Development of Vowel and Phoneme Position Contexts Based Picturable Hindi Word List for Intervention of Children with Speech Sound Disorders

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CERTIFICATE

This is to certify that the dissertation entitled "Development of Vowel and Phoneme Position Contexts Based Picturable Hindi Word List for Intervention of Children with Speech Sound Disorders" is a bonafide work submitted as a part of the fulfilment for the degree of Master of Science (Speech Pathology) of the student registration number: P01II22S123043. It has been carried out under the guidance of a faculty of this institution. It has not been submitted earlier to any other university for the award of any diploma or degree.

Mysore

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CERTIFICATE

This is to certify that the dissertation entitled "Development of Vowel and Phoneme Position Contexts Based Picturable Hindi Word List for Intervention of Children with Speech Sound Disorders" has been prepared under my supervision and guidance. It is also certified that this dissertation has not been submitted earlier to any other university for the award of any diploma or degree.

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DECLARATION

This is to certify that the dissertation entitled "Development of Vowel and Phoneme Position Contexts Based Picturable Hindi Word List for Intervention of Children with Speech Sound Disorders" is a result of my study done under the guidance of Dr Amulya P Rao, Assistant Professor, Department of Language Pathology, All India Institute of Speech and Hearing, Mysore. This dissertation has not been submitted earlier to any other university for the award of any diploma or degree.

Mysore **Registration No.: P01II22S123043**

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Anima

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CHAPTER 1

Introduction

Speech Sound Disorders (SSDs) are a general term used to characterize a variety of difficulties with children's speech production (McLeod and Baker, 2017). These variations observed in articulation may stem from diverse factors, including organic abnormalities, emotional conflicts, acoustic and perceptual deficiencies, challenges in phonetic discrimination, compromised motor coordination, inadequate modelling, suboptimal environmental conditions, or functional issues. It poses significant challenges for individuals across the lifespan, impacting communication and social interactions.

Various treatment approaches have been developed in order to improve the accuracy in speech production that would ultimately have a positive effect on communication and social interactions. One among them is ‘Contextual Approach’ or ‘Contextual Utilization’ (Bleile, 2006). This approach is used to establish the speech sound that is absent in the child’s repertoire. This approach is based on the principle that in typical speech, sounds are not isolated entities but rather function as essential components of a multi-segmental utterance, inevitably influencing other adjacent components of the speech. This phenomenon is termed ‘coarticulation’ where speech sounds exhibit physiological and acoustic variations influenced by the speech context and the sounds preceding or following them. For example, in phrases like "red car," where the [d] may assimilate into the subsequent [k], or in "voice" assimilation, as seen in a phrase like ‘I have to,’ where the voiced [v] assimilates into the voiceless [t] and is perceived as [f] (Bill & Kris, 2008).

These influences of speech sounds on each other have been studied extensively both in typically developing children as well as in children with speech sound disorders. The literature review reports the presence of certain phonetic contexts facilitating the production of specific speech sounds during the normal speech development (Bleile, 1991, 1996, 2006; Bauman-Waengler, 2012). The phonetic contexts that have been studied widely are phoneme positions and vowel contexts. For the acquisition of majority of the speech sounds in English Quebecois French, and Dutch, initial position has been found to be highly facilitating (Bleile, 2006; Dodd, Holm, Hua, & Crosbie, 2003; McLeod, Sutton, Trudeau, & Thordardottir, 2011; Smit, Hand, Freilinger, Bernthal, & Byrd, 1990; Stoel-Gammon, 1985; Watson & Skucanec, 1997b). In Kannada, a Dravidian language, initial position has been found to facilitate bilabials, velars, palatal /ʃ/; medial-position facilitate palatals, dentals, dental /s/ and glottal sounds. On the other hand, retroflex acquisition is facilitated in both initial and medial positions in children aged between 12-to18-months (Shishira & Sreedevi, 2013), 18-to 24- months (Sushma & Sreedevi, 2013) and 2-to 6-years (Deepa & Savithri, 2010). In Malayalam, acquisition of affricates /c/ and /ɟ/ are reported to be facilitated in the medial position first compared to initial. In contrast, fricatives /s/ and /ʃ/ are acquired first in the initial and then in the medial-position (Divya, 2010; Neenu, 2011).

Acquisition of English alveolars, velars and bilabials have been found to be facilitating in the vowel context of front, back and central vowels respectively (Davis & McNilage, 1995). Indian studies have also reported on facilitating vowel contexts. During babbling stage, it has been found that vowel [a] is preferred with majority of the consonants whereas vowel [i] with dentals (Anjana & Sreedevi, 2008). During the first fifty-word stage, bilabials were found to be produced more in the context of central vowels and coronals and velars in the context of high front vowels (Shishira & Sreedevi, 2013).

There are several Western and Indian reports related to contextual facilitation in children with various communication disorders. Fricative /s/ and liquid /r/ in Arabic speaking children with dyslalia were found to be facilitated more in the initial than final positions (Ghandour & Kaddah, 2011). Stokes and Griffith (2010) validated that word-final positions and back vowel contexts facilitated the production of fricative [ʃ]. Back vowels have also been found to be facilitating the production of velar phonemes (Cleland, Scoobie, & Wrench, 2015). In the Indian context, acquisition and production of velars in Malayalam speaking children with hearing impairment have found to be facilitated in the context of vowel /a/ (Anu Rose, 2017); affricates in the medial position and fricatives in the initial position (Merin, 2017). Amulya and Sreedevi (2018) reported that in Kannada speaking children with speech sound disorders velar production was facilitated in the context of initial position – vowel /a/; retroflex in medial position – vowel /u/; affricate and fricative either in initial or medial position in the context of vowel /i/. In addition, unvoiced retroflex /ʈ/ was found to be facilitated in the context of /a/ and /o/ in word initial position and /u/ in word medial position. The voiced retroflex stop /ɖ/ was facilitated in the context of /o/ in word initial position and /u/ in the word medial position for Malayalam-speaking children with Down syndrome (Anitha & Sreedevi, 2022).

Need of the Study

The above literature outcomes have paved the usage of facilitating context clinically to improve speech production in children with communication disorders. Bleile (1991b, 2006) and Bauman and Wangler (2012) have provided the key environments using which the treatment targets in English can be established quickly. For example, voiced fricatives between vowels, alveolar stops preceding the front vowels at the beginning of words, and so on.

In addition, a few clinically applied SSD intervention approaches such as sensorimotor approach (McDonald, 1964), cycles approach (Hodson & Paden, 1983), and paired stimuli approach (Irwin & Weston, 1971) are based on the assumptions of contextual facilitation. Also, literature validates the implication of considering phonetic contexts clinically (Bernthal & Bankson, 1981; Curtis & Hardy, 1959; House, 1981; Kent, 1982; Spriestersbach & Curtis, 1951; Swisher, 1973).

The literature review highlights the fact that the studies have been majorly carried out to find out the facilitating contexts in various population and various languages as coarticulation is language-specific. These facilitating contexts have also been applied clinically. Tailor made stimuli were used in these studies. Developing the stimuli that is contextually based itself is tedious process. There are contextual based assessment tools like Deep Test of Articulation by McDonald (1964a) in English, Secord Contextual Articulation Test (Secord & Shine, 1997), the Deep test of articulation in Kannada-Sentence form (Rohini & Savithri, 1989; vowel environment), the Deep test of articulation in Malayalam- Sentence form (Maya & Savithri, 1990; vowel environment), the Deep test of articulation in Hindi – Picture form (Deepa Shankar & Savithri, 1998; consonant environment), the Deep test of articulation in Bengali – Picture form (Animesh & Savithri, 1991; consonant environment), the Deep test of articulation in Nepali – Picture form (Bhavani & Savithri, 1995; consonant environment), and the Deep test of articulation in Tamil – Picture form (Sangeetha & Savithri, 1995; consonant environment). The stimuli of these test materials can also be used for intervention purposes. However, not all the speech sounds are covered in the particular language and a few are in picture form and a few in sentence form. Number of syllables are also not taken into consideration to develop these tests and hence, applicability of these test stimuli for younger age group is questionable.

In specific, the Deep test of Articulation in Hindi-Picture Form (Deepa Shankar & Savithri, 1998) is the only currently available context-based stimuli for assessment and therapy. However, in this, the major focus has been the consonant environment and not the vowel environment. Hence, there is a requirement to develop a word list based on vowel environment as well as phoneme position as they have shown to facilitate the acquisition and production of speech sounds. Also, a contextual word list in Hindi is required in consideration of the number of syllables in a word (bisyllabic, trisyllabic or tetrasyllabic) so that it can be used with a wider range of severity cases related to speech sound disorders. For therapeutic purposes, the number of stimuli used per context should also be more. However, in these currently available stimuli from the Deep test of Articulation in Hindi-Picture form (Deepa Shankar & Savithri, 1998) only 83 stimuli are present which might not be sufficient for practice sessions.

Further, most word lists in literature are in English, and Goda & Hegde M N (2006), have created a drill book specifically for consonants. Additionally, articulation drill books in Telugu, Hindi, Kannada, and Malayalam are available for those with cleft palates (Paloor, 2011) and for hearing impairment (Rajeev Ranjan & Arun Banik, 2014). However, contextual facilitation has not been considered while preparing the word list for in any of these articulation drill books.

All the above factors necessitate the need for the development of a picturable contextual-based list in Hindi for the intervention of Hindi-speaking children with speech sound disorders. This would aid in reducing the time in developing the stimuli for the intervention as well as help in fastening the positive progress towards a more accurate production of the treatment targets. Hence, the current study was taken up.

Aim of the study

This study aims to develop a contextual-based picturable word list in Hindi for the intervention of children with developmental speech sound disorder.

Objective

To develop vowel and phoneme position contexts-based word lists for the frequently erred sounds in Hindi-speaking children with developmental speech sound disorders.

CHAPTER 2

Review of literature

Speech production involves a complex motor skill that requires rapid and precise articulator movement patterns. Successful speech communication depends, in part, on this motor skill to produce adequate contrasts and transitions between speech sounds (e.g., Nittrouer, 1995; Smith & Zelaznik, 2004). The intricate motor skill of producing speech calls for quick and accurate articulator movement patterns. Creating appropriate contrasts and transitions between speech sounds is essential for effective communication (Perkell et al., 1995).

2.1 Speech and sound disorders and their prevalence.

Speech Sound Disorders (SSDs) is a broader term used to characterise a variety of difficulties with children's speech production (McLeod & Baker, 2017). These variations observed in articulation may stem from diverse factors, including organic abnormalities, emotional conflicts, acoustic and perceptual deficiencies, challenges in phonetic discrimination, compromised motor coordination, inadequate modelling, suboptimal environmental conditions, or functional issues. SSD might also be caused due to underdeveloped speech production or perception systems that force kids to produce speech more straightforwardly or damage their phonological processes (Vance et al., Citation 2005). It poses significant challenges for individuals across the lifespan, impacting communication, academics, and social interactions. Even in children without a sensorimotor deficiency, neurological issues, or facial anatomical abnormalities, children with SSD find it difficult to produce intelligible speech (Anthony et al., Citation2011).

SSD is found to be one of the most prevalent communication disorders in early childhood/ or preschool children (American Speech and Hearing Association, 2014; Broomfield & Dodd, 2004; Eadie et al., 2015; McLeod & Harrison, 2009; Shriberg et al., 1999). According to the National Institute on Deafness and Other Communication Disorders (NIDCD, 2016), 8–9% of preschool-aged children have SSD. In an Iranian study, among 14.8% of participants exhibiting speech disorders, 1.2% had stuttering, 0.3% had voice disorders and 13.8 % had speech sound disorders. The prevalence was higher in males (16.7%) than compared to females (12%) (Karbasi et al, 2023). A recent prevalence report by Jayashree, Anuraj and Madhusudaeshan (2015) revealed 18.6% the total of children in and around Mysuru Karnataka suffered from speech sound disorder.

A few studies also report that the prevalence rate of SSD ranges from 2.3% to 24.6% (Eadie et al., 2015; Jessup et al., 2008; Keating et al., 2001; Law et al., 2000; McKinnon et al., 2007; Shriberg et al., 1997b; Shriberg et al., 1999). Thapa et al. (2019) and Hapsari et al. (2020) found that 8.1% of the school-going children had speech and language disorders. A community- cohort study reported that 6.88% of children diagnosed with stuttering also had a diagnosis of SSD (Unicomb et al, 2020).

Furthermore, longitudinal studies indicate that early intervention can significantly reduce the long-term prevalence of SSD, highlighting the importance of early and accurate diagnosis (Rvachew & Brosseau-Lapré, 2012). A number of interventions have been developed that differ in method used to improving a child's speech speech (Baker & McLeod, 2011; Wren et al., 2018). One among them is the 'Contextual Aproach' which utilises the concept of coarticulation to facilitate the production of the target sounds.

A community – cohort study reported that 6.88% of children diagnosis with stuttering also had a diagnosis of SSD.

2.2 SSD and coarticulation

Coarticulation refers to the articulatory adjustments made by segments in a multi-segmental utterance due to the influence of neighbouring segments. Coarticulation occurs in authentic speech, where segments do not exist in isolation. The phenomenon is so prevalent in continuous speech that it has become a key focus of experimental and theoretical research in articulatory phonetics. To develop a comprehensive theory or model of speech production and, to a lesser extent, speech perception, it is crucial to consider coarticulation. Coarticulation also has significant implications for phonological theory, particularly the relationship between phonology and phonetics. Effective modelling of coarticulation is essential for understanding how abstract, context-independent units suggested by phonology relate to practical, context-dependent characteristics of continuous speech. Understanding co-articulatory patterns in speech provides insights into the planning mechanisms of consecutive consonants and vowels and the execution of coordinated articulatory movements during the production of these segmental units.

Coarticulatory effects involve changes in articulatory displacement over time, either in anticipation of (leftward) or as a carryover from (rightward) the influencing sound. The nature and extent of these effects depend on the specific articulator involved (e.g., lip, velum, tongue, jaw, larynx), the articulatory properties of the individual consonants and vowels, and nonsegmental factors such as speech rate, stress, and language (Haruo Kubozono, 2017). Segmental contrast and coarticulation are facets of speech production that necessitate precise motor control and may provide insights into the development and disorders of complex speech motor skills (Maas et al, 2017).

The coarticulatory process involves two fundamental modifications: feature reduction and feature spreading. The inherent features of adjacent sounds may become identical during feature spreading if the same articulators produce them (/d/ is dentalized and devoiced when adjacent to /θ/ in "width"), and if different articulators produce the adjacent sounds, there may be facilitation of the transfer of a feature from one sound to another (transfer of lip rounding feature of /u/ on /t/ in "two"). During the feature reduction process, nearby sounds can affect the primary articulatory movement that produces a sound, resulting in the articulators to not achieve the target position or shift in the target location under the influence of neighbouring sounds. For instance, the influence of the sounds that precedes and follows leads to vowel centralization. In the production process, contextual variations determine coarticulation; that is, certain contexts are said to facilitate coarticulatory influence. For example, tongue positions are not significantly influenced by bilabial consonants of various vowels, but alveolar consonants allow back vowels to shift in tongue position (Noiray et al, 2013).

In typical speech development, the literature presents conflicting findings on whether children exhibit more excellent, comparable, or lesser anticipatory coarticulation than adults. In a study on /s/ and /ʃ/, Nittrouer et al. (1989) found that children aged 3 to 7 years demonstrated greater anticipatory coarticulation than adults when examining second formant (F2) ratios, showing higher F2 in fricatives before /i/ than before /u/ (Nittrouer et al., 1996; Siren & Wilcox, 1995). This increased coarticulation indicated larger phonetic planning units in children compared to adults, with the subsequent emergence of smaller, phoneme-sized units (Nittrouer et al., 1989). According to this view, greater coarticulation is expected if children's planning units include both the consonant and the vowel, as the identity of the subsequent vowel is integral to the planning of the consonant. Conversely, if planning involves separate consonant and vowel units, the vowel is less likely to influence the preceding consonant (Maas et al, 2017).

For coarticulatory production to happen accurately even coarticulatory perception should be proper. Fowler (1984); Martin and Bunnel (1982) support a coproduction model of coarticulation, where speech gestures overlap in time, providing evidence for multiple segments within a given timeframe. This overlap does not result in a complete blending of segments in perception. Evidence from Fowler and Beddor et al. (2002) indicates that co-articulatory influences on the target segment are perceived as indicators of the upcoming context vowel rather than being integrated into the perception of the target vowel. Listeners compensate for the coarticulation by hearing an unmodified target vowel while anticipating the upcoming vowel. Fowler describes this as a single parsing process, where listeners separate the overlapping acoustic cues into properties of the local segment (the perceptual target) and those of the distal context. After accounting for the effects of the immediate local context, the remaining variations can be used to predict the upcoming context.

2.3 Evidences related to phonetic context.

Phonetic contexts, also referred to as phonetic environment or key environments, encompass the surrounding speech sounds of a target sound (Bleile, 1996). These contexts can include adjacent sounds or pauses occurring either at the beginning or end of a syllable within a word or phrase. For instance, in the word /ske:l/, if /k/is the target sound, the preceding fricative /s/ and the following vowel /e/ along with the position context of /k/ collectively form its phonetic environment. Similarly, in the phrase /mikki mouse/, if /k/ is the target sound, its phonetic environment is defined by its medial position in the first word /mikki/, the following vowel /i/, the pause after the syllabus /ki/, and the initial consonant or syllable of the subsequent word /mous/. These surroundings elements, whether consonants, vowels, or junctures (pause), significantly influence the articulation and perception of the target speech sound. Thus, understanding phonetic environments is crucial for analyzing how specific sounds are produced and perceived in various linguistic contexts.

The study by Stephens and Holt (2002) shows that the perception of both speech and nonspeech sounds is strongly influenced by preceding phonetic context, especially liquid consonants like /l/ and /r/. This result is consistent with earlier studies showing that phonetic context affects the recognition of subsequent consonants. It also showed that stop consonants are perceived differently depending on the liquid consonants that preceded them. This result was extended to nonspeech sounds spectrally similar to the stop consonants, indicating that these context effects are not unique to speech sounds but rather arise from general perceptual interactions among spectral characteristics. The findings are consistent with the theory that phonetic context effects are largely driven by spectral contrast (Stephens & Holt, 2003). This implies that the auditory system processes and contrasts the spectral characterstics of sounds, leading to context effects in perception.

Numerous physiological techniques, including EMG, X-ray, ultrasound, and articulograph, have been used in the physiological studies on the effects of context on speech sound production. The contextual influence for vowels and consonants in CVC syllables is indicated by the results of multiple systematic examinations of tongue muscles using electromyography (EMG) (MacNeilage & DeClerk, 1969). The EMG activity for the production of the bilabial /b/ was found by Fromkin (1966) to be higher in the initial position than in the final position. Utilizing ultra-sound imaging

Gick et al. (2008) reported adult-like /r/ being produced more in the post-vocalic position in typically developing 11-month old infants. Irfana (2017) used ultrasound imaging to study retroflex sounds in Kannada and how they relate to the vowel /u/. When compared to other vowels, the study discovered that retroflex sounds showed a high degree of coarticulation with the following vowel, /u/. This suggests that the following /u/ has a significant influence on the tongue contour of retroflex sounds in Kannada, leading to different articulatory patterns.

Research conducted by Zue (1976), Halle, Hughes, and Radley (1957), and Fisher-Jorgensen (1954) has demonstrated that the vowel context greatly affects the acoustic characteristics of consonants. In experiments by Liberman (1957) and Delattre et al. (1955), participants were asked to distinguish voiced consonants /b, d, g/ based on steady-state second formants that were near the critical loci for velar, alveolar, and bilabial places of articulation. In Indian study by Manasa et al. (2007) investigated duration of fricatives in the context of the following vowel /i/. According to their research, fricatives like /s/ show longer durations when the vowel /i/ comes after them. The assimilatory effect of the vowel and fricative phonetic gestures is responsible for this phenomenon. The research demonstrates how the vowel's articulatory characteristics affect the preceding fricative, resulting in longer duration because of the coarticulatory interactions between the sounds.

2.4 Treatment based on Contextual Facilitation

It is essential to consider the phonetic context when selecting phoneme sequences to represent a target sound in a specific word position (Preston et al., 2019). If a client can produce the sound correctly in at least one phonetic context, practising that facilitative context can help the client experience success during a session. If the client struggles with the sound in all contexts, choose syllables that might theoretically be facilitative. For instance, /ɑɹ/ can help with /ɹ/ because /ɑ/ promotes pharyngeal constriction; /ts/ may assist with /s/ due to the preceding alveolar stop; /ʊk/ might help with /k/ because of the mid-high back vowel (Browman & Goldstein, 1989).

Selecting sound sequences that sample various phonetic environments to promote the accurate production of movement gestures across different co-articulatory contexts is beneficial. When pairing consonants with vowels, consider nonadjacent vowels on the vowel quadrilateral; for example, to address /ɹ/ in the onset position, use /ɹi/ and /ɹɑ/ due to the high-front and low-back vowels, instead of /ɹi/ and /ɹɪ/, which are closer on the vowel quadrilateral. Similarly, choosing consonant clusters with different places of articulation, such as /dɹ-/ and /ʃɹ-/, is beneficial because they vary in place of articulation, manner, and voicing of the first phoneme, unlike /dɹ/ and /tɹ/, which differ only in voicing, Preston, J. L., Leece, M. C., & Storto, J, (2019).

Practicing with such variations can facilitate the acquisition of contextually driven allophones (cf. Mielke, Baker, & Archangeli, 2016). However, several studies suggest that a mechanism of perceptual compensation alleviates potential confusion in vowel identification. Fowler (1981, 1984), Fowler and Smith (1986), and Beddor, Harnsberger, and Lindemann (2002) show that listeners adjust for V-to-V influences on a target vowel, reducing or eliminating the co-articulatory effects on vowel quality when these effects are attributed to a context vowel in a neighbouring syllable. Additionally, there is evidence that listeners benefit from V-to-V coarticulation, as the altered acoustic form of the target vowel helps predict the identity of an upcoming vowel (Fowler, 1984; Martin & Bunnell, 1982; Whalen, 1990).

In Kannada, a Dravidian language, certain positions within words facilitate the acquisition of different sounds. For instance, initial positions aid in articulating bilabials, velars, and the palatal /ʃ/, while medial positions help with palatals, dental, dental /s/, and glottal sounds. Retroflex sounds are more accessible to acquire in both initial and medial positions for children aged 12 to 18 months (Shishira & Sreedevi, 2013), 18 to 24 months (Sushma & Sreedevi, 2013). Similar results were found in the study by Deepa and Savithri (2010) on children who speak Kannada was centered on the ways in which different word positions affect the way in which different sounds are learned. These facilitate the articulation of the palatal /ʃ/, velars, and bilabials. These aid in the production glottal sounds, dental /s/, palatal sounds, and dental sounds. For children ages 12 to 18 months, 18 to 24 months, and 2 to 6 years, these are easier to obtain in both initial and medial positions. These results are noteworthy because they demonstrate how crucial phonetic contexts are for the development of speech sounds in children who speak Kannada.

In Malayalam, the affricates /c/ and /ɟ/ are learned first in medial positions compared to initial ones, whereas fricatives /s/ and /ʃ/ are acquired first in initial positions before medial ones (Divya, 2010; Neenu, 2011). In English, the acquisition of alveolars, velars, and bilabials is facilitated by the context of front, back, and central vowels, respectively (Davis & McNilage, 1995). Indian research also highlights the role of vowel contexts in facilitating sound acquisition. During the babbling stage, the vowel [a] is commonly paired with many consonants, whereas the vowel [i] is often used with dentals (Anjana & Sreedevi, 2008). Central vowels are frequently used with bilabials during the first fifty-word stage, and high front vowels are used with coronals and velars (Shishira & Sreedevi, 2013).

Both Western and Indian studies have examined contextual facilitation in children with various communication disorders. In Arabic-speaking children with dyslalia, fricative /s/ and liquid /r/ are more easily produced in initial positions than final ones (Ghandour & Kaddah, 2011). Stokes and Griffith (2010) confirmed that word-final positions and back vowel contexts aid in producing the fricative [ʃ]. Similarly, back vowels help produce velar phonemes (Cleland et al., 2015). In the Indian context, according to a 2017 study by Anu Rose, children who speak Malayalam and have hearing problems find it simpler to make velar sounds when they are associated with the vowel /a/. This discovery is a component of a larger investigation into phonetic ease and articulation errors in kids wearing digital hearing aids. Because the vowel /a/ requires particular articulatory gestures that are well-suited to velar production, the context of this vowel creates a more conducive phonetic environment for the production of velars. Malayalam-speaking children with hearing impairments find it easier to produce velars in the context of the vowel /a, affricates in medial positions, and fricatives in initial positions (Merin, 2017). In an Indian study by Amulya and Sreedevi (2018) six naturally speaking Kannada-speaking children, ranging in age from 4 years and 0 months to 5 years and 10 months, showed fronting errors for retroflex sounds. The researchers elicited target words with retroflex sounds using a phonetic placement technique. The International Phonetic Alphabet (IPA) was used to transcribe the children's responses, which were captured on audio. Three vowels (/a/, /i/, and /u/) have been examined for their impact on the generation of retroflex sounds (/ʈ/, /ɖ/, /ɳ/, and /ɭ/). Following /i/ and /a/, the acquisition of the retroflexes /ʈ/, /ʂ/, and /ɳ/ was greatly aided in the context of the vowel /u/. The lateral retroflex /l/ was facilitated in the context of the vowel /i/, followed by /u/ and /a/, velar production is facilitated in initial positions with the vowel /a/, retroflex in medial positions with the vowel /u/, and affricates and fricatives in either initial or medial positions with the vowel /i/. Additionally, the unvoiced retroflex /ʈ/ is facilitated by the vowels /a/ and /o/ in word-initial positions and /u/ in word-medial positions. The voiced retroflex stop /ɖ/ is facilitated by the vowel /o/ in word-initial positions and /u/ in word-medial positions for Malayalam-speaking children with Down syndrome (Anitha & Sreedevi, 2022).

As mentioned, the literature has underscored the clinical application of facilitating contexts to enhance speech production in children with communication disorders. Scholars like Bleile (1991b, 2006) and Bauman and Wangler (2012) have identified vital environments to swiftly establish treatment targets in English, such as voiced fricatives between vowels and alveolar stops preceding front vowels at the beginning of words.

Furthermore, several clinically applied Speech Sound Disorders (SSD) intervention approaches are grounded in the principles of contextual facilitation, including the sensorimotor approach (McDonald, 1964), the cycles approach (Hodson & Paden, 1983), and the paired stimuli approach (Irwin & Weston, 1971). The literature supports the clinical relevance of considering phonetic contexts (Bernthal & Bankson, 1981; Curtis & Hardy, 1959; House, 1981; Kent, 1982; Spriestersbach & Curtis, 1951; Swisher, 1973).

Few interventions based on contextual facilitation exist, despite the fact that they tend to have large evidence supporting their efficacy. A study by Speake et al. (2012) investigates the effectiveness of a vowel-targeted intervention (VTI) on two 10-year-old children with severe speech difficulties improve the intelligibility of their speech. This was conducted to ascertain whether VTI could improve the accuracy of vowel production in children who have severe and persistent speech difficulties.

Tasks to improve speech production, metaphonological abilities, and auditory discrimination were the main focus of the VTI. Minimal pairs discrimination, rhyme production and detection, silent sorting, word sorting by vowel sounds, CVC word blending and segmentation, articulatory drills, and word, phrase, and sentence production were among the activities. Following the intervention, both children showed increased speech intelligibility. Demi's mean intelligibility score rose from 8.12% to 46.8%, while Ryan's increased from 32.25% to 50.76%. Ryan's imitation of sentences and single words improved significantly, but his spontaneous speech did not. Demi demonstrated notable progress in every category of speech samples. Ryan produced vowels with much more accuracy, especially in CVC structures. Demi also demonstrated notable improvements in her ability to produce vowels, especially in VC and CVC structures. The study draws the conclusion that children with severe and persistent speech difficulties can benefit from targeted vowel intervention in order to improve speech intelligibility.

The literature review reveals that research has predominantly focused on identifying facilitating contexts across various populations and languages, as coarticulation is language-specific. These facilitating contexts have been clinically applied using tailor-made stimuli, which are inherently challenging to develop. Context-based assessment tools such as the Deep Test of Articulation by McDonald (1964a) in English, Secord Contextual Articulation Test (Secord & Shine, 1997), and several deep tests of articulation in Kannada (Rohini & Savithri, 1989), Malayalam (Maya & Savithri, 1990), Hindi (Deepa et al., 1998), Bengali (Animesh & Savithri, 1991), Nepali (Bhavani & Savithri, 1995), and Tamil (Sangeetha & Savithri, 1995) have been developed. These test materials can also be utilised for intervention purposes. However, they do not cover all speech sounds in a given language, with some tests presented in picture form and others in sentence form. The number of syllables was not considered while developing these tests, making their applicability to younger age groups questionable. In addition, the Deep test of Articulation in Hindi-Picture Form (Deepa Shankar & Savithri, 1998) majorly focuses on consonant environment and not vowel environment and there are only 83 stimuli are present which might not be sufficient for practice during articulatory intervention sessions.

Further, the currently available word lists in literature are in English (Goda & Hegde, 2006), have created a drill book specifically for consonants. Additionally, articulation drill books in Telugu, Hindi, Kannada, and Malayalam are available for individuals with cleft palates (Paloor, 2011) and for hearing impairment (Rajeev Ranjan & Arun Banik, 2014). Yet, contextual facilitation has not been considered while preparing these word lists.

As a result, the above literature review demands for the development of a ready-to-use intervention wordlist and pictures based on vowel context and phoneme positions in Hindi language.

CHAPTER 3

Method

The development of Hindi contextual based wordlist was carried out in two phases:

Phase 1: Developing wordlists along with digital pictures.

Phase 2: Administration of the developed wordlist.

Phase 1: Developing a wordlist along with digital pictures.

This phase involved a total of 5 stages. The first stage was selection of the target sounds followed by the second stage, development of the wordlist for those selected target sounds. In the third stage familiarity rating of the words in the wordlist was done followed by the fourth stage where picturization of the selected words were carried out. In the last stage, the developed pictures were rated for their iconicity, clarity and familiarity.

Stage 1. Selection of target sounds

The target sounds in Hindi were selected based on middle and late-acquiring speech sounds that were often erroneous. As per the literature, the most commonly erred sounds by Hindi speaking children are /k/, /kh/, /g/, gh/, /d/, /dh/, /t/, /th/, /ʈ/, /s/, /r/, /l/, /h/, /p/, ph/, /j/, /ʧ/, /ʃ/ (Deepa Shankar & Savithri, 1998; Anima & Sreedevi, 2021). Thus, word lists for velars (/k/, /kh/, /g/,gh/), alveolars (/d/,/dh/,/t/,/th/,/), retroflex (/ʈ/,/ ɖ/,) fricatives (/s/,/ʃ/), approximants (/r/,/l/,/h/), bilabials (/p/,/ph/), and affricates (/ʧ/, /ˁ/) were established for the current study making it a total of 19 sounds.

Stage 2. Development of contextual-based wordlist for the target sounds

Meaningful bisyllabic, trisyllabic, and tetrasyllabic words were selected from daily conversation, Hindi textbooks of primary grade, and Hindi children's dictionaries. Words have the target sounds in the initial, medial positions in the following vowel contexts: /a/, /i/, /u/, /e/, and /u/, and in the final position. In each context, a minimum of 3 and a maximum of 5 words were selected for each target sound. So overall, one target phoneme has a minimum of 30 words and a maximum of 50 words.

Stage 3. Familiarity rating of the wordlist

During the familiarity test, each word was rated on a 3-point scale by three native Hindi-speaking speech and language pathologists (SLPs) as highly familiar, familiar, or not familiar. Words rated as familiar and highly familiar by at least 2 SLPs served as stimuli, and unfamiliar words were discarded.

Stage 4. Picturization of the wordlist

Pictures without copyright issues were generated from websites like Leonardo AI, Chatgpt 4, Pixabay, Pexels, and Gemini AI. The website address for pictures have been provided along with the picture in the annexure.

Stage 5. Iconicity, clarity and familiarity rating of the pictures developed for the wordlist

Three pictures for each word were generated or selected for the wordlist. The selected pictures for stimuli words were rated for clarity and iconicity by three Speech-Language Pathologists (SLPs) with more than two years of experience in the field using a 2-point rating scale. The picture that received positive evaluations for clarity and iconicity from at least two Speech-Language Pathologists (SLPs) was selected and presented along with orthographic forms using Microsoft PowerPoint for each target sound.

Phase 2: Administration of the developed wordlist.

Administration of the wordlist was carried out based on the availability of the participants (purposive and convenience sampling). The objective of this phase was to examine clinicians' usability of the wordlist.

2.1 Participants

Three Hindi-speaking children diagnosed with developmental SSD were enrolled for speech therapy, and three speech-language pathologists providing therapy for these three children served as participants.

Inclusion Criteria

Inclusion Criteria for patients were as follows:

1. Children should be typically developing with Hindi as native language
2. The chronological age of all three participants should be 3-years and/or above
3. The language age for all three participants should be 3-years and/or above
4. Speech-language pathologist’s native language must also be Hindi language

Exclusion Criteria

Participants with any comorbidity (Intellectual disability, autism spectrum disorder, cleft lip and palate, apraxia of speech and hearing disability, hearing impairment and others) were excluded based on informal language tests, oromotor examination and previous clinical reports available if any.

A written consent was taken from the parents of all the participants. The format of consent form is provided in (Appendi 1). Further, the study also adheres to the institutional board Ethical Guidelines for Bio-Behavioral Research Involving Human Subjects (Venkatesan & Basavaraj, 2009). The demographic details of participants are provided in Table 2.2.1

Table 3.2

Demographic details of the participants.

Sl. no	Participants	Gender	Age (years)
1	A1	Male	6.6
2	A2	Female	5.1
3	A3	Male	9

2.2 Procedure

2.2.1 Intervention procedure

Checking for the presence of facilitating contexts: The clinicians checked for the presence of any facilitating context for the target sounds using the contextual-based wordlist for at least one or two target sounds that are erred and documented the same. Further, clinicians noted the contexts in the hierarchy of their faciliatory nature in the baseline assessment form. Note that the target sounds were selected based on the Hindi Articulation test.

Selection of Stimuli words: Based on the hierarchy of the facilitating contexts noted down in the previous step, stimuli words were selected for the target sound from the developed contextual based wordlist.

Duration of the therapy: A total of 10 sessions were taken up. The duration of each session was 45 minutes. The first, fifth, and tenth sessions, including the baseline assessment, were video/audio recorded.

Approach used: Clinicians provided five trials for producing each target word and noted the number of accurate productions during each session. Drill-based speech therapy was given using a phonetic placement approach. Practice of stimuli words were terminated once a particular stimuli word was produced correctly for 75% of the times in three consecutive sessions.

2.2.2 Data Analysis

Percentage of accurate production of target sounds were calculated for each session. In a recent study it has been reported that, a child can accurately produce the target sound in the facilitating context by the fourth speech therapy session (Amulya & Sreedevi, 2018). Hence, it was noted down whether the target sounds reach the pleatue of 75% or more in three consecutive sessions.

In addition, clinicians were asked to subjectively rate their experience of using the contextual-based Hindi picturable wordlist during the therapy sessions for children with SSD on a 5-point rating scale (1-strongly disagree, 2 – Disagree, 3-Neutral, 4-Agree, and 5 – Strongly agree) for the ease of use, benefits, and further recommendation of the material to be used by others.

CHAPTER 4

Results & discussion

The results of the present study aiming to develop contextual-based Hindi wordlist along with pictures for the intervention of children with speech and sounds disorders are also described under the same headings as in the method section.

Phase I: Development of wordlist along with digital pictures and

Phase II: Administration of the wordlist

Phase I: Development of context based Hindi wordlist

The results of this phase I have been described under each stage (a total of 5) as mentioned in the method section. The results are as follows:

Stage 1: Selection of target sounds

A total of nineteen most frequently errored phonemes were selected as targets. These 19 phonemes have been depicted in Table 4.1.

Table 4.1

Target phonemes selected for the wordlist.

Target Phonemes selected	/k/	/kʰ/	/g/	/gʰ/	/d/	/dʰ/	/t/	/tʰ/	/ʈ/	/s/	/r/	/l/	/h/	/p/	/pʰ/	/j/	/ʧ/	/ʃ/	/ɖ/

Stage 2: Development of contextual-based wordlist for the target sounds

A total of 569 words were selected from daily conversation, Hindi text book of primary grade and Hindi children’s dictionary. These words included meaningful bisyllabic, trisyllabic, and tetrasyllabic words with target sounds in the initial, medial positions in the following vowel contexts: /a/, /i/, /u/, /e/, and /u/, and in the final position. The number of words selected for each target sound as per the contexts considered are provided in Table 4.2.

Table 4.2

Total number of words selected

Sl. no.	Phonemes	Total no of words selected	/a/	/i/	/u/	/o/	/e/	final
1.	/k/	65	19	11	12	10	10	05
2.	/kʰ/	20	08	07	02	02	02	00
3.	/g/	46	12	09	13	05	04	06
4.	/gʰ/	12	07	02	01	02	00	01
5.	/d/	30	10	10	07	01	00	03
6.	/dʰ/	11	07	00	02	01	00	01
7.	/t/	32	08	07	03	03	06	06
8.	/tʰ/	7	02	02	01	00	01	01
9.	/ʈ/	35	13	05	02	04	02	10
10.	/s/	43	11	10	08	03	04	10
11.	/r/	54	15	09	04	04	05	17
12.	/l/	48	14	13	03	04	02	12
13.	/h/	18	09	03	00	01	05	01
14.	/p/	16	07	03	01	00	04	01
16.	/pʰ/	18	05	05	02	03	03	00
17.	/j/	10	05	00	03	01	00	02
18.	/ʧ/	26	13	04	04	01	02	02
19.	/ʃ/	21	08	01	03	01	02	09
20.	/ɖ/	11	10	02	00	00	01	00

Stage 3: Familiarity rating of the wordlist

Only those words rated as familiar and highly familiar by at least 2 SLPs were considered as stimuli. According to the rating, out of 569 words a total of 50 words were rated unfamiliar and were removed from the list accounting to a total of 519 words. The final wordlist is the Appendix 4.

Stage 4 & 5: Picturization of the wordlist and Iconicity, clarity and familiarity rating of the pictures developed

Post iconicity, clarity and familiarity rating of the three pictures for each target word, one picture which was rated high on all the three parameters was finalized. The final pictures are provided in Appendix 5.

Phase 2: Administration of the wordlist

To check for the usability of the wordlist, three children (A1, A2, A3) with speech sound errors under three different SLPs were recruited for the study. SLPs were asked to select one or two target sounds and to test for the presence of any facilitating contexts for the target sounds selected for ther clients. The information related to the target sounds selected for each client and the facilitating contexts for those target sounds as documented by the SLPs are provided in Table 4.3.

Table 4.3

Target sounds and their facilitating contexts in hierarchy

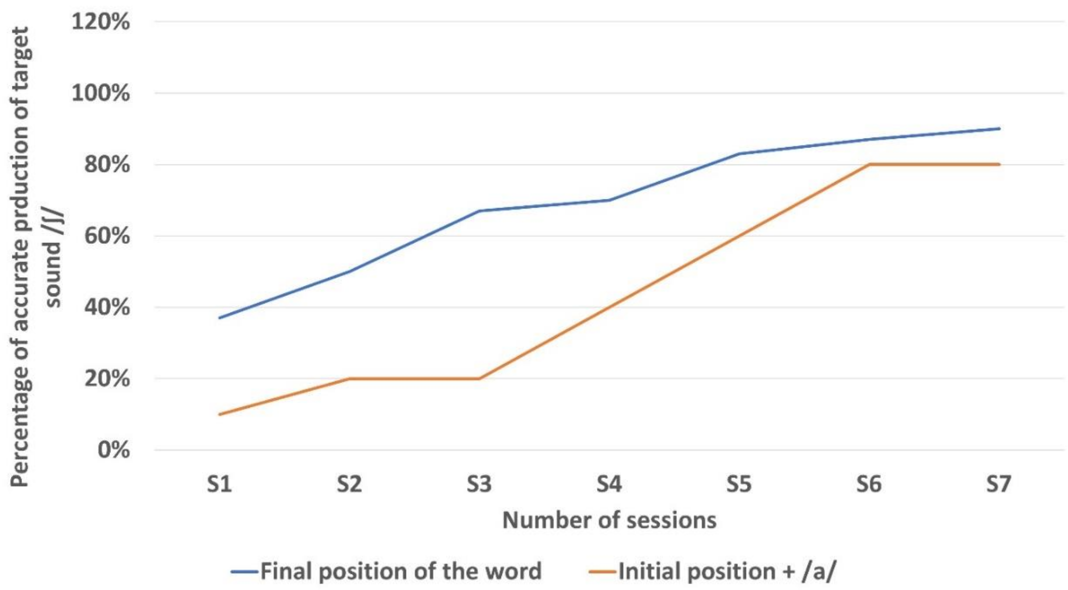
	Target Sounds	Hierarchy of facilitating contexts
A1	/ʃ/	Final position of the word > /o/ in the initial and medial positions of the word > preceding /i/ context with phoneme in the medial position
A2	/r/ and /g/	/r/: /u/ (in all three phoneme position) > /a/ > /e/ > /i/ > /o/ /g/: no facilitating context
A3	/k/	No facilitating context

Then, SLPs were asked to start the intervention with the highly facilitating context and then move on to the next one based on the hierarchy they have documented. The criterion to shift to the next context as well as to terminate the sessions was 75% accurate productions of the target sounds in three consecutive sessions. Also, the criterion of accurate production of the target sound in the facilitating context well within 5 sessions as provided by Amulya and Sreedevi (2018) was considered. Accordingly results of the therapy sessions are described for each client below:

A1: Percentage of accurate production of the target sound /ʃ/ in A1's highly facilitating context, final position of the word and the least facilitating context vowel /a/+initial position has been depicted in Figure 4.1.

Figure 4.1

Percentage of accurate production of target sound /ʃ/ in the highly facilitating and the least facilitating context.

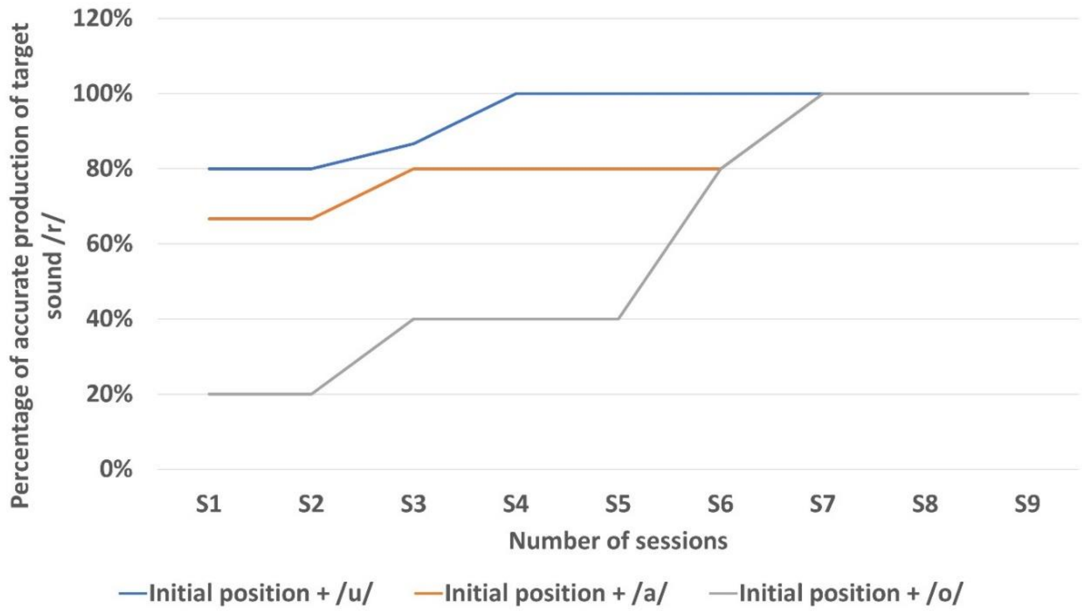


From Figure 4.1 it is clear that the 75% accurate production of the target sound had started by session 5 in the context of target sound in the final position of the word. On the other hand, in the initial position with vowel context /a/ 75% accurate production of the target sound took more than 5 sessions.

A2: In the graph (Figure 4.2), the percentage of accurate production of target words in the A2's two highly facilitating vowel contexts and the least facilitating vowel context in the initial position of the words have been depicted for the sound /r/.

Figure 4.2

Percentage of accurate production of target sound /r/ in the highly facilitating and the least facilitating context.



From the figure 4.2., it is very evident that the target sound /r/ was produced accurately more than 75% of the times in three consecutive sessions well within the first five sessions in the context of highly facilitating vowels /u/ (within 3 sessions) and /a/ (within 5 sessions) and in the initial position of the word. On the other hand, A2 took more than 5 sessions to attain ≥75% accurate production of /r/ across three consecutive sessions in the least facilitating context i.e., vowel /o/ and /r/ in the initial position of the word.

The next target sound was /g/ which had no facilitating contexts. Hence, SLP has initiated the sessions with /g/ in the initial position of the word and in the contexts of vowel /a/ and /e/. The results of A2's performance is depicted in Figure 4.3.

Figure 4.3

Percentage of accurate production of target sound /g/ in the highly facilitating and the least facilitating context.

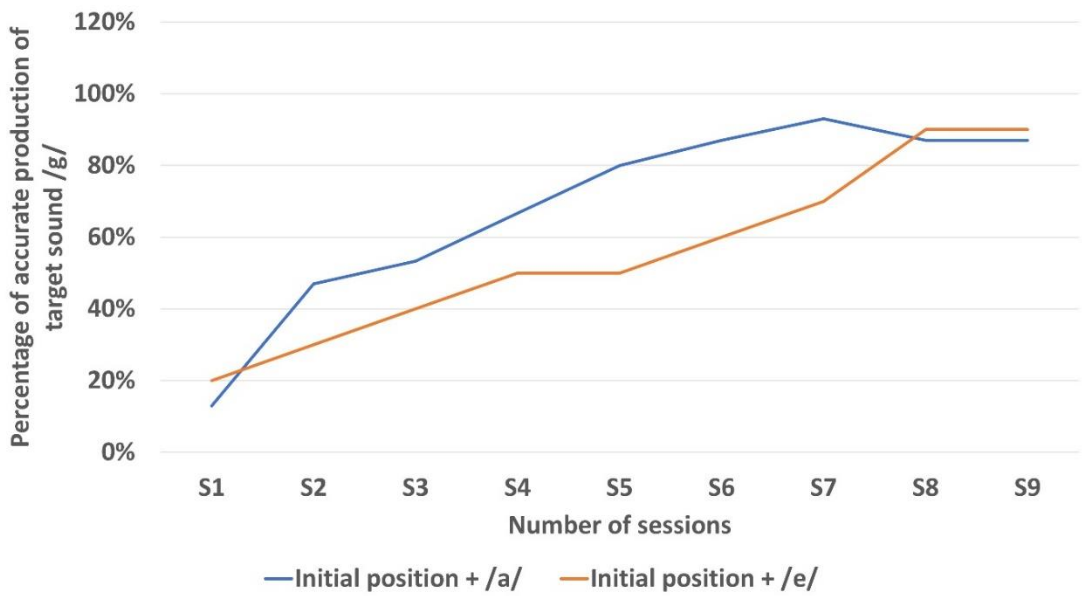
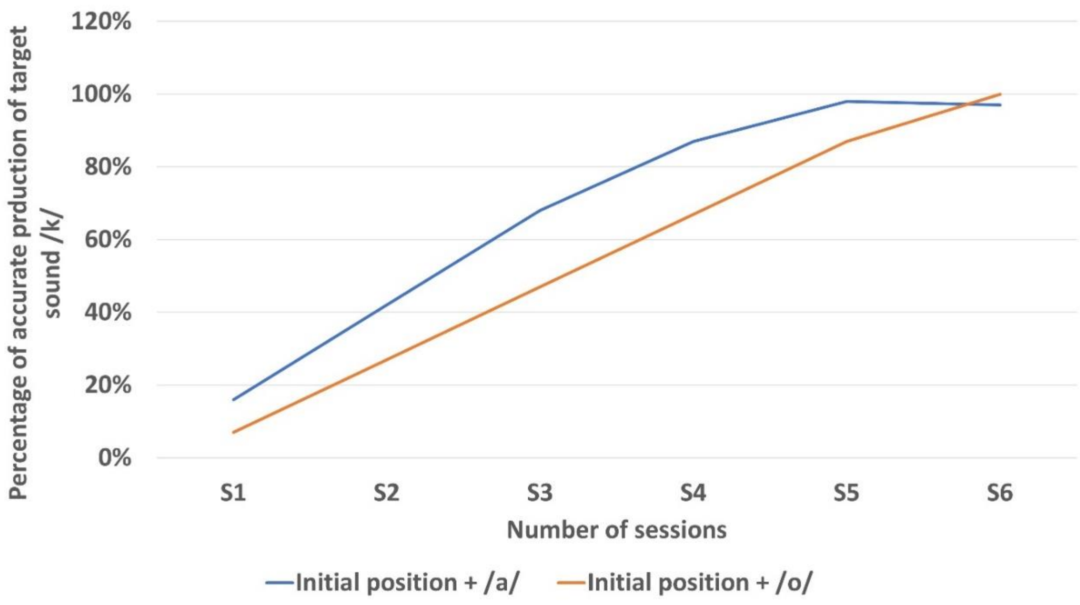


Figure 4.3 indicates that neither vowel /a/ nor /e/ were highly facilitating for the accurate production of the target sound /g/. However, vowel /a/ was found to be more facilitating than vowel /e/ as more than 75% accurate production of the target sound across three consecutive sessions were achieved faster in the former context (by session 7) than the latter (by session 9).

A3: Figure 4.4 depicts the accurate production of target /k/ in the initial position along with the vowel context /a/ and /o/. No facilitating contexts were found for A3 for the production of /k/. Hence, SLP has worked in the contexts of vowels /a/ and /o/.

Figure 4.4

Percentage of accurate production of target sound /k/ in the highly facilitating and the least facilitating context.



Similar to A2's production of target sound /g/, even for A3 Figure 4.4 indicates that neither /a/ nor /o/ were facilitating contexts. This is because A3 took more than 5 sessions to achieve 75% accurate production of the target.

In addition, SLPs were asked to subjectively rate their experience of using (Usability testing) the contextual-based Hindi picturable wordlist during the therapy sessions on a 5- point rating scale (1-strongly disagree, 2 – Disagree, 3- Neutral, 4- Agree, and 5 – Strongly agree) for the ease of use, benefits, and further recommendation of the material to be used by others. The ratings from each SLP for the three parameters are represented in Figure 4.5, 4.6 and 4.7 respectively:

Figure 4.5

Indicates the ease of use for clinicians.

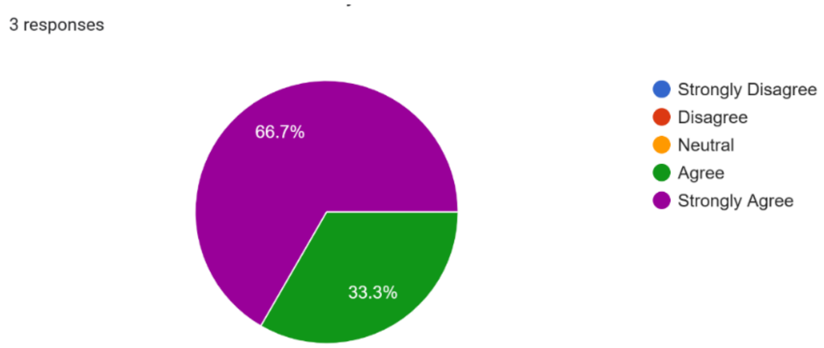


Figure 4.6

Indicates benefit to the patient rated by clinicians.

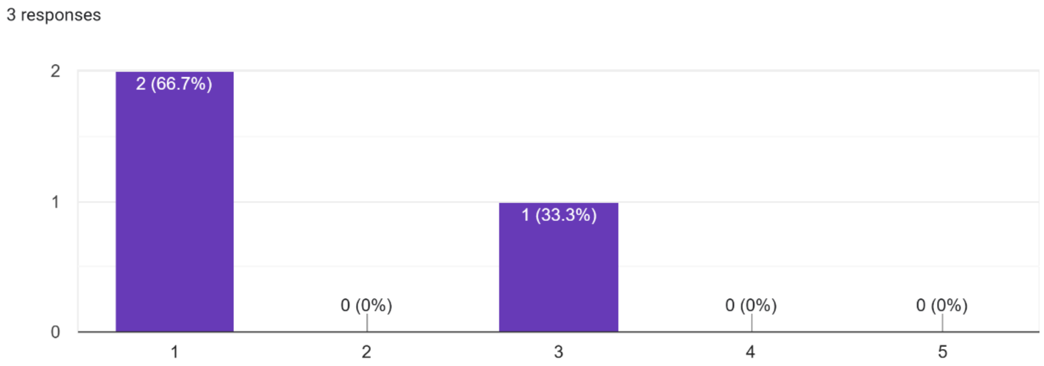
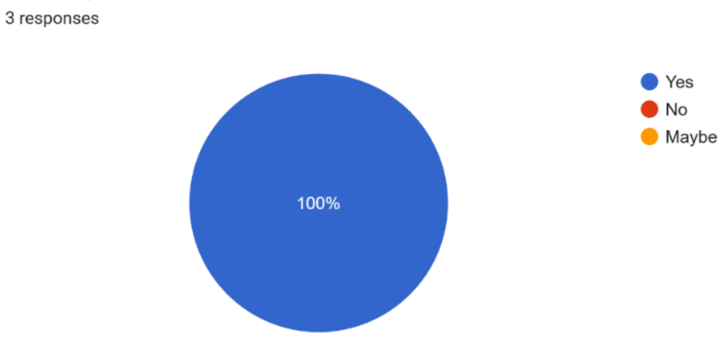


Figure 4.7

Indicates clinician's recommendation



Based on the above three figures it is clearly noticed that 2/3 SLPs have strongly agreed for the ease of use and benefits of the wordlist. In addition, all the three SLPs have indicated recommending the use of this wordlist to other fellow professionals.

Thus, from the results it can be inferred that utilizing facilitating contexts can aid in faster improvement in the accurate production of the target sounds. In all three participants A1, A2, and A3 the target sounds were accurately produced 75% in the highly facilitating vowel and phoneme position context well within 5 sessions. On the other hand, in the least facilitating context, 75% accurate production was attained only after 5 sessions. This is in accordance with the study conducted by Amulya and Sreedevi (2018).

In addition to this, all three SLPs who utilized the developed contextual wordlist have indicated that the wordlist with pictures developed are easy to use and highly beneficial. Also, they have strongly agreed to recommend the present wordlist to fellow SLPs as well. This highlights that developing a contextual based Hindi wordlist for articulation therapy has served the purpose. However, this finding needs to be validated on a larger sample size by more SLPs. Further, the actual benefit of this contextual-based wordlist can be investigated through a group comparison study by comparing the benefits of using contextual and non-contextual based wordlists.

CHAPTER 6

SUMMARY AND CONCLUSION

Facilitating contexts for the speech sounds have been studied based on observational studies as well as case studies in both western and Indian contexts across various languages. All those studies have indicated the presence of facilitating contexts for various sounds with respect to phonetics of that particular language. Contextual approach has also been applied for speech sound intervention. However, there are no ready to use contextual-based wordlists for therapy purposes that would aid SLPs. Hence, the present study was carried out to develop and validate contextual-based wordlist in Hindi for the intervention of children with speech sound disorders.

The study had two phases with the first being the development of the contextual based wordlist with digital pictures and the second being administration or utilization of the wordlist. In the first phase, in order to prepare the wordlist most frequently errored sounds were chosen from previous studies. A total of nineteen sounds were selected. Thereafter, linguistically and culturally appropriate words were selected from various sources. A total of 519 words were included in the final wordlist post familiarity rating of the words by three experience SLPs. The wordlist includes monosyllabic, bisyllabic and trisyllabic words in initial and medial positions in vowel context /a/, /i/, /o/, /e/ and /u/ and in final for the target sounds selected. Then pictures without copyright issues were generated for these words from the websites like Leonardo AI, Chatgpt 4, Pixabay, Pexels, and Gemini AI and were given for iconicity, clarity and familiarity rating. Based on the rating, digital pictures were finalized.

This newly developed wordlist was further given to three SLPs to utilize with their three respective Hindi speaking children with speech sound disorder during therapy. Initially, SLPs were asked to select either one or two target sounds and test for the presence of any facilitating vowel context and phoneme position in the hierarchy using the developed wordlist. Then, SLPs were asked to provide ten continuous online sessions spread across 10 days with a duration of 45 min each. They were instructed to initiate the session with the highly facilitating context. They were asked to document the percentage of accurate productions of the target sounds on 5 trials for each target word. The criterion to shift to the next context as well as to terminate the sessions was 75% accurate productions of the target sounds in three consecutive sessions. Also, the criterion of accurate production of the target sound in the facilitating context well within 5 sessions as provided by Amulya and Sreedevi (2018) was considered. Further, SLPs were asked to subjectively rate their experience of using this developed contextual-based Hindi picturable wordlist during the therapy sessions on a 5-point rating scale (1-strongly disagree, 2 – Disagree, 3- Neutral, 4-Agree, and 5 – Strongly agree) for the ease of use, benefits, and further recommendation of the material to be used by others.

Results of the present study indicated that initiating the articulation therapy with the most facilitating context did bring in a faster improvement (well within 5 sessions) in the accurate production of target sounds. Also, a greater number of sessions were required to attain the 75% criterion of accurate production when the least facilitating context. This indicates that SLPs need to look for these facilitating contexts in the hierarchy before selecting the stimuli words for articulation therapy. Also, all the three SLPs indicated that the that the wordlist with pictures developed are easy to use and highly beneficial. Further, they have strongly agreed to recommend the present wordlist to fellow SLPs as well indicating that the development of this wordlist served the purpose. However, the findings of the present study needs to be validated on a larger sample size.

Implications

- This wordlist can reduce the time required for SLPs to develop or prepare the words and pictures in Hindi.

- Developed wordlist will provide quick reference for the clinicians using contextual facilitation technique for intervention purposes.
- The desired result of this study will be to contribute valuable resources for early childhood language acquisition in Hindi.
- By focusing on contextual relevance and integrating picturable elements, this word list can be used for both assessment and intervention purposes of children with speech sound disorder.
- The wordlist can also act as a readily available stimulus for research purposes.

Limitations of the study

- The target sounds selected were most frequently occurring, obtained from few studies hence not all the sounds errored in Hindi were included.
- Words selected for few sounds /th/, /g/, /j/, /dh/ and /ɖ/ were 7, 12, 10, 11, 11 respectively which is low in number compared to other selected sounds. This is due to the limitation of words in Hindi considering comprehensibility for children and picturization of words.
- The number of participants (clinicians and patients) recruited for the usability testing was comparatively less.
- Dialects of Hindi were not considered in the preparation of current wordlist.

Future Directions

- All the speech sounds of Hindi can be included to prepare vowel context-based words.
- Validation of the wordlist can be carried out on large sample and on diverse clinical population of SSD and on wide age range.
- Wordlist can also be developed in other Indian languages.

- Can compare the utilization of contextual and non-contextual based wordlist on two different groups (A group comparison study) to investigate whether utilization of facilitating context does make a difference in the improvement of the child's production.

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APPENDIX 1

All India Institute of Speech and Hearing, Naimisham Campus, Manasagangothri, Mysore-

INFORMATION AND CONSENT FORM

Information to participants:

I, Ms. Anima Raj, studying MSc in Speech-Language Pathology at All India Institute of Speech and Hearing, Mysuru, is conducting a study titled " Development of Vowel and Phoneme Position Contexts Based Picturable Hindi Word List for Intervention of Children with Speech Sound Disorders" under the guidance of Dr. Amulya P. Rao, Assistant Professor, Department of Language Pathology, AIISH, Mysuru. You are invited to participate in the study which aims to develop a contextual-based picturable word list in Hindi for the intervention of children with developmental speech sound disorder. The study will take 10 sessions for around 30-40 minutes.

Participants will go under treatment for misarticulation, baseline assessment will be done before starting the treatment. Responses will be audio recorded for each session. The participant's identity will not be revealed at any time, and the audio will be kept confidential. The data obtained from the participants will not be disclosed, and access will be limited to individuals working on the study. Participation in this study is voluntary. You can refuse to participate or withdraw at any point in the study without penalty or loss of benefits to which you are otherwise entitled. The procedures of the study are non-invasive, and no risks are associated.

INFORMED CONSENT

I have been informed about the aims, objectives, and procedure of the study. I have read the foregoing information, or it has been read to me in the language I understand. I have had the opportunity to ask questions about it, and any questions that I have asked have been answered to my satisfaction. I consent voluntarily to participate in this study.

I, ____, the undersigned, give my consent to be participant of this investigation/study.

Signature of the participant **Signature of the investigator**

Name & Contact No: **Name of the investigator:**

APPENDIX 2

BASELINE ASSESSMENT FORM

Client's Name: **Age/ Sex**:

Case No.: **Date:**

Clinician's Name:

Baseline/ Session:

Please assess the presence of any facilitating context using the contextual-based wordlist for at least two target sounds. Note down the contexts in hierarchy of their faciliatory nature below.

Target Phoneme:

Word Complexity	Word Position	/a/	/i/	/e/	/o/	/u/
Monosyllabic	Initial					
	Middle					
	Final					
Bisyllabic	Initial					
	Middle					
	Final					
Trisyllabic	Initial					
	Middle					
	Final					

Hierarchy of facilitating vowel context as noted in baseline assessment (Most facilitating comes first):

> > > >

APPENDIX 3

SESSION RECORD FORM

Patient name: **Clinician name:**

Age/Sex: **Date:**

Target phoneme:

Instruction: Please mention the percentage of correct productions in the cells of the table corresponding to each vowel context and word complexity for the target phoneme.

Start with highly facilitating context and moving on towards least facilitating for the two target sounds taken up in the baseline assessment.

Total No. of trials administered for each target word: 5

Words	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8	Session 9	Session 10

APPENDIX 4

Developed vowel context based wordlist in Hindi.

WORDLIST

/k/	/kh/	/g/	/gh/	/d/	/dh/	/t/	/th/	/ṭ/	/s/
Initial (a)	Initial(a)	Initail(a)	Initail(a)	Initial(a)	Initial(a)	Initail(a)	Initial(a)	Initial(a)	Initial(a)
कान	खाट	गाल	घास	दाल	धान	तार	थाल	टच	साँप
कार	खत	गांव	घाट	दांत	धन	ताला	थाली	टब	सात
कांच	खाना	गन	घर	दस	धागा	तालाब	Initial(u)	टमाटर	साग
कार्ड	खजूर	गाजर	घाटी	दाढ़ी	धनुष	तारा	थूक	टमटम	सांड
कप	खटमल	गाना	घड़ा	दवा	Initial(u)	तरबूज	Initial(e)	टायर	साड़ी
कलश	खरबूजा	गदा	घड़ी	दरवाजा	धूप	Initial(i)	थेला	टाई	सड़क
कलम	खाना	गधा	घड़ियाल	Initial(i)	धुआँ	तीन	medial(i)	टांग	सब्ज़ी
कमल	Initial(i)	Initial(i)	Initial(i)	दिल	Initial(o)	तीतर	हाथी	Initial(i)	साइकिल
काला	खीर	गिद्ध	घी	दीप	धोबी	तितली	पॉलिथीन	टीवी	सारंगी
कालीन	खींच	गिरगिट	घीया	दीपक	Medial(a)	तिलचट्टा	Final	Initial(u)	Initial(i)
काग़ज़	खिड़की	गिलास	Initial(u)	दीया	पौधा	Initial(u)	हाथ	टूट	सीट
काँटा	खीरा	गिला	घुटना	दीवार	गधा	तुलसी		Initial(o)	सिर
काजू	खिलौना	गिलहरी	Initial(o)	दिमाग़	कन्धा	तूफ़ान		टोपी	सींग
कमरा	Initial(u)	Initial(u)	घोड़ा	Initial(u)	Final	Initial(o)		टोकरी	सीटी
कमर	खून	गुफा	घोंघा	दूध	दूध	तोप		Initial(e)	सितार
कवर	Initial(o)	गुलाब	Medial(i)	दुकान		तोता		टेबल	सियार
कपड़ा	खोल	गुणा	कंघी	दुपट्टा		तोडना		टेनीस	सिंघाड़ा
कारीगर	खोद	गुफा	Final	Initial(o)		Initial(e)		Medial(a)	Initial(u)
	Initial(e)	गुठली	बाघ	दो		तेल		छोटा	सूट
कारखाना	खेत	गुलाबी		Medial(a)		तेरह		काँटा	सूंड
	Medial(a)	गुड़ीया		बादाम		तेईस		चटाई	सूरज
Initial (i)	पंखा	गुलबहार		गेंदा		तेंदुआ		घटाना	सुबह
कील	Medial(i)	गुब्बारा		परदा		Medial(a)		दुपट्टा	सुनना
क्रीम	मक्खी	Initial(o)		मदान		सितार		तिलचिट्टा	सुई
किताब	सूर्यमुखी	गोल		Medial(u)		◌ीता		Medial(i)	Initial(o)
किडा	Medial(u)	गोंद		जादूगर		तख़्ता		मिट्टी	सोना
किशमिश	नाख़ून	गोल्फ़		तेंदुआ		Medial(i)		बाल्टी	सोफ़ा
किसान		गोबर		बंदूक		मोती		चींटी	Initial(e)
किचन		गोभी		कद्दू				स्कूटी	सेब

किनारा		Initial(e)		Medial(i)		मोमबत्ती		Medial(u)	सेम
Initial(u)		गेंद		नदी		नाशपाती		लट्टू	सेना
कूद		गेंदा		चादी		Medial(u)		Medial(o)	सेना
कुत्ता		गोबर		हल्दी		शहतूत		ऑटो	Medial(a)
कुआ		गोभी		मंददीर		Medial(e)		कटोरा	किसान
कूकर		Medial(a)		Final		जूते		Final	समोसा
कुल्फी		धागा		नींद				खाट	
कूदना		मुर्गा		गेंद		नमस्ते		घाट	Medial(i)
कूड़ेदान		चमगादड़		छेद		Final		ईंट	पेंसिल
Initial(o)		बलगाड़				रात		ऊंट	रस्सी
कोट		रेलगाड़ी				भात		चोट	तुलसी
कोयल		Medial(i)				सात		पेट	Medial(u)
कोहनी		गिरगिट				भूत		अखरोट	लहसुन
कोतवाल		मैगी				रेत		चॉकलेट	बाँसुरी
Initial(e)		बगीचा				शहतूत		क्रिकेट	Medial(o)
केक		सारंगी						जैकेट	रसोइया
केश		Medial(u)							Final
केला		अंगूर							घास
केसर		अंगूठी							बांस
क्रेयन		बगुला							मांस
केतली		रसगुल्ला							तीस
केंचुआ		Final							बीस
Medial(a)		आग							जूस
क्लास		नाग							ओस
दूकान		साग							टेनीस
चक्का		बाग							अनन्नास
छिलका		झाग							तेईस
Medial(i)		पिग							
खिड़की									
तकिया									
साइकिल									

Medial(u)									
स्कूल									
चाकू									
डाकू									
चीकू									
स्कूटी									
Medial(o)									
त्रिकोण									
शठकोण									
रेनकोट									
Medial(e)									
स्केल									
क्रिकेट									
जैकेट									
Final									
नाक									
याक									
डाक									
थूक									
केक									

WORDLIST - IPA

/k/	/kh/	/g/	/gh/	/d/	/dh/	/t/	/th/	/ʈ/	/s/
Initial (a)	Initial(a)	Initail(a)	Initial(a)	Initial(a)	Initial(a)	Initail(a)	Initial(a)	Initial(a)	Initial(a)
/kəp/	/kʰəʈ̪/	/gən/	/gʱər/	/dəs/	/d̪ʱən/	/ta:r/	/t̪ʰa:l/	/ʈət͡ʃ/	/sã:p/
/ka:r/	/kʰa:ʈ/	/ga:v/	/gʱa:ʈ/	/da:nt/	/d̪ʱa:n/	/ ताला: /ta:la:/	/t̪ʰa:li:/	/ʈəb/	/sa:t/
/ka:tʃ/	/kʰa:na:/	/ga:l/	/gʱa:s/	/da:l/	/d̪ʱa:ga:/	/ta:la:b/	Initial(u)	/ʈəma:ʈər/	/sa:g/
/ka:ʈək/	/kʰəd͡ʒu:r/	/ga:d͡ʒər/	/gʱa:ʈi:/	/dəʈi:/	/d̪ʱənuʃ/	/ta:ra:/	/t̪ʰu:k	/ʈəmʈəm/	/sã:ɳɖ/
/ka:n/	/kʰəʈmər/	/ga:na:/	/gʱəʈa:/	/dəʋa:/	Initial(u)	/t̪ərbu:d͡ʒ/	Initial(e)	/ʈa:jər/	/sa:ʈi:/
/kələʃ/	/kʰərbu:d͡ʒa:/	/gəda:/	/gʱəʈi:/	/dərʋa:d͡ʒa:/	/d̪ʱu:p/	Initial(i)	थेला/t̪ʰe:la:/	/ʈa:i/	/səʈək/
/kələm/	/kʰa:na:/	/gəd̪ʱa:/	/gʱəfʈəʈa:l/	Initial(i)	/d̪ʱuã:/	/ti:n/	medial(i)	/ʈa:ŋ/	/səbzi:/
/kəməl/	Initial(i)	Initial(i)	Initial(i)	/dil/	Initial(o)	/ti:ʈ̪ər/	/ha:t̪ʰi:/	Initial(i)	/saɪkɪl/
/ka:la:/	/kʰi:r/	/gid̪d̪ʱ/	gʱi:/	/di:p/	/d̪ʱo:bi:	/t̪it̪əli:/	/pɔ:lit̪ʰi:n/	/ʈi:vi:/	/sa:rəŋgi:/
/ka:li:n/	/kʰi:t͡ʃã:/	/girgiʈ̪/	/gʱi:ja:/	/di:pak/	Medial(a)	/t̪ilət͡ʃəʈʈa:/	Final	Initial(u)	Initial(i)
/ka:gəz/	/kʰəʈəki:/	/gila:s/	Initial(u)	/di:ja:/	/pəʊd̪ʱa:/	Initial(u)	/ha:t̪ʰ/	/ʈu:ʈu:/	/si:ʈ/
/ka:ʈa:/	/kʰi:ra:/	/gila:/	/gʱʊʈna:/	/di:va:r/	/gəd̪ʱa:/	/tulsi:/		Initial(o)	/sir/
/ka:dʒu:/	/kʰəkʰlo:na:/	/giləɦri:/	Initial(o)	/dima:gʱ/	/kənd̪ʱa:/	/tu:fa:n/		/ʈo:pi:/	/siŋg/
/kəmra:/	Initial(u)	Initial(u)	/gʱo:ɖa:/	Initial(u)	Final	Initial(o)		/ʈokəri:/	/si:ʈi:/
/kəmər/	/kʰu:n/	□ /gufa:/	/gʱo:gʱa:/	/d̪u:d̪ʱ/	/d̪u:d̪ʱ/	/to:p/		Initial(e)	/sɪta:r/
/kəvər/	Initial(o)	/gula:b/	Medial(i)	/du:ka:n/		/to:ta:/		/ʈe:bl̩/	/sɪja:r/
/kəpʈa:/	/kʰo:l/	/gʊɳa:/	/ka:ŋgʱi:/	/d̪upəʈʈa:/		/toʈna:/		/ʈeni:s/	
/ka:rigər/	/kʰod̪/	/gufa:/ (repeated)	Final	Initial(o)		Initial(e)		Medial(a)	Initial(u)
/ka:rkʰa:na:/	Initial(e)	/gʊt̪hli:/	/ba:gʱ/	/do:/		/te:l/		/t͡ʃʰo:ʈa:/	/su:ʈ/
/kəp/	/kʰet̪	/gula:bi:/		Medial(a)		/te:rəh/		/kãʈa:/	/su:ɳɖ/
/ka:r/	Medial(a)	/gʊʈi:ja:/		/ba:da:m/		/te:ɪ̯/		/t͡ʃəʈa:i:/	/su:rəd͡ʒ/
Initial (i)	/pã:kʰa:/	/gulbəɦa:r/		/ge:nda:/		/te:nd̪u:a/		/gʱəʈa:na:/	/subəɦ/
/ki:l/	Medial(i)	/gʊbba:ra:/		/pərda:/		Medial(a)		/d̪upəʈʈa:/	/sʊnna:/
/kri:m/	/mak.kʰi:	Initial(o)		/məda:n/		/sɪta:ra:/		/t̪ilət͡ʃəʈʈa	/sui/

								:/	
/frəkta:b/	/su:rjəmukh̪i:/	/go:l/		Medial(u)		/ˈt͡ʃi:tə		Medial(i)	Initial(o)
/frəkʈa:/	Medial(u)	/go:nd/		/d͡ʒa:du:gər/		/təxt̪a:/		/mɪʈʈi:/	/so:na:/
/frəkʃəfrəmʃ/	/na:kʰu:n/	/go:lf/		/te:nd̪u:a/		Medial(i)		/ba:lʈi:/	/so:fa:/
/frəksa:n/	Final	/go:bər/		/ba:nd̪u:k/		/mo:ti:/		/t͡ʃi:ɳʈi:/	Initial(e)
/frəkət͡ʃən/	/a:ŋkʰ/	/go:bʱi:/		/kəd̪d̪u:/		/mo:mbət̪i:/		/sku:ʈi:/	/seb/
/frəkna:ɾa:/		Initial(e)		Medial(i)		/na:ʃpa:ti:/		Medial(u)	/sem/
Initial(u)		/ge:nd/		/nədi:/		/mo:ti:/		/ləʈʈu:/	/se:na:/
/ku:d̪/		/ge:nda:/		/t͡ʃa:di:/		Medial(u)		Medial(o)	
/kʊt̪a:/		/go:bər/		/həld̪i:/		/ʃəɦt̪u:t̪/		/ɔ:ʈo:/	Medial(a)
/ku:a:/		/go:bʱi:/		/ma:nd̪i:r/		Medial(e)		/kəʈo:ra:/	/kɪsa:n/
/ku:kər/		Medial(a)		Final		/d͡ʒu:te/		Final	/səmo:sa:/
/kʊlfi:/		/d̪ʱa:ga:/		/ni:ndõ:/		/nəməste:/		/kʰa:ʈ/	
/ku:d̪na:/		/mʊrga:/		/ge:nd̪/		/d͡ʒu:te/		/gʱa:ʈ/	Medial(i)
/ku:ɽe:d̪a:n/		/t͡ʃəmga:d̪ɽ/		/t͡ʃʰed̪/		Final		/i:ɳʈ/	/pen̪sil/
Initial(o)		/bəlga:ɽ/				/ra:t/		/u:ɳʈ/	/rəsi:/
/ko:ʈ/		/re:lga:ɽi:/				/bha:t/		/t͡ʃo:ʈ/	/tulsii/
/ko:ɦni:/		/girgiʈ/				/bʱu:t/		/əkʰro:ʈ/	lahsun/
/ko:t̪ʊa:l/		/maɪgi:/				/re:t/		/t͡ʃɔ:kleʈ/	/bã:sʊri:/
Initial(e)		/bagi:t͡ʃa:/				/ʃəɦt̪u:t̪/		/likeʈ/	Medial(o)
/ke k/		/sa:rəŋgi:/						/d͡ʒe:keʈ/	/raso:i:ja:/
/ke ʃ/		Medial(u)							Final
/kela:/		/əŋgu:r/							gʱa:s/
/keɾ/		/əŋgu:ʈʰi:/							/bã:s/
/krejan/		/bəgula:/							/ma:ns/
/ke t̪əli:/		/rəsgul:a:/							/ti:s/
/kẽt͡ʃua:/		Final							/bi:s/
Medial(a)		/a:g/							/ju:s/
/kla:s/		/na:g/							/os/
/du:ka:n/		/sa:g/							/tenis/
/t͡ʃəkka:/		/ba:g/							/ənəna:s/
/t͡ʃʰɪlka:/		/d͡ʒha:g/							/te:is/

Medial(i)		/pig/							
/kʰɪʈəki:/									
/təkija:/									
/sa:ɪkɪl/									
Medial(u)									
/sku:l/									
/t͡ʃa:ku:/									
/ɖa:ku:/									
/t͡ʃi:ku:/									
/sku:ti:/									
Medial(o)									
/lət̪rəko:ɳ/									
/ʃət̪ʰko:ɳ/									
/re:nəko:ʈ/									
Medial(e)									
/sku:l/									
/likeʈ/									
/d͡ʒe:keʈ/									
Final									
/na:k/									
/ja:k/									
/ɖa:k/									
/t̪hu:k/									
/ke k/									
/na:k/									

/r/	**/l/**	**/h/**	**/p/**	**/f/**	**/j/**	**/ʧ/**	**/ʃ/**	**/ɖ/**
Initial(a)	Initial(a)	Initial(a)	Initial(a)	Initial(a)	Initial(a)	Initial(a)	Initial(a)	Initial(a)
/ra:t/	/la:l/	/ɦəl/	/pəʈɾ/	/pʰəl/	/ja:k/	/t͡ʃa:j/	/ʃa:k/	/ɖʌk/
/ra:ni:/	/la:lʈen/	/ha:t̪/	/pɑ:nʈʃ/	/ˈfa:ɪl/	Initial(u)	/t͡ʃɑ:nd̪/	/ʃa:m/	/ɖa:l/
/ra:d͡ʒa:/	/la:ʈʰi:/	/ɦəʊən/	/pɑ:n/	/fa:lu:da:/	/jʊd̪d̪ʰ/	/t͡ʃa:ɾ/	/ʃəˈɦəd̪/	/ɖa:k/
/rəbəɽ/	-	/ha:ɾ/	/pa:lək/	Initial(i)	Initial(o)	/t͡ʃa:ʈək/	/ˈʃəb̪d̪/	/ɖəɾ/
/ra:ni:/	-	/ha:t̪ʰi:/	/pɾəʊəkta:/	/fɹɪd͡ʒ/	/jo:g/	/t͡ʃa:d͡ʒək/	/ˈʃa:kʰa:/	/ˈɖɔ:kʈəɾ/
/ra:d͡ʒa:/	Initial(i)	/həra:/	/pələk/	/fi:ta:/	Medial(a)	/t͡ʃa:ku:/	Initial(i)	/ɖəˈməɾu:/
	/ lɪft/	Initial(i)	Initial(i)	Initial(u)	/pja:z/	/t͡ʃɑ:ndi:/	/ˈʃi:ʃa:/	/ɖa:ku:/
Initial(u)	/lɪkʰ/	/ɦɪɾəɳ/	/pi:ʈʰ/	/pʰu:l/	/gjɑ:rəɦ/	/t͡ʃɑ:ɖəɾ/	Initial(u)	/ˈɖɹaɪvəɹ/
/ru:pəja:/	/lɪkʰna:/	/hi:ra:/	/pi:la:/	/pʰu:k/	/pja:la:/	/t͡ʃa:ʋəl/	/ʃʊʈəɾˈmʊɾg/	/ˈɖa:ɳɖi:jɑ: /
/ru:i:/	/li:t͡ʃi:/	/hi:ʈər/	Initial(u)	Initial(o)	/əd̪ʰjɑ:pək/	/t͡ʃa:bʱi:/	Initial(o)	/ˈɖa:kɪjɑ:/
/ru:ma:l/	Initial(o)	Initial(o)	/pu:nʈʃ	/pʰo:n/	Medial(u)	/t͡ʃəna:/	/ʃo:ɾ/	Initial(i)
Initial(o)	/lo:mɽi:/	/ɦo:nʈʰ	Initial(e)	/pʰo:ʈo:ˈfre:m/	/njʊ:z/	Initial(i)	Initial(e)	/ˈɖɪb:a:/

/ro:l/	/lo:ɦa:/	Initial(e)	/pe:ʈ/		/kəmˈpju:təɹ/	/t͡ʃi:l/		
/ro:ʈi:/	Medial(a)	/ˈhɛdˌphoʊn/	/pe:ɽ/	Initial(e)	Final	/t͡ʃɪɽi:jɑ:/	Medial(a)	
/ro:na:/	/ke:la:/		/pe:n/	/pʰo:n/	/ga:j/	/t͡ʃɪkɪt̪sək/	/po:ˈʃa:k/	Initial(e)
Initial(e)	/pi:la:/	Medial(a)	/pe:nsɪl/	/ˈfo:ʈo:ˌfre:m/	/kʃe:t̪ri:j/	/t͡ʃi:l/	/nəkʃa:/	/ɖe:n/
/re:t/	/me:la:/	/t͡ʃu:ɦa:/	Medial(a)	Medial(a)		Initial(u)	/ˈʃi:ʃa:/	
/re:nəko:ʈ/	/ni:la:/	/pəɦa:ɽ/	/go:lgəp:a:/	/ˈso:fa:/		/t͡ʃu:ɦa:/	Medial(e)	
/re:ləgəsta:n/	/ã:ʋla:/	/ʊpʰa:ɾ/	Medial(i)	/gʊˈfa:/		/t͡ʃumbək/	/məˈʃi:n/	
/re:lga:ɽi:/	/gəla:/	Medial(e)	/pəˈpi:ta:/	Medial(i)		/t͡ʃu:lʱa:/	Medial(u)	
/re:lɖəjo:/	/bəgula:/	/nəˈɳʰi:/	Final	/kulˈfi:/		/t͡ʃʊkənd̪əɾ/	/pəʃu:/	
Medial(a)	/kəla:i:/	/d̪əˈɦi:/	/kəp/	/ˈka:fi:/		Initial(o)	/t̪rɪˈʃu:l/	
/həra:/	/məla:i:/	/pəˈləɦjɑ:/		/ˈʈɔ:fi:/		/tʃo:t̪/	Final	
/gəd͡ʒra:/	/ʋəɳkəma:la:/	/kəɽa:ɦi:/		Medial(o)		Initial(e)	/t̪a:ʃ/	
/bʱu:ra:/	/rəsgul:a:/	Final		/ˈhɛdˌfoʊn/		/ˈt͡ʃe:ɾʌ/	/la:ʃ/	
/frəpa:nd͡ʒra:/	Medial(i)	/mʊɦ/		Medial(e)		/ˈt͡ʃe:ri:/	/ke:ʃ/	
/hi:ra:/	/mu:li:/			/ˈfoʈo:ˌfrem/		Medial(a)	/t̪a:ʃ/	
/sənt̪ra:/	/frəbli:/					/əˈt͡ʃa:ɾ/	/ˈhændˌwɑ:ʃ/	
/gub:a:ra:/	/ʊŋgli:/					/bəˈgi:t͡ʃɑ:/	/ləkʃələmʃ/	
/səpe:ra:/	/ɪmli:/						/ˈba:rɪʃ/	
/ʈʰʈʰe:ra:/	/mʌʈʰli:/					Medial(i)	/d̪ʰə.nuʃ/	
Medial(i)	/frət̪t̪əli:/					/li:t͡ʃi:/	/kʰəɾgo:ʃ/	
bakri:/	/t̪a:ʋljɑ:/					Final	/t̪a:ʃ/	
/ʃəri:r/	/t͡ʃəme:li:/					/kɑ:ntʃ/		
/ba:rɪʃ/	/t͡ʃɪpəkli:/					/pɑ:ntʃ/		
/dəri:/	Medial(u)							
/t͡ʃe:ri:/	/bʱa:lu:/							
/na:rɪjəl/	/a:lu:/							
/əlma:ri:/	/ul:u:/							
/ləgləɦəri:/	Medial(o)							
/ba:nsuri:/	/glo:b/							
Medial(u)	/kʰəkʰlaʊn							
/əmaru:d̪/	Medial(e)							
Medial(o)	/tʃɔ:klet̪/							
/əkʰro:ʈ/	/d͡ʒəle:bi:/							
Final	Final							
/pəhre:da:ɾ/	/ba:l/							
/t͡ʃa:r/	/da:l/							
/d͡ʒa:ɾ/	/d͡ʒa:l/							

/kʰiːɾ/	/t͡ʃaːl/							
/t͡ʃoːɾ/	/d͡ʒʰiːl/							
/moːɾ/	/bɔːl/							
/beːɾ/	/goːl/							
/əkʰbaːɾ/	/poːl/							
/baːzaːɾ/	/teːl/							
/diːvaːɾ/	/beːl/							
/liːjaːɾ/	/bʊlbʊl/							
/ən̪d͡ʒiːɾ/	/lət̪ɾʃuːl/							
/təsviːɾ/								
/pəniːɾ/								
/kʰəd͡ʒuːɾ/								
/əŋuːɾ/								
/loːŋuːɾ/								

APPENDIX 5

Sample pictures of the developed wordlist.

Sources: ChatGPT 4.0, Leonardo.ai, GeminiAI, Microsoft AI image generator, Pixels and Pixabay.