taken into consideration and the wordlists were finalized

Step 4: Development of picture stimuli

Using the finalized words, a few theme-based pictures: hospital, classroom, home, village, playground, beach, and Deepavali celebration were developed. These were developed using an artificial intelligence (AI) portal, Gemini. The prompts given to AI were:

For the development of picture stimuli loaded with retroflex sound /ʈ/

1. Hospital:

"I would like you to create a cartoon picture for preschoolers featuring Tamil-speaking children. It should be culturally and linguistically relevant and attractive. The following details should be presented in a natural way and be visible for the child to discover. hospital setup, 1. doctor should be there, 2. patients are waiting in a waiting area, 3. one grandma is waiting, 4. one boy injured his knees, 5. one boy is with a plaster cast (maavu kattu) over his hand after a fracture, 4. one patient came with a complaint of tumor. Add a receptionist in the waiting area along with one computer, lock, note, small fish tank"

2. Classroom:

"I would like you to create a cartoon picture for preschoolers featuring Tamil-speaking children. It should be culturally and linguistically relevant and attractive. The following details should be presented in a natural way and be visible for the child to discover. school setup, 1. on board parachute, truck and butterfly were drawn, 2. one boy is singing in front of class, he is wearing vetti shatta (dhoti), on the table, chocolate, notebooks were placed, 3. children are clapping, 4. water bottles are placed on children's tables. One boy is sticking the rocket picture using tape."

3. Village:

"I would like you to create a cartoon picture for preschoolers featuring Tamil-speaking children. It should be culturally and linguistically relevant and attractive. The following details should be presented in a natural way and be visible for the child to discover. village setup, 1. train is running on the bridge, 2. one tea kada (tea shop) with hot tea and biscuits and other snacks with ppl (Indianized), 3. on road one auto is going 4. one man rides the camel and one baby camel walking along with them, 5. one grandma is selling pattani (green peas) near the tea shop, 8. on another side of road the men are cutting with saw the grown tall tree and loading it in the truck. 6.

one shop near by shop where they are selling the colorful kites, 7. some homes are there everything I have mentioned should be in a coherent way in single picture because every seen is important”

4. Home:

“I would like you to create a cartoon picture for preschoolers featuring Tamil-speaking children. It should be culturally and linguistically relevant and attractive. The following details should be presented in a natural way and be visible for the child to discover. school setup, 1. Mother is tying the tie to her son to make him ready for school, 2. Nearby on the table food was kept, which included carrot, eggs, Rotti in different plates and juice in a tumbler, 3. On the other side of the table, one pant is kept with a belt, 4. One photo, a calendar with showing October month, and clock that makes tik tik sounds were on the wall, 5. On the corner of the room the door to bathroom should be there where tap, mat, and towel should be placed”

For the development of picture stimuli loaded with retroflex /ɖ/.

1. Hospital:

“Hospital Scene Description Setting: A bright, friendly, and colourful pediatric hospital waiting area or room with a Tamil cultural feel. Characters: Akka (Older Sister): Sitting on a chair, wearing Kannadi (spectacles), focused on a book she is reading (Padi). Uncle: Standing nearby, holding a steaming cup of tea or water (Suudu). Doctor: Visible through an open door or a glass partition in the background. On the Table: A Dolphin toy (Dolphin bomma). A small container or box (Dappa). A Dairy Milk chocolate bar. Decorations & Surroundings: Photo: A framed picture on the wall showing a man with a beard. Plants: A green potted plant (Chedi) in the corner. Anatomy Poster: A simple, kid-friendly poster on the wall showing the human body and hair to help children learn parts of the body”

2. Beach:

"I would like to create a picture stimuli for /d/ for Tamil speaking children with an age range of 3 to 6 years and it should be culturally suitable for Tamil speaking children and it should be attractive and every detail should be clear and easy to discover by the children. The picture should be coherent and meaningful. a sea set up, 1. on sea one padagu (boat) and some dolphins, 2. on sea shore near the sea, on boy is trying to catch the nandu (crab), and one girl is collecting the shells, 3. people are walking (nada), 4. one juice shop, where the man filtering the juice with filter (vadikatti), and ppl are drinking the juice, 5. one otta vada shop (otta vadai kadai), where ppl are eating the vadai."

3. Playground:

"I would like you to create a cartoon picture for preschoolers featuring Tamil-speaking children. It should be culturally and linguistically relevant and attractive. The following details should be presented in a natural way and be visible for the child to discover. school scene, 1. Children are playing in the playground where the background (on the board) is made up of India map drawing. 2. national flag in the centre of the ground, 3. some children are playing Hopscotch (boxes are filled with number old Tamil outdoor game), in that one girl is jumping across the boxes 4. some children are playing hide and seek in which phase children are hiding, and one boy is searching for others, 5. some children are playing run and catch, 6. One side of the garden is there, some children are planting the plants 7. in garden, on the flower one bug (vandu) is there and 8. some children are dancing. I have reference image for nondi vilaiyaatu" and

4. Deepavali celebration:

"Hi I want to create a cartoon form of pictures scene for 3-6 year preschoolers, and it should be relevant to Tamil-speaking children culturally. In the village Deepavali pandidai scene 1. Theatre: for Deepavali, a new movie released and ppl are celebrating that. In that some adults are fighting, 2. One toy shop which should include umbrella, vessal (kudam), in that shop one boy is playing drum which make sound dum dum dum**,** 3. Dress shop ...ppl is buying new clothes, 4. Children are playing with crackers and boys are burning saram vedi (fire crackers)**,** 5. One otta vadai shop...ppl eating vada**,** 5. On distance... some home with cow outside and a forest is seen"

So, for each target sound, four themes were selected and for each theme three pictures were created from the same prompts given. Hence, a total of twenty-four pictures were created, with twelve scene-based picture stimuli for each target sound across various themes. It was ensured that the target words are present for a minimum of 20% of the time in the developed picture stimuli. Further, these pictures were reverse cross-checked with Google to avoid copyright issues.

Step 5: Content Validation of Picture Stimuli

Content validation of the picture stimuli was assessed in terms of relevancy, clarity, simplicity, stimulability and ambiguity. The relevance parameter evaluates the relevance of the pictures for children in the 3- to 6-year age range. The clarity/iconicity parameter checks how clear or recognizable the picture is. Simplicity parameters provide information on how easily the picture stimuli can be understood by children in the 3- to 6-year age range. Furthermore, the ambiguity parameter checks for potential confusion that might be created for children in that age range. The stimulability parameter provides information about the capacity of the pictures to elicit responses from the children. For this, three special educators, two speech-language pathologists, and three regular teachers were provided with a 4-point rating scale to rate these above-mentioned parameters. Furthermore, the rating was also conducted by the researcher, who provided picture stimuli to two typically developing children aged 3 to 6 years and assessed their ability to narrate the pictures. Table 3.1 provides information on the 4-point rating scale for content validity parameters.

Table No. 3.1

The 4-point rating scale for content validation

Parameter	Rating	Description
Relevance	1	Not relevant
	2	The item needs some revision.
	3	Relevant, but needs some minor revision.
	4	Very relevant
Clarity	1	Not clear
	2	The item needs some revision.
	3	Clear, but needs some minor revision.
	4	Very clear
Simplicity	1	Not simple
	2	The item needs some revision.
	3	Simple but needs some minor revision.
	4	Very simple

Ambiguity	1	Doubtful
	2	The item needs some revision.
	3	No doubt, but it needs some minor revision.
	4	Meaning is clear
Stimulability	1	Not Stimulable
	2	Slightly stimulable
	3	Stimulable with minor revisions
	4	Highly stimulable

Note. Reprinted from "Content validity and its estimation," by F. Yaghmaie, 2003, *Journal of Medical Education*, *3*(1), p. 26. (except stimulability parameter)

Content Validity Index (CVI) was calculated using the formula:

CVI = (agreed item)/ (number of experts)

Content Validity Index (CVI) is the proportion of content experts giving the item a relevance rating of 3 or 4. The pictures getting a CVI score of more than .83 (Lynn, 1986) were selected as the final stimuli.

Phase 2: Utilization of picture stimuli in speech assessment and therapy sessions (Pilot Study)

Study Design:

The case study method (ABA design) with multiple baselines was employed. This is because, in the current phase of the study, the use of picture stimuli in both the assessment and management of children with SSD was being tested. Basically, the focus was improvement in the production of target sounds wen the material was used than checking efficacy of a particular intervention technique or approach. Furthermore, multiple baseline assessments were conducted to ensure that they were not acquiring the target sound naturally, as they would have been at their developmental age.

Participants:

A total of three Tamil-speaking children, aged 3 to 6 years, diagnosed with SSD (phonetic type), served as participants. Two children were recruited from the All India Institute of Speech and Hearing (AIISH) and one child from a private clinic in Tamil Nadu. Participants were selected based on convenience and purposive sampling. The inclusion and exclusion criteria are as follows:

Inclusion Criteria

- Native language should be Tamil
- Should be diagnosed with SSD (phonetic type) using standardised tests like Tamil Articulation Test (Usha, 1986) or Consonant and Phonological Process Test in Tamil (Perumal et al.,2019) and should have errors in retroflex sounds, especially errors in unvoiced retroflex /ʈ/ and voiced retroflex /ɖ/.
- Have errors in these two targets sounds only at the sentence or conversation level
- Either should not have started with articulation therapy for these two target sounds, or should not have acquired these sounds at sentence or conversation level

Exclusion Criteria

- Those with any other co-morbid conditions like hearing impairment, intellectual disability, motor impairments, or language disorders like specific language impairment or any other.

This will be ensured by reviewing the case files as well as administering the Assessment Checklist for Speech-Language Skills (Swapna et al., 2015) to check the language level.

- Children with SSD who have already acquired or are acquiring retroflex at the sentence and conversation level due to articulation therapy.

Procedure

Ethical clearance from the AIISH Ethical Clearance Committee was sought, and the ID number is SH/IRB/M.5/SLP.01/2025-26. The guidelines for Bio-behavioural Research (Basavaraj & Venkatesan, 2009) were followed strictly, and informed consent was obtained from either the parents/caregivers of the participants. The procedure of the current phase was carried out in three steps:

1. Pre-therapy assessments (A – P1, P2, P3)
2. Articulation Therapy (B)
3. Post-therapy assessment (A)

Pre-therapy assessments

Multiple baseline assessments were conducted at three time points: P1 – the first evaluation, P2 – 14 days after the first evaluation, and P3 – 28 days after the first evaluation, to ensure that there is no effect of everyday speech sound development. During these three assessments, the Consonant and Phonological Process Test in Tamil (Perumal et al., 2019) was administered to participants to assess whether they made errors in producing retroflex sounds at the word and sentence levels. Furthermore, the developed picture stimuli were used to assess articulation errors at the narrative level. Only those with errors in retroflex /ʈ/ and /ɖ/ during P3 received articulation therapy. Percentage of type of SODA errors, Percentage of consonant correct – revised (PCC-R) calculation (Shriberg et al., 1997), and speech intelligibility rating using AYJNIHH Speech Intelligibility Scale (AYJNIHH, 1984) served as the outcome measures. PCC-R and percentage of type of SODA errors were calculated using the following formulas respectively:

PCC-R (%) = ((Number of Correct Consonants) ÷ (Number of Correct Consonants + Number of Incorrect Consonants)) × 100

Percentage of S/O/D/A errors = (Number of S/O/D/A errors / Total number of target sounds) x 100

The analysis done at P3 served as the baseline for articulation therapy.

Articulation therapy

Articulation therapy was provided in a one-on-one online setting for 10 sessions, each lasting 45 minutes. The online platform used for the sessions was WhatsApp since parents were comfortable with it. The internet speed during the sessions was at average download speed of 100.14 Mbps, an upload speed of 57.38 Mbps, and a ping latency of 9 ms at both the ends. The video and audio quality were satisfactory for both parent and clinician. The background noises, foreground and background lights were managed to be minimal/sufficient and non-interfering.

During these online sessions, phonetic placement approach, along with prompts, was used. The stimuli used were the developed theme-based pictures. The target words were first taught at the word level and then progressed to the spontaneous level to achieve the correct production of target sounds in the spontaneous speech.

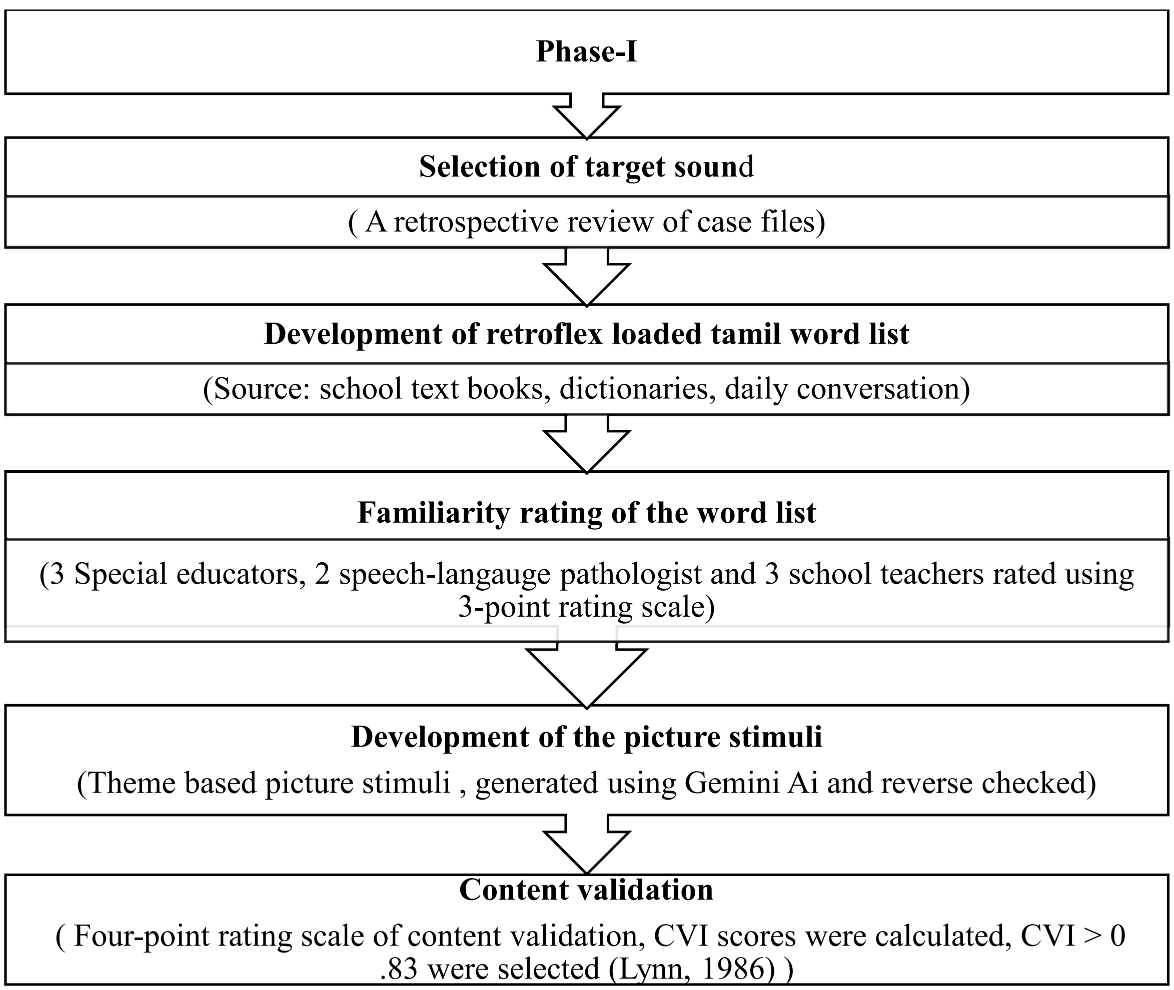
Post-therapy Assessment

Again, the Consonant and Phonological Process Test in Tamil (Perumal et al., 2019) was readministered, along with the developed theme-based picture stimuli, to test the production of target sounds at word, sentence, and narration levels, respectively. During this stage, SODA error analysis, PCC-R calculation, and speech intelligibility rating were performed again.

Summary of the whole method has been provided as a flow chart in figures 1.

Figure 1

Summary of the whole method of the current study.



Phase II

Pre therapy assessments (A)

(Mulitiple base line assessment using consonant and phonological process test along with SODA & PCC-R analysis plus speech intelligibility; P1= 1st evaluation, P2= after 14 days, P3= after 28 days).

Articulation Therapy (B)

(Total number of sessions = 10, Online platform: WhatsApp, duration of each session =45 minutes.)

Post-therapy assessment(A)

(Assess after the last session using developed picture stimuli; analyze intelligibility, PCC-R, & SODA along with consonant and phonological process test)

Chapter IV

RESULTS & DISCUSSION

The results of the study aiming to develop retroflex loaded picture stimuli for Tamil-speaking children with SSD and to determine the utilization of the same are described and discussed in this chapter. It is described and discussed as per the two phases taken up in the method of this study.

Phase 1: Development of the retroflex-loaded picture stimuli

In the first phase of the study, a set of culturally and linguistically appropriate picture stimuli specifically targeting retroflex sounds /ʈ/ and /ɖ/ were developed for the purpose of correcting speech sound errors at sentence and/or narration level in Tamil- speaking children.

Development of Tamil wordlist for retroflex sounds /ʈ/ and /ɖ/

A total of 110 bi- and/or trisyllabic Tamil and/or English loan words (56 words for retroflex /ʈ/ and 54 words for retroflex /ɖ/) were listed out from Tamil textbooks for primary grades, dictionaries, and daily conversations. From this, two separate wordlists were prepared for retroflex sounds /ʈ/ and /ɖ/ respectively. It was ensured that these words contained the target phonemes in the initial, medial, or final positions, following short or long vowels /a, i, e, u, o/ (e.g., /CVCVC/- /ʈeːbel/ and /CVCCVC/- /ɖoːkʈar/).

Familiarity rating of the wordlist

Out of 110 words 106 words were rated to be either highly familiar or familiar by the judges. Out of these 106 words, unvoiced /ʈ/ wordlist consisted of 56 words and voiced /ɖ/ wordlist consisted of 54 words. The finalized wordlists are provided in Appendix A.

Development of picture stimuli

Using the finalized words, theme-based pictures: hospital, home, village, classroom, beach, playground and deepavali celebration were developed using the AI platform, Gemini. It was ensured that the target words are present for a minimum of 20% of the time in the developed picture stimuli. A total of 24 picture stimuli were developed (12 for each target sound) across four themes.

Content Validation of Picture Stimuli

These developed theme-based picture stimuli were provided for content validation to three special educators, two speech-language pathologists, three regular teachers, and two children in the age range 3-to 6- years. These stimuli pictures were rated on a 4-point rating scale for the parameters relevancy, clarity, simplicity, stimulability and ambiguity. Further, CVI calculation was done The CVI scores obtained for each picture for retroflex /ʈ/ and retroflex /ɖ/were given in the table 4.1 and 4.2 respectively.

Table 4.1

Content validation index scores of the developed stimuli for retroflex /ʈ/ (n=8)

Scene	Pictures	E-1	E-2	E-3	E-4	E-5	E-6	E-7	E-8	agreed	UA	CVI
1. Hospital	A	1	1	1	1	1	0	1	0	6	0	0.75
	B	1	1	1	1	1	0	1	0	6	0	0.75
	C	1	1	1	1	1	1	1	1	8	1	1
2. Village	A	1	1	1	1	1	1	1	1	8	1	1
	B	1	1	1	0	1	0	1	0	5	0	0.625

	C	1	1	1	1	1	1	1	0	7	0	0.875
3. Classroom	A	1	1	1	0	1	1	0	0	5	0	0.625
	B	1	1	1	1	1	1	1	1	8	1	1
	C	1	1	0	0	1	0	1	0	4	0	0.5
4. Home	A	1	1	0	0	1	0	1	0	4	0	0.5
	B	1	1	1	0	1	1	1	1	7	0	0.875
	C	1	1	1	0	1	0	0	0	4	0	0.5

Table 4.2

Content validation index of the developed picture stimuli for retroflex /ɖ/ (n=8)

Scene	**Pictures**	**E-1**	**E-2**	**E-3**	**E-4**	**E-5**	**E-6**	**E-7**	**E-8**	**agreed**	**UA**	**CVI**
1. Hospital	A	1	1	1	1	1	1	1	0	7	0	0.875
	B	1	1	1	1	1	1	1	1	8	1	1
	C	1	1	1	1	1	0	1	0	6	0	0.75
2. Beach	A	1	0	1	1	1	1	1	0	6	0	0.75
	B	1	0	1	1	1	1	1	1	7	0	0.875
	C	1	1	1	1	1	0	1	0	6	0	0.75

3. Playground	A	1	0	1	1	1	1	1	1	7	0	0.875
	B	1	0	1	1	1	1	1	0	6	0	0.75
	C	1	0	1	1	1	0	1	0	5	0	0.625
4. Deepavali	A	1	0	1	1	1	1	1	1	7	0	0.875
	B	1	0	1	0	1	0	1	0	4	0	0.5
	C	1	1	1	1	1	1	1	0	7	0	0.875

A total of eight pictures that had a CVI score of more than .83 (Lynn, 1986), were accepted as the final picture stimuli (four picture for each target sounds). The finalized theme-based picture stimuli for the targeted retroflex sounds are provided in Appendix B

Phase 2: Utilization of picture stimuli in speech assessment and therapy sessions (Pilot Study)

This developed finalized theme-based picture stimuli were used in articulation therapy involving three children with a diagnosis of Developmental Speech Sound Disorders to test their utility. Participant details are provided in table 4.3.

Table 4.3

The demographic details of the participants and target sound for the intervention

SI. No	**Participants**	**Age**	**Gender**	**Target sounds**

1	P1	4 years	Female	/ɖ/ and /ʈ/
2	P2	6 years	Male	/ɖ/ and /ʈ/
3	P3	6 years	Male	/ɖ/ and /ʈ/

All three participants (P1, P2, P3) underwent pre-therapy assessment at three time points with a duration gap of two weeks between each assessment. It was found that they had not acquired the speech sounds, /ɖ/ and /ʈ/, on their own as a part of developmental milestone and thus, for all the three participants, both these sounds were considered as the targets. Following this, they underwent 10 online articulation therapy sessions followed by post-therapy assessment. The outcome measures used during these pre- and post-therapy sessions were PCC-R, percentage of type of SODA errors and speech intelligibility at word, sentence and spontaneous speech levels. The results of this phase, has been described for each target sound in the following section by comparing the outcome measures at three levels between pre- and post-therapy sessions.

Retroflex /ʈ/

1. **PCC – R**

The comparison of PCC-R scores for P1, P2 and P3 at word, sentence and spontaneous speech levels are provided in figures 4.1, 4.2 and 4.3 respectively.

Figure 4.1

Comparison of PCC-R scores for retroflex /ʈ/ at word level

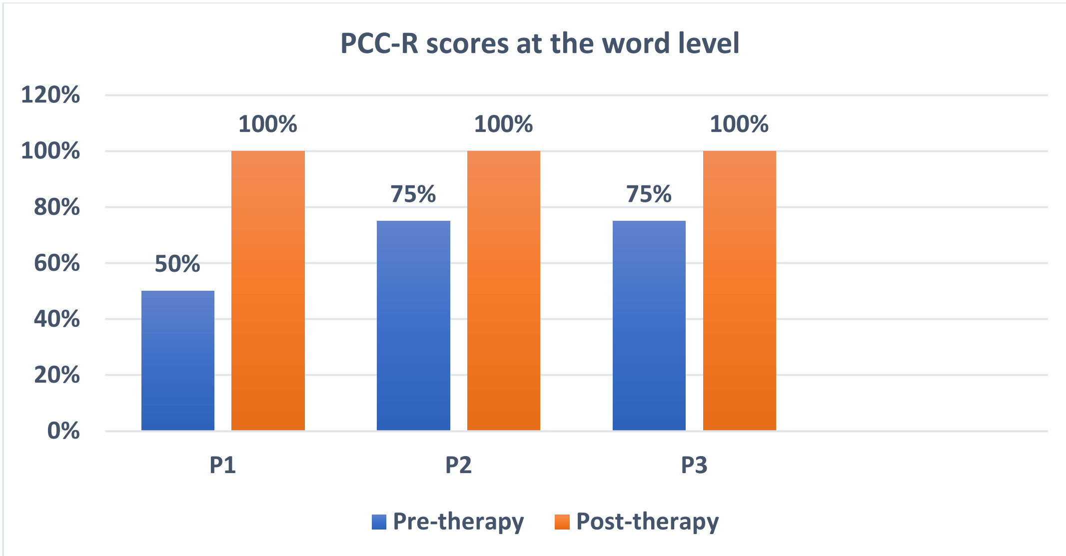


Figure 4.2

Comparison of PCC-R scores for retroflex /ʈ/ at sentence level

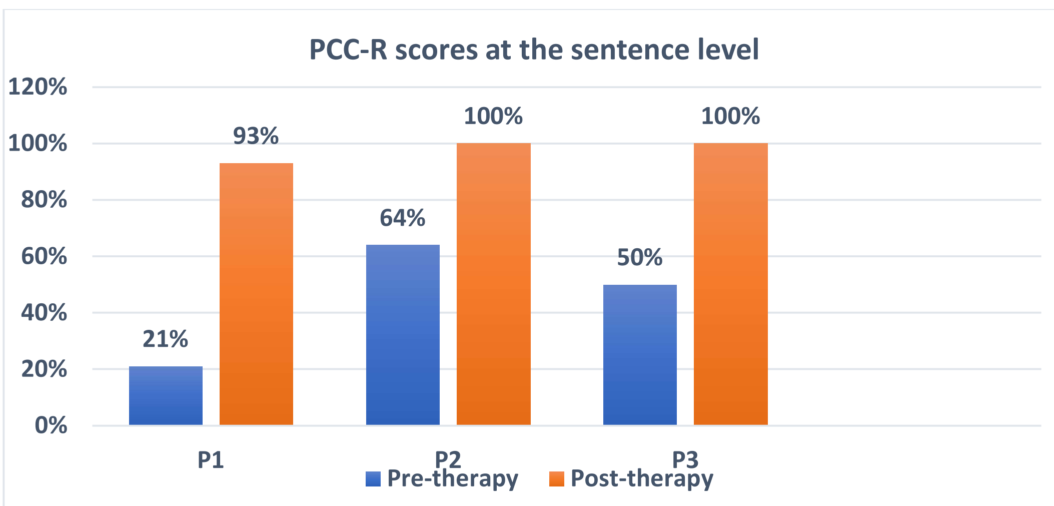
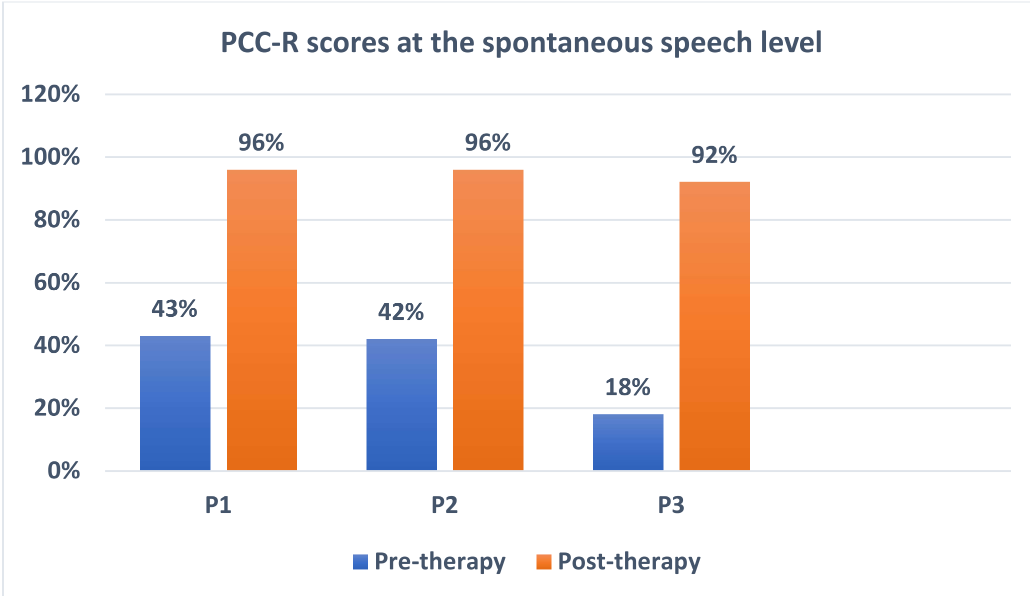


Figure 4.3

Comparison of PCC-R scores for retroflex /ʈ/ at spontaneous speech level



It is very clear from figures 4.1, 4.2 and 4.3, that all three participants showed good improvement in the production of unvoiced retroflex /ʈ/ at all three levels. It is seen that all three have acquired the target to 100% at word level and P2 and P3 at sentence level and more than 90% at spontaneous speech level.

2. **Percentage of type of SODA errors**

Here percentage of substitution, omission, distortion and addition of the target sound was calculated at all three levels and compared between the pre- and post-therapy performances. Tables 4.4, 4.5, and 4.6 indicate the differences in the percentage of type of SODA errors across P1, P2, and P3 at word, sentence and spontaneous speech levels respectively.

Table 4.4

Percentage of type of errors for retroflex /ʈ/ at word level

Participants	Assessment phase	substitution	Omission	Distortion	Addition
P1	Pre-therapy	38%	13%	5%	0%
	Post–therapy	0%	0%	0%	0%
P2	Pre-therapy	25%	0%	4%	0%
	Post–therapy	7%	0%	2%	0%
P3	Pre-therapy	25%	0%	5%	0%
	Post–therapy	0%	0%	2%	0%

Table 4.5

Percentage of type of errors for retroflex /ʈ/ at sentence level

Participants	Assessment phase	Substitution	Omission	Distortion	Addition
P1	Pre-therapy	72%	7%	10%	0%
	Post–therapy	7%	0%	3%	0%
P2	Pre-therapy	36%	0%	3%	0%
	Post–therapy	0%	0%	1%	0%
P3	Pre-therapy	50%	0%	5%	0%
	Post–therapy	0%	0%	2%	0%

Table 4.6

Percentage of type of errors for retroflex /ʈ/ at spontaneous speech level

Participants	Assessment phase	Substitution	Omission	Distortion	Addition
P1	Pre-therapy	54%	4%	5%	0%
	Post–therapy	4%	0%	0%	0%
P2	Pre-therapy	50%	4%	6%	4%
	Post–therapy	3%	3%	2%	0%
P3	Pre-therapy	76%	6%	7%	0%
	Post–therapy	5%	3%	5%	0%

From tables 4.4, 4.5 and 4.6, it can be observed that all three participants had majorly substitution errors at all three levels during pretherapy. Children substituted retroflex /ʈ/ with /t̪/, which is phonemically different in the Tamil language. Further, omission errors and distortion errors were seen in P1 at all three levels where as P2 and P3 exhibited distortion errors at all three levels and omission errors only at spontaneous speech levels.

Post-therapy it is noticed that P1 had zero errors at word level, significantly reduced substitution (72% to 7%) and (54% to 4%), omission (7% to 0%) and (4% to 0%) and distortion errors (10% to 3%) and (5% to 0%) at sentence and spontaneous speech levels respectively. On the other hand, P2 and P3 exhibited significant reduction in substitution errors at all three levels, however, omission and distortion errors, though minimal, still persisted majorly at spontaneous speech level.

P1 has scored less in sentence level (21%) and more in spontaneous speech (43%) during pretherapy, and the same pattern is observed post-therapy (93% in sentence level and 96% in spontaneous speech level). This may be due to the use of different material at each of these levels and the type of responses received. Sentences were assessed using the Consonant phonological and phonological process test in Tamil (Perumal et al 2019), involving repetition task and having restricted chance for independent sentence formation. On the other hand, for spontaneous speech the developed picture stimuli were used, where participants had scope for forming sentences on their own involving more colloquial Tamil. However, such a trend is not observed in P2 and P3 due to age differences and the exposure to repetition of bookish sentences in Tamil at school (P1- 4yrs; P2 and P3 – 6 years).

Retroflex /ḍ/

1. **PCC – R**

The PCC-R scores of three participants between pre- and post-therapy sessions across three levels are depicted in figures 4.4, 4.5, and 4.6 respectively.

Figure 4.4

Comparison of PCC-R scores for retroflex /ḍ/ at word level

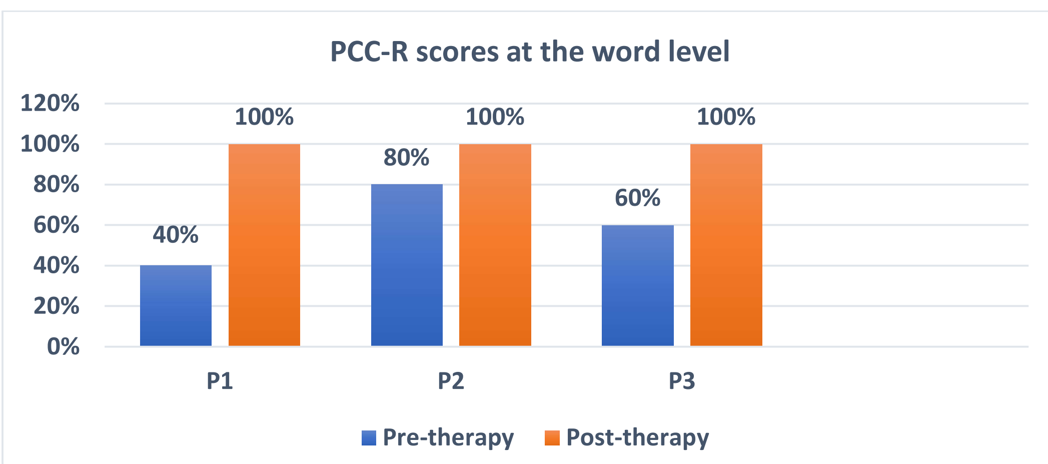


Figure 4.5

Comparison of PCC-R scores for retroflex /ḍ/ at sentence level

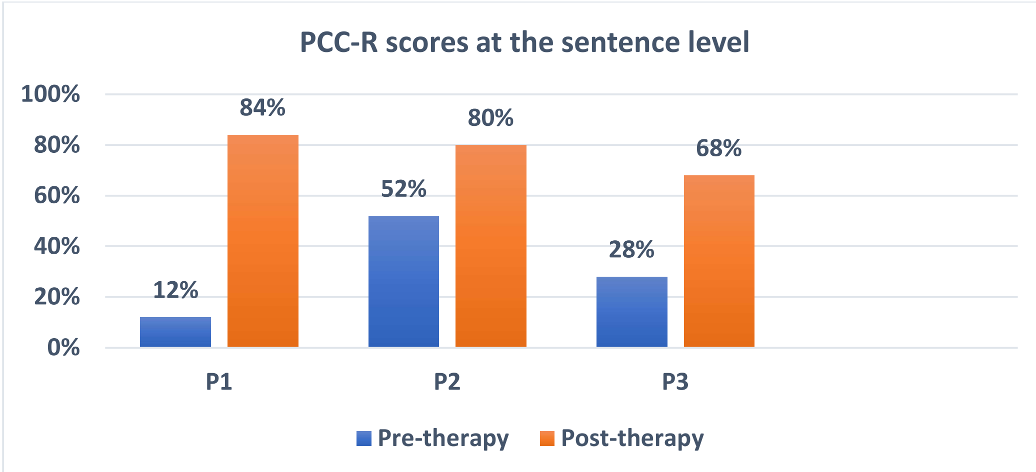
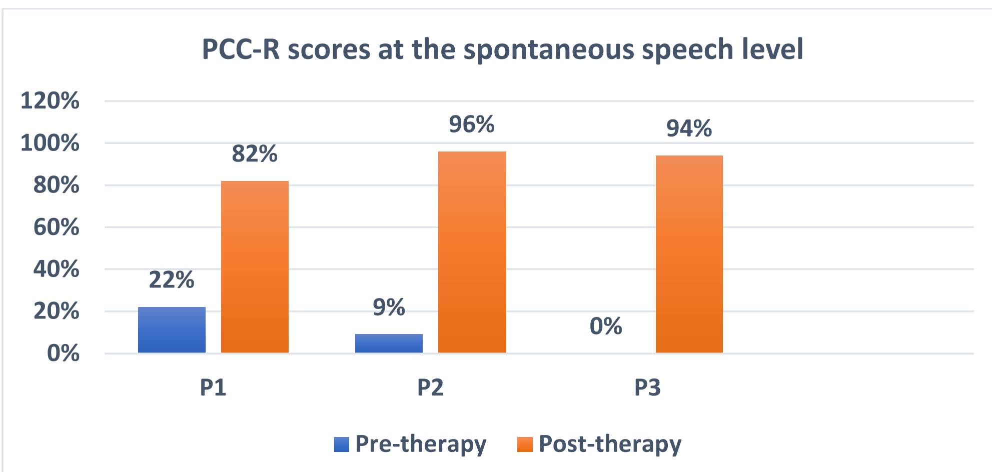


Figure 4.6

Comparison of PCC-R scores for retroflex /ɖ/ at spontaneous speech level



It can be observed from figures 4.4, 4.5, and 4.6 that all three participants showed improvement in the production of the target sound /ɖ/ at all three levels, especially at the word level there was 100% acquisition of the target sound. P1 showed similar improvements at sentence (84%) and spontaneous speech level (82%), whereas, P2 and P3 showed more than 90% accurate production at spontaneous speech level and less than 90% accuracy at sentence level.

2. **Percentage of type of SODA errors**

Substitution and omission errors were observed to be more during the production of voiced retroflex /ɖ/ by all the three participants. It was substituted with /t̪/, /d̪/ and /n/, which are all phonemically different in the Tamil Language. Addition errors were not observed. Percentage of errors of retroflex /ɖ/ during pre- and post-therapy at the word, sentence and spontaneous speech level are listed in tables 4.7, 4.8, and 4.9 respectively.

Table 4.7

Percentage of type of errors for retroflex /ɖ/ at word level

Participants	**Assessment phase**	**substitution**	**Omission**	**Distortion**	**Addition**
P1	Pre-therapy	60%	40%	40%	0%
	Post–therapy	0%	0%	0%	0%
P2	Pre-therapy	20%	0%	0%	0%
	Post–therapy	0%	0%	0%	0%
P3	Pre-therapy	20%	20%	4%	0%
	Post–therapy	0%	0%	0%	0%

Table 4.8

Percentage of type of errors for retroflex /ɖ/ at sentence level

Participants	Assessment phase	substitution	Omission	Distortion	Addition
P1	Pre-therapy	52%	36%	12%	0%
	Post–therapy	0%	16%	4%	0%
P2	Pre-therapy	24%	24%	6%	0%
	Post–therapy	0%	16%	2%	0%
P3	Pre-therapy	36%	36%	11%	0%
	Post–therapy	12%	20%	5%	0%

Table 4.9

Percentage of type of errors for retroflex /ɖ/ at spontaneous speech level

Participants	Assessment phase	substitution	Omission	Distortion	Addition
P1	Pre-therapy	39%	39%	13%	0%
	Post–therapy	9%	9%	5%	0%
P2	Pre-therapy	82%	9%	0%	0%
	Post–therapy	4%	4%	3%	0%
P3	Pre-therapy	60%	40%	15%	0%
	Post–therapy	6%	6%	6%	0%

At word level all three participants were seen to achieve 100% accurate production without any errors (Table 4.7). However, at sentence and spontaneous speech level, there is a reduction in the percentage of substitution, omission and distortion errors, with significant reduction at spontaneous speech level than sentence level (Table 4.8 and 4.9).

For retroflex /ɖ/, the PCC-R at the sentence level were lower for all participants compared to the spontaneous speech level during both pre- and post-therapy. Ideally, the scores should be higher at sentence level than spontaneous speech level, but in the current study, varied results came. This might be again attributed to use of varied material/stimuli. The sentences were taken from the material developed by Perumal et al. in 2019 and for spontaneous speech the developed picture stimuli were used. Number of occurrences of target sounds considered in this study was less in sentences compared to the picture stimuli. So, while calculating percentage, fewer errors in response can reflect more in the percentage in contrast to the developed picture stimuli, where there are more occurrences of target sounds; the optimum number of errors will cause a decrease in the overall percentage of consonants. Another reason could be that the targets in sentences were in the context of clusters for example [ʋiʋe:k ʋe:gama: o:**ɖr**a:n] [ʋa:ni pa:nɖi ʋeɭaja:**ɖr**a:] [ɖe:ʋiɖ paʈʈam ʋi**ɖr**a:n]. Because of this, children might have had difficulty producing the target speech sounds in clusters than the non-cluster target sounds in sentences. (Thora Másdóttir, 2021)

Further, in spontaneous speech, the post-therapy outcome of P2 showed 3% of distortion error but 0% of distortion in pre-therapy measures. This discrepancy can be attributed to the fact that P2 had substitution and omission errors of the target sound /ɖ/ before therapy, and after intervention, these errors minimized and were produced either correctly or with distortions.

Even after scoring more than 90% of PCC-R, the speech was not completely normal. This emphasizes the need to consider all types of error, such as distortion, omission, substitution and addition with equal importance.

In addition, it can be also observed that the PCC-R scores after intervention for both retroflex sounds did not match with the percentage of type of SODA errors. This might be because of the fact that while calculating PCC-R, distortion errors are not considered rather counted as a correct production (Shriberg et al., 1997). Since, all three participants had distortion errors, it is getting reflected in the percentage of SODA errors but not in the PCC-R scores.

Speech intelligibility

The speech intelligibility was assessed using the AYJNIHH speech intelligibility scale (AYJNIHH,1984) at the word, sentence and spontaneous speech level during pre- and post-therapy. This is a 5-point rating scale where '0' indicates normal speech and '4' indicates speech that can be understood with difficulty and concentration especially by family members but not by others. Pre- and post-therapy speech intelligibility ratings at three levels are provided in table 4.10.

Table 4.10

Speech intelligibility ratings at word, sentence and spontaneous speech level during pre- and post-therapy

Participants	Assessment phase	Word level	Sentence level	Spontaneous speech level
P1	Pre-therapy	2	4	4
	Post–therapy	1	2	2
P2	Pre-therapy	2	2	3
	Post–therapy	0	1	1
P3	Pre-therapy	2	4	4

Post–therapy	1	2	2

From table 4.10, it can be observed that prior to therapy speech intelligibility was very poor (4) at sentence and spontaneous speech level for P1 and P3, whereas for P2 at all three levels speech was either understood with little effort (2) or with repetition (3). After speech therapy, the intelligibility rating ranged between 0 to 2. Even after the correct production of target sounds, participants were not completely intelligible due to misarticulation of non-targeted speech sounds. The participants also have errors in fricatives such as /s/, /ʃ/ and trills such as /r/. Since speech is a combination of sounds, the incorrect production of one group of consonants also influences the intelligibility.

Overall, a slightly distinct pattern of progress among the participants was observed. P2 had had greater than 90% of correct production in most of the instances than other participants with better intelligibility rating. This variation could be due to many variables such as home training, family support, severity, and errors of non- targeted sounds during therapy (Pritchard et al., 2025). P2 had lesser severity of the problem compared to the other two. In addition, participants had errors of multiple phonemes, which might have also influenced the progression and resulted in relatively lesser intelligibility.

Further, P1 and P3 were from Karnataka and had Tamil as their mother tongue, and those kids were exposed to multiple languages daily (Kannada, Tamil, and English). The multilingual exposure and dialectal variation might have contributed to distortion of speech sounds and other articulatory challenges. This might have interfered with acquisition of speech sounds and less generalization of learned speech sounds in spontaneous speech than P2, who had more exposure to the Tamil language comparatively (Jasso et al., 2020).

Results also depict differences in performance across the two targets taken-up for the study. Productions of retroflex /ʈ/were more accurate than /ɖ/ in both pre- and post-therapy conditions by all three participants. This can be attributed to the influence of frequency of occurrence of sounds in a language on acquisition or learning of speech sounds. In the Tamil language, the occurrence of retroflex /ɖ/ is relatively lesser than retroflex /ʈ/. Like the sound frequency, the word frequency also affects the therapy outcomes, for example, the commonly occurring words such as grandma, egg, plate and light were learned early, and children could produce them accurately compared to rare words such as parachute, octopus, and celebrations. However, all three participants could produce them correctly, but needed more time (Plante et al., 2011).

To sum-up, in the current study, the use of culturally and linguistically based picture stimuli did show a positive outcome from word to spontaneous speech level in just 10 sessions. Each picture was created with target sounds in different vowel and phoneme position contexts. Further, 4 picture stimuli were present for each target sound and thus providing an opportunity for the production of target sounds a greater number of times by learning more words in different contexts at the same time point. In addition, these words were encouraged to produce at word level initially and then were gradually made to produce in spontaneous speech. This made it easy for participants to transit from word level to spontaneous speech level. Lastly, the results of the present study add on to the literature stating that the use of picture stimuli during intervention results in positive and faster outcomes in children with SSD (Prima et al., 2025)(Petinou, 2025).

Chapter V

Summary & Conclusions

The efficacy of articulation therapy majorly lies in the use of culturally and linguistically appropriate picture stimuli as well as generalization of the learnt speech sounds in spontaneous speech. However, in the Indian context, there is lack of use of appropriate stimuli as well as transition of accurate production to spontaneous speech level. Further, research on these lines is also scare in India. So, developing age-appropriate picture stimuli that are culturally and linguistically relevant, also loaded with target sounds for the production of speech sounds in spontaneous speech will help to bridge the gap in the availability of material for intervention of children with SSD. Further, such material would speed up the transition and generalization of articulation skills in an effective and naturalistic way, especially in younger children (Jesus et al., 2019). Thus, the primary aim of the study was to develop and utilize the retroflex /ʈ/ and /ɖ/ loaded picture stimuli for Tamil-speaking children with Speech Sound Disorder that focused on accurate production of target sounds at spontaneous speech level.

The study was conducted in two phases. In the first phase, voiced and unvoiced retroflex sounds, /ɖ/ and /ʈ/, were selected as the target sounds as these were the most frequently erred sounds in Tamil speaking children with SSD. For these two target sounds, wordlists were prepared by selecting bi-syllabic and tri-syllabic Tamil words from school textbooks, magazines, dictionaries and from general conversation. Then the selected words were given to two special educators, two school teachers and two speech-language pathologists for familiarity rating. The words receiving a rating of either familiar or highly familiar were selected for the final wordlist. A total of 12 theme-based pictures were created for each target sound using Gemini AI. It was ensured that the words containing target sounds were present around 20% of the times in these pictures. Then the pictures were content validated by the same people who rated familiarity of words. A total of 4 pictures receiving a CVI of .83 for each speech sound were finalized. During the second phase, these selected pictures were utilized in the assessment and intervention of three Tamil speaking children with speech sound disorder. Initially, three baselines, with a gap of 14 days between each, were taken to rule out general developmental acquisition of target speech sounds. Then, all three participants received individualized training with the developed and content – validated theme-based pictures. A total of 10 online sessions with a duration of 45 minutes each were provided. Post this, assessments were carried out again.

The outcome measures tested during assessments included percentage of consonants correct- Revised (PCC-R), percentage of type of SODA errors and speech intelligibility rating. These were measured at three levels: word, sentence and spontaneous speech levels. Words and sentences were taken from Consonant phonological and phonological process test in Tamil (Perumal et al 2019), whereas spontaneous speech was elicited using the developed theme-based picture stimuli. The outcome measures were calculated and compared across pre-therapy and post-therapy for all three participants across three levels to test the utility of the developed material.

All three participants showed a noticeable improvement from pre-therapy to post-therapy across all the outcome measures. There was reduction in the percentage of errors, with increase in percentage of correct consonants and speech intelligibility. However, there were a few differences across the three participants performance which can be attributed to the influencing factors like severity, dialect, exposure to languages other than Tamil, duration of the treatment, home training, and motivation.

In sum, developed theme-based picture stimuli did show a positive outcome from word to spontaneous speech level in just 10 sessions. Thus, this study highlights the importance of using culturally and linguistically theme-based picture stimuli during SSD intervention at spontaneous speech level. In addition, sessions started at word level initially and then were gradually shifted to spontaneous speech level using the same theme-based material. This, indicates the ease of transition from word to spontaneous speech level as well.

Limitations of the present study

- Smaller sample size restricting the generalizability of results.
- Reduced duration of the study and assessment program. There was no follow-up assessment conducted limiting the understanding of long-term therapy effects.
- The group was heterogeneous with respect to language exposure.

Clinical Implications

- Can be utilized to assess and provide speech therapy intervention for two retroflex sounds, /ʈ/ and /ɖ/, at spontaneous speech level.

Future directions

- To validate the current study results on a larger sample size
- To test the utility of the developed material on children having any of the following hearing impaired, cleft lip and palate, intellectual disability or cerebral palsy.
- Upcoming studies can extend the duration of the intervention and to perform the follow-up assessments.
- To develop similar theme-based stimuli for other sounds in Tamil language
- To develop similar theme-based stimuli for speech sounds of other Indian languages.
- To develop similar theme-based stimuli for multilingual children

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Appendix A

Table A 1

Finalised Retroflex-loaded wordlist for the target sound /ʈ/

Sl. No.	Words in Tamil	IPA	Words in English
1	ஹாஸ்பிடல்	/ha:spiʈal/	Hospital
2	டாக்டர்	/ɖa:kʈar/	Doctor
3	வெயிட்	/weiʈ/	Wait
4	முட்டி	/muʈʈi/	Knee
5	ஸ்டெதஸ்கோப்	/sʈeteskop/	Stethoscope
6	அடிபட்டுருக்கு	/adipaʈʈrukku/	Injured
7	கட்டு	/kaʈʈu/	Plaster cast
8	கம்ப்யூட்டர்	/kampju:ʈar/	Computer
9	ஆன்டி	/a:nʈi/	Aunty
10	பூட்டு	/pu:ʈʈu/	Lock
11	பாட்டி	/pa:ʈʈi/	Grandma
12	டேபிள்	/ʈe:bal/	Table
13	மீன்தொட்டி	/mi:nt̪oʈʈi/	Fish tank
14	கட்டி	/kaʈʈi/	Lump/tumor
15	ஓட்டு வீடு	/o:ʈʈu vi:ɖu/	Tiled house

16	ட்ரெயின்	/ʈrein/	Train
17	டிரக்	/ʈrak/	Truck
18	வெட்டு	/veʈʈu/	Cut
19	டீ	/ʈi:/	Tea
20	பிஸ்கட்	/biskaʈ/	Biscuits
21	பட்டாணி	/paʈʈa:ni/	Green pea
22	ஒட்டகம்	/oʈʈagam/	Camel
23	ஓட்டிட்டு	/o:ʈʈiʈu/	Riding
24	குட்டி	/kuʈʈi/	Small/ baby
25	ஆட்டோ	/a:ʈʈo/	Auto
26	பட்டம்	/paʈʈʌm/	Kite
27	நோட்	/no:ʈ/	Note
28	கைத்தட்டு	/kait̪aʈʈu/	Tying
29	பாட்டில்	/ba:ʈʈel/	Bottle
30	வாட்டர் பாட்டில்	/va:ʈʈar ba:ʈʈel/	Watter bottle
31	சொக்கலேட்	/ʧa:kale:ʈ/	Chocolate
32	வேட்டி சட்டை	/ve:ʈʈi ʧaʈʈa/	Dhoti and shirt
33	பாட்டு	/pa:ʈʈu/	Song
34	பாராச்சூட்	/pa:ra:ʃu:ʈ/	Parachute

35	பட்டாம்பூச்சி	/paʈʈa:m bu:ʧi/	Butterfly
36	ராக்கெட்	/ra:keʈ/	Rocket
37	டேப்	/ʈe:p/	Tape
38	ஒட்டுறா	/oʈʈura/	Sticking
39	டாப்	/ʈa:p/	Tap
40	டவல்	/ʈawel/	Towel
41	டாய்ஸ்	/ʈo:is/	Toys
42	மேட்	/ma:ʈ/	Mat
43	டைம்	/ʈaim/	Time
44	டிக் டிக்	/ʈik ʈik/	Tik tik
45	போட்டோ	/po:ʈʈo/	Photo
46	டை	/ʈai/	Tie
47	கேரட்	/ke:raʈ/	Carrot
48	டம்ளர்	/ʈʌmlar/	Tumbler
49	பேண்ட்	/pa:nʈ/	Pant
50	ஷர்ட்	/ʃarʈ/	Shirt
51	டார்ச்	/ʈa:rʧ/	Torch
52	அக்டோபர்	/akʈo:bar/	October
53	ஆக்டோபஸ்	/o:kʈo:pʌs/	Octopus

54	டெடி	/**ʈ**eɖi/	Teddy
55	முட்டை	/mu**ʈʈ**ai/	Eggs
56	தட்டு	/t̪a**ʈʈ**u/	Plate

Table A2

Finalized Retroflex-loaded wordlist for the target sound /ɖ/

Sl. No.	Words in Tamil	IPA	Words in English
1	முடி	/mu**ɖ**i/	Hair
2	உடம்பு	/u**ɖ**ambu/	Body
3	செடி	/ʧe**ɖ**i/	Plant
4	டெயரி மில்க்	/**ɖ**eiri milk/	Dairy milk
5	டப்பா	/**ɖ**appa/	Box
6	சூடு	/su:**ɖ**u/	Hot
7	படி	/pa**ɖ**i/	Read
8	டாக்டர்	/**ɖ**a:kʈar/	Doctor
9	தாடி	/t̪a:**ɖ**i/	Beard
10	டால்பின்	/**ɖ**a:lfin/	Dolphin
11	கண்ணாடி	/kanna:**ɖ**i/	Glass/specs
12	கடல்	/ka**ɖ**al/	Sea
13	படகு	/pa**ɖ**agu/	Boat

14	எடுக்குறா	/eɖukura/	Picking
15	சிப்பி ஓடு	/ʧippi oːɖu/	Shells
16	நட	/naɖa/	Walk
17	வடிகட்டி	/vaɖi kat̪t̪i/	Stainer
18	வடை	/vaɖai/	Vada
19	சாப்பாடு	/saːpaːɖu/	Food
20	குடி	/kuɖi/	Drink
21	கடை	/kaɖai/	Shop
22	நண்டு	/nanɖu/	Crab
23	பிடிக்கிறா	/piɖikira/	Catching
24	விளையாடு	/vilaijaːɖu/	Playing
25	நொண்டி/பாண்டி	/nondiː/ or /paːnɖi/	Hopscotch
26	தாண்டி	/t̪aːnɖi/	Cross
27	நடு	/naɖu/	Planting
28	வண்டு	/vanɖu/	Bug
29	பாடு	/paːɖu/	Singing
30	ஓடி	/oːɖi/	Run
31	கொடி	/koɖi/	Flag
32	கிரவுண்ட்	/graunɖu/	Ground

33	போர்டு	/bo:r**ɖ**/	Board
34	இண்டியா	/in**ɖ**ija/	India
35	கொண்டாடு	/kon**ɖ**a:**ɖ**u/	Celebration
36	பண்டிகை	/pan**ɖ**igai/	Festival
37	வீடு	/vi:**ɖ**u/	Home
38	மாடு	/ma:**ɖ**u/	Cow
39	சண்டை	/san**ɖ**ai/	Fight
40	படம்	/pa**ɖ**am/	Movie
41	வெடி	/ve**ɖ**i/	Crackers
42	குடம்	/ku**ɖ**am/	Vessel
43	ட்ரம்ஸ்	/**ɖ**rams/	Drums
44	குடை	/ku**ɖ**ai/	Umbrella
45	டும் டும்	/**ɖ**um **ɖ**um/	Dum dum
46	புடவை	/pu**ɖ**avai/	Saree
47	எடு	/e**ɖ**u/	Pick
48	சாப்பிடு	/sa:ppi**ɖ**u/	Eating
49	காடு	/ka:**ɖ**u/	Forest
50	பின்னாடி	/pinna:**ɖ**i/	Backside
51	கடிகாரம்	/ka**ɖ**iga:ram/	Clock

Appendix B

Part 1: Unvoiced Retroflex /ʈ/ -loaded Theme-based Picture Stimuli for Tamil-speaking Children with SSD

1. *மருத்துவமனை (/marut̪uvamanai/- hospital)*

Sl. No.	Words in Tamil	IPA	Words in English
1	ஹாஸ்பிடல்	/ha:spiʈal/	Hospital
2	டாக்டர்	/ɖa:kʈar/	Doctor
3	வெயிட்	/weiʈ/	Wait
4	முட்டி	/muʈʈi/	Knee
5	ஸ்டெதஸ்கோப்	/sʈet̪asko:p/	Stethoscope
6	அடிபட்டுருக்கு	/aɖipaʈʈurukku/	Injured
7	கட்டு	/kaʈʈu/	Plaster cast
8	கம்ப்யூட்டர்	/kampju:ʈʈar/	Computer
9	பூட்டு	/pu:ʈʈu/	Lock
10	பாட்டி	/pa:ʈʈi/	Grandma
11	டேபிள்	/ʈe:bil/	Table
12	மீன்தொட்டி	/mi:nt̪oʈʈi/	Fish tank
13	கட்டி	/kaʈʈi/	Tumor/ lumps
14	ஆன்டி	/a:nʈi/	Aunty

2. கிராமம் (/kramam/- village)

Sl. No.	Words in Tamil	IPA	Words in English
1	ஒட்டு வீடு	/o:ʈʈu vi:ɖu/	Tiled house
2	ட்ரெயின்	/ʈre:n/	Train
3	டிரக்	/ʈrak/	Truck
4	வெட்டு	/veʈʈu/	Cut
5	டீ	/ʈi:/	Tea
6	பிஸ்கட்	/biskaʈ/	Biscuit
7	பட்டாணி	/paʈʈa:ni/	Green pea
8	ஒட்டகம்	/oʈʈagam/	Camel
9	ஓட்டிட்டு	/o:ʈʈiʈʈu/	Riding
10	குட்டி	/kuʈʈi/	Baby/ small
11	ஆட்டோ	/a:ʈʈo/	Auto
12	பட்டம்	/paʈʈam/	Kite

3. வகுப்பறை- /vaguparai/- classroom

Sl. No.	Words in Tamil	IPA	Words in English
1	நோட்	/no:ʈʈu/	Note
2	கைத்தட்டு	/kait̪aʈʈu/	Clapping
3	டேபிள்	/ʈe:bil/	Table
4	பாட்டில்	/ba:ʈʈil/	Bottle
5	வாட்டர் பாட்டில்	/wa:ʈʈar ba:ʈʈil/	Water bottle
6	சொக்கலேட்	/ʧa:kale:t/	Chocolate
7	வேட்டி சட்டை	/ve:ʈʈi saʈʈa/	Dhoti and shirt
8	பாட்டு	/pa:ʈʈu/	Song
9	டிரக்	/ʈrak/	Truck
10	பாராச்சூட்	/pa:ra:ʃu:ʈ/	Parachute
11	பட்டாம்பூச்சி	/paʈʈa:mbu:ʧi/	Butterfly
12	ராக்கெட்	/ra:keʈ/	Rocket
13	டேப்	/ʈe:p/	Tape
14	ஒட்டுறா	/oʈʈura/	Sticking

4. வீடு - /vi:du/- home

Sl. No.	Words in Tamil	IPA	Words in English
1	டாப்	/ʈa:p/	Tap
2	டவல்	/ʈawal/	Towel
3	டாய்ஸ்	/ʈɔɪs/	Toys
4	மேட்	/ma:ʈ/	Mat
5	டேபிள்	/ʈe:bil/	Table
6	டைம்	/ʈaim/	Time
7	டிக் டிக்	/ʈik ʈik/	Tik tik
8	போட்டோ	/po:ʈʈo/	Photo
9	டை	/ʈai/	Tie
10	கட்டு	/kaʈʈu/	Tying
11	கேரட்	/ka:raʈ/	Carrot
12	டம்ளர்	/ʈamblar/	Tumbler
13	பேண்ட்	/pe:nʈ/	Pant
14	ஷர்ட்	/ʃarʈ/	Shirt
15	டார்ச்	/ʈa:rʧ/	Torch
16	அக்டோபர்	/akʈo:bar/	Octobar
17	ஆக்டோபஸ்	/o:kʈo:pʌs/	Octopas
`18	டெடி	/ʈeɖi/	Teddy
19	முட்டை	/muʈʈai/	Eggs
20	தட்டு	/t̪aʈʈu/	Plate

Part -2

Voiced Retroflex /ɖ/ -loaded Theme-based Picture Stimuli for Tamil-speaking Children with SSD

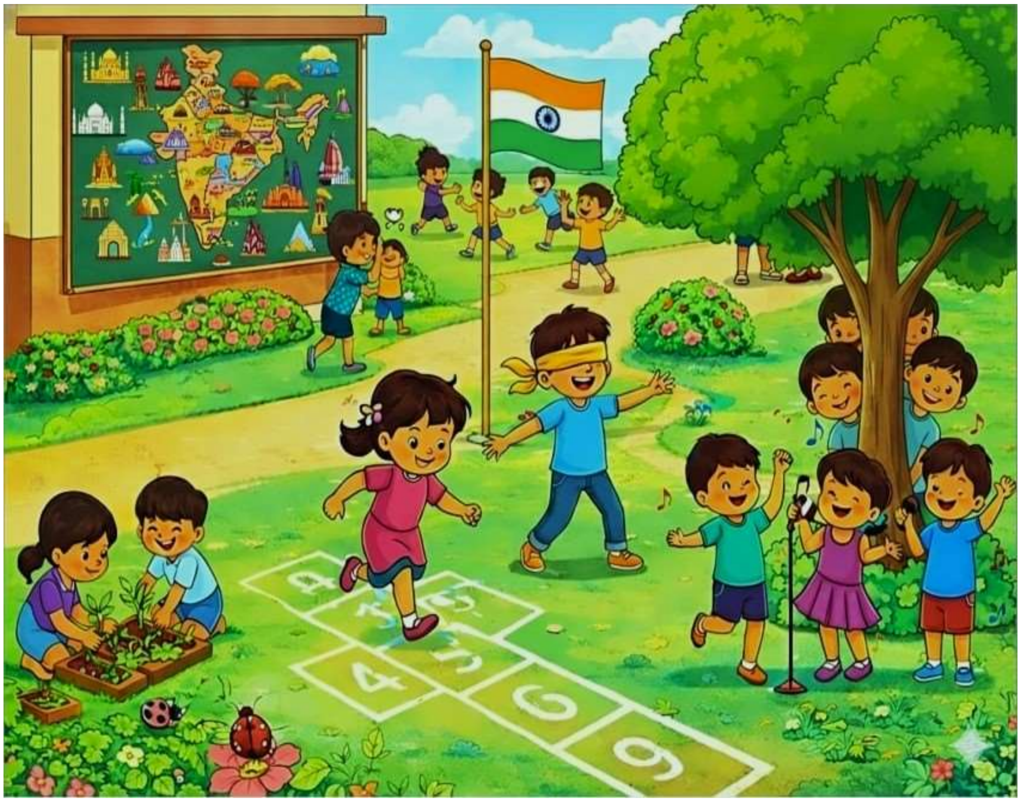
1. மருத்துவமனை (/maruṯuvamanai/- hospital)

Sl. No.	Words in Tamil	IPA	Words in English
1	முடி	/muɖi/	Hair
2	உடம்பு	/uɖambu/	Body
3	செடி	/ʧeɖi/	Plant
4	டெயரி மில்க்	/ɖeiri milk/	Dairy milk
5	டப்பா	/ɖappa/	Box
6	சூடு	/su:ɖu/	Hot
7	படி	/paɖi/	Read
8	டாக்டர்	/ɖa:kṯar/	Doctor
9	தாடி	/ṯa:ɖi/	Beard
10	டால்பின்	/ɖa:lfin/	Dolphin
11	கண்ணாடி	/kanna:ɖi/	Glass/specs
12	கடிகாரம்	/kaɖiga:ram/	Clock

2. கடற்கரை - /kaɖarkarai/- beach

Sl. No.	Words in Tamil	IPA	Words in English
1	கடல்	/ka**ɖ**al/	Sea
2	டால்பின்	/ɖa:lfin/	Dolphin
3	படகு	/pa**ɖ**agu/	Boat
4	எடுக்குறா	/e**ɖu**kura/	Picking
5	சிப்பி ஓடு	/ʧipi o:**ɖ**u/	Shells
6	நட	/na**ɖ**a/	Walk
7	வடிகட்டி	/va**ɖ**i kaʈʈi/	Stainer
8	வடை	/va**ɖ**ai/	Vada
9	சாப்பாடு	/sa:pa:**ɖ**u/	Food
10	குடி	/ku**ɖ**i	Drink
11	கடை	/ka**ɖ**ai/	Shop
12	நண்டு	/nan**ɖ**u/	Crab
13	பிடிக்கிறா	/pi**ɖ**ikira/	Catching

3. விளையாட்டு மைதானம் (/vilaija:ʈʈu mait̪a:nam/- playground)



S. No	Words in Tamil	IPA	Words in English
1	விளையாடு	/vilaija:ɖu/	Playing
2	நொண்டி	/nondi:/ or /pa:nɖi/	Hopscotch
3	தாண்டி	/t̪a:nɖi/	Cross
4	செடி	/ʧeɖi/	Plant
5	நடு	/naɖu/	Planting
6	வண்டு	/vanɖu/	Bug
7	பாடு	/pa:ɖu/	Singing
8	ஓடி	/o:ɖi/	Run
9	கொடி	/koɖi/	Flag
10	கிரவுண்ட்	/graunɖ/	Ground
11	போர்டு	/bo:rɖu/	Board
12	இந்தியா	/inɖija/	India

4. **தீபாவளி பண்டிகை** (/ḍi:pa:vali: panḍigai/- Deepavali festival)

S. No	Words in Tamil	IPA	Words in English
1	கொண்டாடு	/konɖa:ɖu/	Celebration
2	பண்டிகை	/panɖigai/	Festival
3	வீடு	/vi:ɖu/	Home
4	மாடு	/ma:ɖu/	Cow
5	சண்டை	/sanɖai/	Fight
6	படம்	/paɖam/	Movie
7	வெடி	/veɖi/	Crackers
8	வடை	/vaɖai/	Vada
9	கடை	/kaɖai/	Shop
10	குடம்	/kuɖam/	Vessel
11	ட்ரம்ஸ்	/ɖrams/	Drums
12	குடை	/kuɖai/	Umbrella
13	டம் டம்	/ɖum ɖum/	Dum dum
14	புடவை	/puɖavai/	Saree
15	எடு	/eɖu/	Pick
16	சாப்பிடு	/sa:ppiɖu/	Eating
17	காடு	/ka:ɖu/	Forest
18	பின்னாடி	/pinna:ɖi/	Backside