FACILITATORY EFFECT OF VOWEL CONTEXT ON ARTICULATION OF VELARS IN CHILDREN WITH HEARING IMPAIRMENT

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Register No.: 15SLP006

A Dissertation Submitted in Part Fulfilment of Degree of Master of Science

(Speech-Language Pathology)

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May, 2017

CERTIFICATE

This is to certify that this dissertation entitled **"*Facilitatory effect of vowel context on articulation of velars in children with hearing impairment*"** is a bonafide work submitted in part fulfilment for degree of Master of Science (Speech-Language Pathology) of the student (Registration Number: 15SLP006). 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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CERTIFICATE

This is to certify that this dissertation entitled **"*Facilitatory effect of vowel context on articulation of velars in children with hearing impairment*"** has been prepared under my supervision and guidance. It is also been 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 **"*Facilitatory effect of vowel context on articulation of velars in children with hearing impairment*"** is the result of my own study under the guidance of Dr. N. Sreedevi, Reader and Head, Department of Clinical Services, 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.

Mysuru, Registration No. 15SLP006

May, 2017

Dedicated to my

Amma, Pappa, Minsu

Appacha, Ammachi, Arathi

and Sreedevi Mam

ACKNOWLEDGEMENTS

Let us come before him with thanksgiving and extol him with music and song. Thank you GOD for your countless blessings and support through happiness and hard times.

It is with great pleasure that I express my gratitude to my guide Dr. N. Sreedevi, for her constant support, guidance and patient listening even during the midst of her busy schedule. Thank you so much mam for sitting till late hours to help us. I have always always admired you Mam from the first time you taught me in B.Sc. Any amount of thanks wouldn't be enough....

I would like to offer my greatest appreciation to Amulya akka for her timely help, suggestions and willingness to spent time to help for my dissertation. Thank you very very much dii... Can't stop thanking you di... ☺

I express my deep sense of gratitude to the Director, Dr. S.R. Savithri whose permission has enabled me to undertake this study.

My sincere gratitude to Dr. Vasanthalakshmi for her timely guidance with the statistical analysis of the data.

My warm and sincere thanks to Dr. R. Manjula for her assistance during the preparation of my dissertation.

My sincere thanks to Irfana chechy and Anitha chechy for their valuable suggestions for the dissertation.

I wish to thank staff of Clinical Services- Sujatha mam, Preethi mam, Jyotsna chechy, Merlin chechy, Merin chechy and Reuben sir- for their timely help. Thank you for your help with dissertation.

I also extend my sincere thanks to all the children and

parents who participated in my study.

Happiness starts with family..... Words are insufficient to express my heartfelt gratitude to my amma, pappa, Minsutty, ammachi and appacha. Thank you so much for your unconditional love and support. Thank you for being the best family I can ever have, for believing in me and for knowing my skills. Amma, you are the sole reason for me having chosen this field. I learnt from all of you to be strong, independent, but at the same time affectionate and empathetic.

A friend in need is a friend indeed.... Thank you Arathi (my buddy) and Devika (Deka) for all the good times, hours of laughter, for the awesome times we have spent and constant support. Thank you my buddy for all your support even when you are not here.

Had a great time with you Merin.... Dissertation partner....
Thank you so very much..... Sarga, Anjuba, Devi, Binsu, Anju baby, Chaya, Rashmi, Manisha, Sneha, Naini, Kirti, Anoopa, Jeena, VP, Varsha, Jasiya, Jesnu, Meher..... for all of your support.
Thanks to all my friends..... Any help in a small way is always appreciated..... Thank you Mighty Masters!!!!!
A big thanks to all my juniors (II B.sc and III B.Sc) for helping me and for their support throughout the preparation of my dissertation.....

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Introduction

Intelligible speech is the most important indicator of oral communication competence. It is highly compromised in individuals with speech sound disorders. According to ASHA (2014), speech sound disorder refers to difficulties in perception, motor production, and/ or phonological representation of speech sounds and speech segments which also includes the phonotactic rules of the language that affects speech intelligibility. Slater (1992) reports speech sound disorder accounting for 32% of all the communication disorders. Around 10 % -16 % of preschoolers and 6% of students in grade I - XII have speech sound disorder (ASHA, 2006). Forty four percent of the speech language service caseloads showed speech sound disorder of which 11.61% were pure speech sound disorders (Kim, Kim, Ha & Ha, 2015a).

Speech sound disorders have an impact on the form and function of speech sounds in most communication disorders especially in children with hearing impairment. Among various communication disorders which co-occur with speech sound disorder includes intellectual disorder (25.44%) followed by hearing loss (14.65%), brain injury (10.28%), autism spectrum disorder (4.88%) and oral mechanism abnormality (3.59%) (Kim, Kim, Ha & Ha (2015b). There are 26 individuals per 1000 individuals who present with speech defects such as articulation errors, according to National Sample Survey Organisation, NSSO in 2002. A retrospective study conducted by Devadiga, Varghese, Bhat (2014) at Kasturba Medical College, Mangalore revealed 62% of auditory disorders, 24% of language disorders and 11% speech disorders. Articulation disorders were found to be 48.4% and more prevalent in paediatric group.

A speech disorder may leave the affected individual and family anxious. Speech errors if untreated can lead to unintelligible speech causing oral communication breakdown. Later on, it may lead to psychosocial disturbances such as poor self- concept to total isolation of the individual in the community. It can also influence critical skills such as spelling and reading development (Community Affairs References Community, 2014). Eleven to fifteen percent of school going children with speech sound disorder also have specific language impairment (Shriberg, Tomblin & McSweeny, 1999) and approximately, 50% - 70% of high school children diagnosed as having speech sound disorder experience academic difficulties (Pennington & Bishop, 2009).

Hearing Impairment can be defined as an organically based speech sound disorder, wherein these individuals exhibit significant difficulty in the perception of speech sounds in varying frequencies (Bernthal, Bankson & Flipsen, 2009) leading to abundant speech errors. The speech production of a hearing impaired child can be delayed as early as the stages of vocalizations. According to National Sample Survey Organisation, NSSO (2002), the prevalence rate was second highest for hearing disability i.e. 291 individuals per 1, 00,000 persons.

The degree of hearing impairment can have an effect on the speech sound development and speech intelligibility. In general, the impairment would cause delay in the receptive and expressive communication skills which in turn would result in academic difficulties. The difficulties in communication may become the reason for poor self concept and social withdrawal and isolation in these children (ASHA, 2005). It is a common finding that better the hearing level, better is the speech intelligibility of the child (as cited in Klippi & Launonen, 2008). Children having loss lesser than 80 dB can gain significant benefits from articulation therapy, whereas those who have

loss greater than 80 dB will have difficulty in acquiring intelligible speech as they have global speech production deficits along with neutralisation or greater number of substitutions, additions, and nasalization of vowels and also omission of initial consonants (Osberger & McGarr, 1982; Roth & Worthington, 2016). Speech intelligibility of 17 year old children with severe hearing loss (n=10) and profound hearing loss (n= 10) were analyzed by Anttilainen (1987). Results revealed average speech intelligibility in these two groups of children with 79% and 29% respectively. A study carried out by Huttunen (2000) in children with mild (n=7), moderate (n=17), severe (n= 13) and profound (n= 14) hearing loss, revealed a strong association between degree of hearing impairment and speech intelligibility. Intelligibility scores were 98%, 96%, 86% and 52% respectively (as cited in Klippi & Launonen, 2008). In children with severe to profound degree of loss (71 to 91 dB), the most commonly misarticulated sound classes are palatal plosives, fricatives, affricates and nasal /ŋ/ (Smith, 1975). Research conducted during 1960s-1980s revealed that in spite of amplification and speech therapy efforts, the speech intelligibility of children with severe to profound hearing loss was approximately 20% (Kent, 1992). Hence, the remedial task of speech- language pathologists is to improve the speech intelligibility.

Literature reports that children acquire various speech sounds in an organised manner and the development is influenced by position, stress, context, juncture, adjacent consonants and rules of the language. Facilitation is defined as a relative improvement in judged adequacy of sound production determined by phonetic factors such as stress, contexts and neighbouring words (Kent, 1982). Certain phonetic environments tend to be more facilitating in the production of phonemes than others. Therefore, the need to explore such facilitating environments becomes necessary to improve the speech characteristics of individuals with speech disorders.

Only handful of studies has been reported in literature. Most of the studies are concerned with determining the contextual effects of phoneme position and very few with vowel contexts. Several studies suggest preferential combination of consonants and vowels in babbling and early speech (Davis & MacNeilage, 1990, 1995, 2004; Anjana & Sreedevi, 2008; To, Cheung & McLeod, 2013). Most of the sounds are first acquired in the initial position of the word and later in the final position, in English (Bleile, 2006; Dodd, Holm, Hua, & Crosbie, 2003). McLeod, Sutton, Trudeau, and Thordardottir (2011) studied the acquisition of consonants in Quebecois French in pre-school aged children and found consonants being acquired earlier in the initial position of the word followed by medial position and then final position.

Similar studies have been carried out in Dravidian languages such as Kannada, Malayalam and so on. Deepa and Savithri (2010) in Kannada speaking children revealed velars, dentals, bilabials, nasals, and glides acquiring both in the initial and medial positions by 2.6 years. Affricates were acquired in both initial and medial positions by 4 years, retroflex sounds and fricatives (/s/, /ʃ/) by 5 years of age. According to Neenu, Vipina, Vrinda and Sreedevi (2011), velars (/k/, /g/) are acquired by 3.3 years in initial and medial positions, fricatives, affricates and retroflexes are mastered by 4.0-4.3 years in Malayalam.

Clinical observations and various studies suggest that production of phonemes is facilitated more easily in particular phoneme positions and vowel contexts in individuals with speech sound disorders (Houde, 1967; Stokes & Griffiths, 2010; Bauman- Wangler, 2012). Curtis and Hardy (1959) found /r/ to be more facilitated in consonant clusters than with vowel contexts in a group of children with functional misarticulation. Investigation carried out by Rockman and Elbert (1984) on untrained acquisition of fricative /s/ in child with phonological disorder suggested /s/ being

acquired in final position followed by initial position. A study by Shalini and Sreedevi (2016) observed production of trill /r/ being facilitated in medial position in non-words.

Need for the study

Speech intelligibility is the major aspect of speech production which is compromised in children with hearing impairment. A typically developing child is 75%- 100% intelligible to parents and 50% intelligible to strangers by 36 months of age even when some articulation and phonological differences are likely to be present (Bowen, 2011). As Monsen noted nearly 30 years ago, "A strange fact about the contemporary education of the hearing-impaired is that the intelligibility of their speech is seldom measured."(Ertmer, 2011, pp. 52). The statement still holds well in the present situation. Even after children are integrated into school by 6 years of age, the major issue remaining is their poor speech intelligibility.

Research in the past apparently stresses on the importance of utilizing key environments in the assessment and intervention of individuals with speech sound disorders. Very few articulation tests utilize contextual analysis, which is mostly available for English language. Most of the literature is based on clinical observations and experiences (Bleile, 1996 & 2006; Bauman-Wangler, 2012) and these have less empirical evidence. In contrast, the present study provides empirical evidence on key environments. Several studies are available in English in typically developing children (Davis & MacNeilage, 1990, 1995, 2004; Boysson-Bardies, 1993; Cheung & McLeod, 2013) and children with speech sound disorders (Stringfellow & McLeod, 1994; Bleile, 1996 & 2006; Cleland, Scoobie, & Wrench, 2015). There is lack of studies on hearing impairment. Researches focus more on late acquiring phonemes such as /s/ (Bennet & Ingle, 1984), /ʃ/ (Stokes & Griffiths, 2010) and /r/ (Curtis &

Hardy, 1959). However, the present study focuses on early acquiring phonemes /k/ and /g/. Coarticulation and language are interdependent. Therefore, one cannot use assessment materials or apply facilitative environments of one language to another.

Thus, from the literature review it is evident that there exist many facilitative contexts in order to achieve correct production of various target sounds. Research in the Indian context mainly focuses on the effect of phoneme position in typically developing children (Shishira & Sreedevi, 2013; Sushma & Sreedevi, 2013) and children with speech sound disorders (Krishna & Manjula, 1991; Shalini & Sreedevi, 2016). However, such studies on vowel contexts are limited.

In the Indian context, articulation therapy for children with hearing impairment is seldom conducted using the facilitating contextual and positional effect as such information has not been documented. Lack of a systematic procedure can cost money and time for both the client and clinician. As an alternative, a methodical procedure can be designed, taking into account the facilitating contextual and positional effect. It will yield better prospects within a short time span. Hence, the present study aims at identifying those vowel contexts which can facilitate the correct production of target phonemes in children with hearing impairment.

Aim

To determine the vowel contexts facilitating the correct production of velars (/k/, /g/) in native Malayalam speaking children with hearing impairment

Objective

The objective of the study is to understand the facilitating effect of following vowels (/a/, /i/, /u/, /o/, /e/) on misarticulated velars (/k/, /g/), in Malayalam speaking children with hearing impairment.

Hypothesis

There is no significant effect of vowels in facilitating the correct production of velars (/k/, /g/) in native Malayalam speaking children with hearing impairment.

Clinical Implications

The earlier studies focused on facilitative phoneme position, particularly in children with speech sound disorder. Moreover, there is lack of studies in other disorders such as hearing impairment. This study will provide evidence on various facilitating vowel contexts for different phonemes misarticulated by children with hearing impairment.

Furthermore, intervention begins at bisyllabic level rather than at a single syllable level. There is convincing evidence that typical speech and language development is initiated at a word level than at sound level (Velleman & Vihman, 2002). It also saves time it takes for the child to generalize from isolation level to syllable level to word level.

Children produce phonemes more easily in certain contexts than others. Identifying key environments help in contextual analyses of various target phonemes during assessment thereby helping the clinician in planning a straightforward intervention.

In the Indian scenario, by and large articulation training does not utilize key environments due to lack of research in this area. The use of trial and error method to teach sound production adds to the duration of therapy.

Articulation training can be initiated in a graded manner, by directly using the highly facilitating vowel context and later move on to less facilitating or non-facilitating contexts (Kent, 1982), thus reducing the pressure on SLPs. This will aid

the clinicians to conduct articulation therapy for such children in a systematic manner which will yield better prospects, faster improvement, and reduce the duration of articulation therapy considerably.

Chapter 2

Review of Literature

The effect of phoneme positions, vowel contexts and syllable stress, on the acquisition of speech sounds in typically developing children and in individuals with speech sound disorders (Kent, 1982) have been studied considerably. There exist phonetic environments in which the client's target productions are perceived as being produced correctly (Ertmer, 2008, pp. 75). These phonetic environments are called 'facilitative phonetic environments' or 'key environments'. The notion of contextual facilitation was first put forth by McDonald in 1964 through Deep Test of Articulation. McDonald proposed that, for those individuals who present with inconsistencies in target sound production, the variations can be identified through contextual testing.

2.1 Effect of vowel context on speech sound development in typically developing children

The effect of phonetic environment on speech sound development in typically developing children have been studied majorly through Frame content Theory put forth by Davis and MacNeilage (1990).

The theory describes the co-occurrence of specific vowels and consonants. Theory hypothesizes a strong co-occurrence of labial sounds with central vowels, coronal sounds with front vowels and dorsal sounds with back vowel in a CV syllable structure. The authors in 1990 described the interaction of consonant and vowel production from 14-to-20 months, of a single child speaking English. It was inferred from their results that high front vowels occurred most frequently with alveolars, high back vowels with velars and mid and low central vowels with labials in early speech

and babbling. Production of labial consonants does not involve active tongue movement indicating tongue at rest during the production of central vowel in labial-central vowel pair.

According to Davis and MacNeilage (2004), bilabials [p], [b] and [m] was found to occur more frequently with low central vowel [a]; high back vowel [u] occurred predominantly with bilabials, dentals; and velars and high front vowel [i] with dentals and velars and less with bilabials. Similar results were obtained in a study conducted by Kern et al (2011) in French, Turkish and Dutch babies. Tunisian babies exhibited coronal-front and labial-central co-occurrence patterns, but not dorsal-back co-occurrence, and Romanian babies only exhibited strong front-coronal co-occurrence patterns (Kern et al, in 2011).

Research conducted by De Boysson-Bardies in 1993 on 10- to- 12 months old infants from French, English, Swedish and Yoruba language community. They confirmed the association of labials and central vowels in French, Swedish and Yoruba infants; labial- frontal vowels association in English and dental- frontal vowels association in Swedish, English, and French. Oller and Steffans in 1993 observed similar consonant vowel co-occurrences in four 10-to-12 months' old children. Maximum association was observed between coronals and high vowels and labials with low vowels.

A study conducted along similar lines by Vihman (1992) implied that labials were followed by central vowels and that the association of velars and back vowels were rare although they were produced together whenever they occurred in the productions. However, alveolars were not significantly associated with front vowels. This may be because the author considered /æ/ as the central vowel which complicated the results on alveolar- front vowel associations. Vihman's study was

partially in disagreement with the study by Davis and MacNeilage (1990) since there was no significant relation between alveolars and front vowels. The authors reasoned this difference might be due to the strong role played by the lexical use of children considered in the study (as cited in Davis and MacNeilage, 1995).

The occurrence of phonological patterns for initial consonants in the context of front, central and back vowel was explored by To, Cheung and McLeod (2013) in children from 2.6-to-6.0 years. The phonological patterns either reduced or increased when associated with certain vowel contexts. Fronting of /k-/ to /t-/ was reduced in the context of back vowels and stopping of /ʧ-/ to /t-/, /s-/ to /t-/ in front vowel context. Backing of /t-/ and /t^h-/ was reduced in the context of front vowel even though there was no statistical significance.

Similar studies are limited in Indian languages. A study by Anjana and Sreedevi (2008) in 6-to-12 month old children partially supports the theory stated by Davis and MacNeilage (1990) i.e. high front vowel [i] frequently occurred with dentals, high back vowels with velars and central vowels with labials. Their findings revealed the co-occurrence of central vowel [a] with bilabials [p], [b] and [m] in 6-9 month range; with dentals in 6-to-8 months range and with velars [k] and [g] and continuant [j] and [w] in multisyllabic utterances as age advanced. However, bilabials, dentals and velars preferably occurred with high back vowel [u] in all age groups. High front vowel [i] was more associated with dentals and velars; mid front vowel [e] with glottal fricative [h] at 6-7 months and mid back vowel [o] with [j] in 11- 12 months range. To conclude, central vowel [a] was associated the most with all consonants and the authors suggest that this particular association may be since [a] is a major frequently occurring vowel in Kannada and it is also found abundantly being

produced by children of all age groups. Furthermore, place of articulation of [a] provides minimal constraints on the movement of tongue.

Shishira and Sreedevi (2013) examined preferential combination of consonants and vowels in Kannada speaking children in the age range of 12-18 months. Bilabials, coronals and velars co occurred most frequently with vowel [a]. This result supports one of the hypotheses of Frame Content Theory that bilabials co occur with central vowel.

A similar study was conducted by Sushma and Sreedevi (2013) in 18- 24 months old Kannada speaking children. Results reported a strong association of bilabials with central vowels, coronals with front vowels and dorsal sounds with back vowels. These results are in partial agreement with the hypothesis proposed by Davis and MacNeilage, 1995) in their Frame Content Theory. In children aged 18-21 months, strongest co-occurrence was between labials and central vowels which is in agreement with first hypothesis (pure frame: labial-central) of Frame Content Theory. Both the first and second hypothesis (pure frame: labial-central and front frame: alveolar- front respectively) are observed in children aged 21-24 months.

Reeny (2017) studied preferential consonant- vowel combination in typically developing children in the age range of 4-to-12 months in Malayalam and Hindi. In Malayalam, velar-front, velar- central, coronal- central, labial-central, labial- frontal and coronal-frontal associations were observed. Most noted CV combinations in Hindi were labial-central, coronal-central, velar-central and coronal-frontal.

The above researches shed light on the development of speech sounds in various vowel contexts in typically developing children. They describe the importance of co occurrence of consonants in particular vowel contexts during the developmental period which suggests that analyzing such contexts would give better insight in

developing an assessment and treatment plan for children with speech sound disorders.

Occasionally erred sound productions may be noticed only in certain phonetic contexts, for instance, production of a target sound preceding or following certain vowels or consonants. This may provide an explanation for the occurrence of phonological deviations such as assimilation, coalescence, cluster reduction and other idiosyncratic productions. For example, /k/ and /g/ may be misarticulated only in words which include alveolars or /s/ may be omitted only in /s/ clusters (Gordon-Brannan & Weiss, 2007). Probing into facilitative phonetic context thus becomes necessary and articulation tests such as The Deep Test of Articulation by McDonald (1964a), Secord Contextual Articulation Test (Secord & Shine, 1997) and Deep test of articulation in Kannada- sentence form (Rohini & Savithri, 1989) assist clinicians in analyzing such key phonetic contexts. The Deep test of articulation- sentence form developed by Maya and Savithri (1989) in Malayalam, tested target consonants /s/, /ʃ/, /ʂ/, /r/, /ɭ/, /ɻ/, /ɾ/ and /j/ with preceding and following short and long vowels /a/, /i/, /u/, /e/ and /o/ and with preceding and following consonants /t/, /k/, /ʈ/, /m/, /n/, /p/, /c/, /l/, /j/, /h/, /r/, /v/, d/, /g/ in three age groups from 5-to-8 year old typically developing children. The vowel contexts were easier than the consonant environments. The list of facilitating vowel environments in Malayalam is given in table 2.1. Only the highly facilitating key environments are listed.

Table 2.1

Facilitating vowel environments for various phonemes in Malayalam (Maya & Savithri, 1989)

Target phonemes	**Age range**	**Key environments**
/s/, /ɻ/, /j/	5-to-6 years	/a/, /i/, /u/, /o/

/ʃ/, /ʂ/, /r/, /ɾ/		/a/, /i/, /u/, /e/, /o/
/ɭ/		/a/, /i/, /e/, /o/
/s/, /ʃ/, /ʂ/, /ɭ/,/r/, /ɾ/	6-to-7 years	/a/, /i/, /u/, /e/, /o/
/ɻ/, /j/		/a/, /i/, /u/, /o/
/s/, /ʃ/, /ʂ/,/ɭ/, /r/, /ɾ/, /ɻ/	7-to-8 years	/a/, /i/, /u/, /e/, /o/
/j/		/a/, /i/, /u/, /o/

Similar study was conducted by Rohini and Savithri (1989) in Kannada. The authors investigated the target consonants /g/, /ɖ/, /d/, /c/, /ɟ/, /ɳ/, /s/, /ʂ/, /h/, /j/, /r/, /ɭ/ and /v/ preceding and following short and long vowels /a/, /i/, /u/, /e/ and /o/ in 5-to-9 year old children. Table 2.2 provides a list of highly facilitating vowel contexts in Kannada.

Table 2.2

Facilitating vowel environments for various phonemes in Kannada (Rohini & Savithri, 1989)

Target phonemes	**Age range**	**Key environments**
/d/, /ɳ/, /r/, /v/, /ʂ/	5-to-6 years	/a/, /i/, /u/, /e/
/g/, /ɖ/, /c/, /ɟ/		/a/, /i/, /u/, /e/, /o/
/ɭ/		/i/
/j/		/a/, /e/
/s/		/a/, /i/, /u/
/h/		/a/, /i/, /e/
/g/, /ɖ/, /c/, /ɟ/, /d/, /r/, /ɳ/, /s/	6-to-7 years	/a/, /i/, /u/, /e/, /o/
/ɭ/		/i/
/v/		/a/, /i/, /e/
/j/		/a/, /e/
/ʂ/		/a/, /u/, /i/

/h/		/a/, /i/, /o/, /e/
/g/, /ɖ/,/c/, /ɻ/, /r/, /d/	7-to-8 years	/a/, /i/, /u/, /e/, /o/
/v/		/a/, /i/, /e/
/j/		/a/, /e/
/s/		/a/, /i/, /u/, /o/
/h/		/e/, /i/, /o/
/ʂ/		/a/, /i/, /u/

2.2 Effect of vowel context on speech sound production in disordered population

There are very few investigations considering the contextual effect of vowels in the facilitation of sound production and most of the studies have been carried out in children with speech sound disorders.

Literature reports consonant clusters as one of the context which facilitates the production of /r/ (Curtis & Hardy, 1959; Kent, 1982; McCauley & Skenes, 1987). Hoffman, Schuckers and Ratusnik (1977) studied a group of 10 children who had inconsistent misarticulations of /r/. Results indicate consonant clusters and preceding vowel contexts as key environments for the production of /r/. The most facilitating is long front vowel /æ/, followed by long front vowel /i/ and high back vowel /u/. This is because; the movement necessary for production of /i/ and /u/ are in close proximity with the target [r]. Although this is not true for / æ/, it shares common features (+ long and + front) with /i/.

Bennet and Ingle (1984) conducted a study on 50 children with functional articulation disorder in the age range of 6-to12- years. Children had misarticulation of /s/. Results revealed prevocalic /s/ in the context of vowel /ʌ/ having least number of articulation errors and word initial /s/ clusters having most errors. This study was

partially contradictory to the research by Gallaghar and Shriner (1975a) describing consonant clusters as the most facilitating context for /s/ than consonant vowel context.

A case study conducted by Stringfellow and McLeod (1994) describes the use of facilitative context to reduce the occurrence of an atypical form of gliding. The 5 year old participant who had delayed speech and language abilities diagnosed at the age of 3.8 years, consistently substituted /l/ for /j/. From 3.8-to-5 years of age, traditional articulatory approach and minimal pair approach were used to teach the production of /j/, but it proved ineffective. The authors used the key word approach by Van Riper (1963) in which the key word [ija] was used which contains the two vowels ([i] and [a]) constituting the glide [j]. During the intervention, the child was made to glide slowly from [i] to [a]. The gap between [i] and [a] were increased until the participant could produce [i] and [ja] separately. Minimal contrastive pairs were taken up to make the participant discriminate between /l/ and /j/. By the fifth session, the participant was able to consistently use the glide /j/ in natural phrases.

CV interaction of a Cantonese speaking child with speech sound disorder was studied by Cheung and Abberton in 2000. The production of alveolar/ palatal sounds /t- , t^h, ʧ-, ʤ-/ could be attained if they are followed by high front vowels /i/ or /y/. The authors concluded that CV interactions affect the acquisition of Cantonese consonants in children with speech sound disorders and emphasizes on the importance of contextual assessment.

A single subject case study carried out by Stokes and Griffiths (2010) described the use of facilitative vowel context in the treatment of persistent post alveolar fronting for fricative [ʃ]. The participant was a 7 year old male with SSD, phonetic type. Intervention was successful with the use of facilitative vowel contexts

by helping the participant establish a motor program for [ʃ]. The authors also emphasized on the importance of identifying facilitative contexts suitable for the child.

A more recent study was carried out by Cleland, Scobbie and Wrench (2015) using ultrasound in children with persistent primary speech sound disorder. Accordingly, velars were found to be facilitated in the context of back vowels. The results were in agreement with the results of the study by Davis and McNeilage (1990, 2004) and Anjana and Sreedevi (2008) suggesting contextual facilitation to be similar to those observed in the acquisition stage of typically developing children.

Bleile (1996) describes facilitative phoneme positions and vowel contexts for the production of various phonemes. The key vowel environments are provided in table 2.3.

Table 2.3

Facilitative environment for successful production of a sound class in English (Bleile, 1996)

Treatment targets	**Facilitative environments**	**Example**
Nasal consonants	Before a low vowel	***Ma****d*
Alveolar consonants	Beginning of words before front vowels in the same syllable	***Te****a*
Velar stops	End of word	*Pea****k***
	Beginning of words before a back vowel in the same syllable	***Go***

Bleile (2006) provided facilitative contexts for late acquiring sounds in typically developing children. The same is depicted in table 2.4.

Table 2.4

Facilitative environment for late acquiring sounds in English (Bleile, 2006)

Treatment targets	Facilitative environments	Example
/θ/	End of a syllable or word	*Tee**th***
	Before high front vowel	***Th**in*
/ð/	Between vowels	*Wea**th**er*
	Before high front vowel	***Th**ese*
/s/	End of a syllable or a word	*Bu**s***
	Before high front vowel	***S**ee*
/z/	End of a syllable or a word	*Fi**zz***
	Before high front vowel	***Z**ip*
	After [d] and before [i]	*D**z**i*
	After [d] occurring in the same syllable	*Bead**s***
/l/	Light /l/: Before high front vowel	***L**eaf*
	Dark /l/: after a high back vowel at the end of a syllable	*Ca**ll***
Vocalic /r/	Word consisting single stressed syllable	*Gi**r**l*
Consonantal /r/	Before high front vowel	***R**id*
	Between vowels	
	Syllable initial consonant velar cluster	*C**r**eek*
/ʃ/	End of syllable or word	*Fi**sh***
	Before high front vowel	***Sh**e*
/ʧ/	End of syllable or word	*Ba**tch***
	After high front vowel	*Wi**tch***

Similarly, 'key environments' have also been discussed and described by Bauman -Wangler (2012). However, it has to be noted that contexts may be unique to an individual. The same has been described in table 2.5.

Table 2.5

Compatible and incompatible vowel contexts to teach error sounds (Bauman & Wangler, 2012)

Target sound	**Compatible vowel/sound**	**Reason**	**Incompatible vowel/sound**	**Reason**
[s] and [z]	[i], [ɪ], [ɛ], [e], [æ]	Both the sounds have similar articulatory movements: anterior position of the tongue with lip spread. The authors report that this condition facilitates the establishment of [s] and [z] in a child's repertoire.	[u], [ʊ], [o], [ɔ]	The vowel [u] has a contrast movement of articulators with respect to [s] or [z]: posterior tongue placement and lip rounding which works against the establishment of [s] and [z].
[ʃ] and [ʒ]	[i], [ɪ], [ɛ], [e], [æ]	If the difficulty is with tongue placement, then the authors suggest establishing these sounds in the context of high front vowels.	[u], [ʊ], [o], [ɔ]	The authors report that articulatory movement of [u] contradicts the movement of these sounds if the error is due to the placement of the tongue.
	[u], [ʊ], [o], [ɔ], [ɝ], [ɚ]	If the difficulty is with rounding of lips, then the authors suggest establishing these sounds in the context of high	[i], [ɪ], [ɛ], [e], [æ]	The authors report that, if the error is due to rounding of lips, high front vowels work against

Table 2.5 continued

Target sound	Compatible vowel/sound	Reason	Incompatible vowel/sound	Reason
		back vowels and few central vowels with some degree of lip rounding.		the target.
[k]	[u], [ʊ], [o], [ɔ], [ɑ]	If the child is substituting, front sounds for [k], then the authors suggest using high back vowel to establish the posterior tongue placement for the production of [k].	[i], [ɪ], [ɛ], [e], [æ]	The articulatory movement for [i] would facilitate front tongue placement which has been reported to be against the production of [k]
	[i], [ɪ], [ɛ], [e], [æ]	High front vowel phonetic context has been suggested, if velar sounds are produced postdorsal uvular. The sequence suggested is high-front, mid-front, low-front, central, low-back, mid-back, and high-back vowels		

Table 2.5 continued

Target sound	Compatible vowel/sound	Reason	Incompatible vowel/sound	Reason
[g]	[ŋ]	They suggest that more than vowel context, it's in the context of abutting consonant [ŋ], [g] is established easier. They also suggest to teach [g] following [k].		
[l]	Low-back [ɑ], low-front [æ]	These vowel phonetic contexts are proposed to be used if visibility is important and when [w] is substituted for [l].	Mid-front vowels [ɛ], [e]; and high-back vowels [o], [ɔ].	Not recommended if [w] is substituted for [l], as these vowel contexts facilitate lip rounding which in turn facilitate production of [w] instead of [l].
	Back vowels	Recommended in case of [l] distortions as the concave posture of the tongue are believed to support relaxation of the lateral edges. In addition, they also propose that the dark /l/ would be easily established in the word-final position.		
		Believed to facilitate production of dark /l/.		

Table 2.5 continued

Target sound	Compatible vowel/sound	Reason	Incompatible vowel/sound	Reason
		The authors suggest the following sequence of vowels: high-back, mid-back, low-back, central, low-front, mid-front, and high front vowels.		
	High-front vowels	Aid in the production of light [l]. The authors suggest the following sequence of vowels: high-front, mid-front, low-front, central, low-back, mid-back, and high-back vowels.		
[r]	Central vowel without r-coloring [ɑ]	Produced with elevated mandibular position which is believed to support the production of [r]	Front and back vowels	The posterior and anterior positioning of the tongue does not support the production of [r] as stated by the authors.
	Back vowels	Facilitates the production of bunched [r] which involves lip rounding feature as present in production of back vowels.		

Table 2.5 continued

Target sound	Compatible vowel/sound	Reason	Incompatible vowel/sound	Reason
[ð] and [θ]	High-front vowels [i], [ɪ], [ɛ], [e], [æ]	Both the target sound and the vowel need anterior movement of the tongue and hence the establishment of these sounds in the context of high-front vowels has been recommended by the authors. Authors also provide possible vowel sequence: high-front, mid-front, low-front, central and later back vowels in the order from low to high.	High-back vowels [u], [ʊ], [o], [ɔ]	These vowels would need posterior movement of the tongue which is opposite to the movement of tongue required for the production of the target sound. Hence, high-back vowel context is not proposed to establish the production of these target sounds.
[f] and [v]	High-front vowels [i], [ɪ], [ɛ], [e], [æ] and central vowel [ɑ]	Authors provide possible vowel sequence: high-front, mid-front, low-front, central and later back vowels in the order from low to high.	High-back vowels [u], [ʊ], [o], [ɔ]	The lip rounding feature of these vowels has been proposed to be unfavorable for the establishment of [f].
[ʧ] and [ʤ]	High-front vowels [i], [ɪ], [ɛ], [e], [æ]	High-front vowels have been suggested to provide support for the production of affricates, as the feature, anterior tongue placement is common for both, and hence, facilitates the		

Table 2.5 continued

Target sound	Compatible vowel/sound	Reason	Incompatible vowel/sound	Reason
		production of affricates. The authors suggest the vowel sequence under this circumstance is: high to low front vowels followed by central and then back vowels.		
	High-back vowels [u], [ʊ], [o], [ɔ]	The authors also report that there are two advantages of working on affricates in the context of back vowels: (1) lip rounding of high-back vowels might provide articulatory support for the production of [ʧ] (this affricate also has lip rounding feature), (2) posterior movement of the tongue during the production of back vowels may enhance the backward gliding movement of the tongue during the transition from stop to fricative portion of the affricate.		

Table 2.5 continued

Target sound	Compatible vowel/sound	Reason	Incompatible vowel/sound	Reason
		The vowel sequence under this circumstance has been proposed to be high to low back vowels followed by central and then front vowels.		

Facilitatory effects of vowel context have been explored in the Indian context by a couple of researchers. Krishna and Manjula (1991) studied a 15 year old participant with misarticulation of retroflex /ʈ/. The target sound /ʈ/ was taken up in various vowel contexts in disyllabic and trisyllabic levels. Pre-therapy and post therapy comparison was carried out using acoustic analysis. The production of retroflex / ʈ / was found to be facilitated more in the context of vowels /a/ and /i/ compared to /u/, /e/ and /o/.

Amulya (2017) studied facilitatory vowel contexts for retroflex sounds /ʈ/, /ɖ/, /ɳ/ and /ɭ/. Vowel /u/ facilitated the production of /ʈ/, /ɖ/ and /ɳ/ while vowel /i/ facilitated production of /ɭ/.

From the literature it is apparent of certain key environments facilitating the production of particular phonemes. Thus designing a systematic procedure, considering facilitating contexts will be beneficial for carrying out articulation training particularly in children with communication disorders.

Chapter 3

Method

The aim of the study was to determine the facilitating effect of vowel context (/a/, /i/, /u/, /o/, /e/) on the correct production of velars (/k/, /g/) in native Malayalam speaking children with hearing impairment.

3.1 Participants

Six children with moderately severe/ severe to profound degree of hearing impairment, in the age range 3-to7- years served as participants. Convenience and purposive sampling methods were employed for the selection of participants attending speech and language therapy at the All India Institute of Speech and Hearing, Mysore. Participant details are given in table 3.1.

Table 3.1

Details of the participants

Participant	Age/ gender	Severity of hearing loss		Mean length of utterance
		Right ear	Left ear	
1	5.3 years/Male	Severe – profound	Profound	3-4 words
2	4.5 years/Female	Profound	Severe	3-4 words
3	4.7 years/Male	Severe	Moderately Severe	2 words
4	7 years/Male	Severe	Severe	3-4 words
5	5 years/Male	Severe	Severe	2 words
6	5years/ Female	Profound	Profound	2 words

3.2 Inclusion criteria

1. Children who were enrolled in speech and language therapy with the diagnosis of delayed speech and language with bilateral moderate/ severe to profound sensori-neural hearing loss.
2. Children who were aided by at least three years of age.
3. Regular users of hearing aids with listening frequencies within the speech spectrum.
4. No motor production of velars (/k/, /g/)
5. Mean length of utterance of two to four words.
6. Speech intelligibility less than 80%.
7. No presence of any other co-morbid disorders.
8. Native speaker of Malayalam language and exposed to the same language.

3.3 Design

Single subject time series design was used. Initially, the participants underwent a baseline assessment. Mid-therapy assessments were carried out after child achieved motoric production of the each target phoneme in at least one vowel context. Post therapy assessment was performed after the participant acquired correct motoric production of all the target phonemes.

3.4 Stimuli

Frequently erred phonemes in childhood language disorders in Malayalam were reported by Rofina (2015). Accordingly, velars (/k/, /g/), the highly misarticulated speech sound category by children with hearing impairment were considered as target phonemes. Two sets of bisyllabic (**CVCV**) non-word stimuli in

vowel harmonized and vowel non- harmonized environments were prepared for each of the target phonemes in various vowel contexts in Malayalam. These sets were used to provide a controlled environment for the stimuli. Vowel harmonized set has different consonants in same vowel combination as in /ka-pa/. However, vowel non-harmonized set has different consonants in different vowel combinations in non-words, for example, /ka-pi/. Both vowel harmonized and non- harmonized sets were used to establish the facilitating vowel contexts. Stimuli prepared had velars (/k/, /g/) in combination with vowels /a/, /i/, /u/, /o/, and /e/. An example for the two sets of non-word list (vowel harmonized and non- harmonized set) for target phonemes /k/ is provided in table 3.2.

Table 3.2

Example for the vowel harmonized set and non- harmonized set for phoneme /k/

Vowel harmonized		**Vowel non- harmonized**			
C_1/a/- C_2/a/	/ka/- /pa/	C_1/a/- C_2/i/	/ka/- /pi/	C_1/i/- C_2/a/	/pi/- /ka/
C_1/i/- C_2/i/	/ki/- /pi/	C_1/a/- C_2/u/	/ka/- /pu/	C_1/u/-C_2/a/	/pu/- /ka/
C_1/u/- C_2/u/	/ku/- /pu/	C_1/a/- C_2/o/	/ka/- /po/	C_1/o/-C_2/a/	/po/- /ka/
C_1/e/- C_2/e/	/ke/- /pe/	C_1/a/- C_2/e/	/ka/- /pe/	C_1/e/- C_2/a/	/pe/- /ka/
C_1/o/- C_2/o/	/ko/- /po/				
Total = 5 x 2 = 10		**Total = 20 x 2 = 40**		**Total = 20 x 2 = 40**	

1. In Table 3.2, C_1 is the target sound (/k/ or /g/) and C_2 is phoneme /p/. Most of the children with hearing impairment have fronting errors, i.e. they substitute dental /t/ for velar /k/. /p/ is a visible bilabial phoneme and it provides least

constrains on the movements of the tongue for the production of lingual sounds. Hence, /p/ was selected as C_2.

2. In the first set, that is the vowel harmonized set, C_1 and C_2 for eg. /k/ and /p/ were paired with all the vowels /a/, /i/, /u/, /o/, /e/. In this way, a total of 10 stimuli were presented including both the velar cognates (/k/, /g/).
3. In the second, vowel non-harmonized set, there were two subsets. In the first subset, for C_1 a particular vowel (eg. /a/) was kept constant and for C2, vowels (eg. /i/, /u/, /o/, or /e/) were alternated. There were 4 such stimuli. This was done in a similar manner for all the five vowels. Hence a total of 20 stimuli were prepared for /k/ and another 20 for /g/. Therefore, the total stimuli were 40 in number, including both the velar cognates (/k/, /g/).
4. The second subset of non-harmonised stimuli was the reverse of the first set. Here, a particular vowel (eg. /a/) was kept constant for C_2 while other vowels (eg. /i/, /u/, /o/, /e/) were varied for C_1. For each vowel paired with C_2, there were 4 stimuli. This was done in a similar manner for all the vowels. Thus a total of 20 stimuli each were present for /k/ and /g/. Therefore, a total of 40 stimuli were prepared including both the target sounds (/k/, /g/).
5. The total number of stimuli were 45 (5 in set 1 and 40 in set 2) for a single target phoneme. A grand total of 90 stimuli were prepared comprising both the target sounds (/k/, /g/). Complete list of stimuli for phonemes /k/ and /g/ is provided in Appendix 1.

3.5 Procedure

The participants meeting the inclusion criteria were selected for the therapy program with the consent of their parents. Details of recent (within 6 months)

audiological evaluation (aided pure tone audiometry and aided speech identification scores) and speech and language evaluations were obtained from case files of the participants. The aided pure tone thresholds were within the speech spectrum according to the recent evaluation. The consistency of usage and benefit of the hearing aid for the participant were determined from the recent evaluation reports and parent/ caregiver's observations. Scales of Early Communication Skills for Hearing Impaired Children (Moog & Geers, 1975) was used to assess the language age of the child. Only the Verbal Receptive and Expressive scales of the test were used.

3.5.1 *Pre-therapy assessment*

Each participant was made to repeat the two sets of stimuli items, beginning with the vowel harmonized set. Number of correct production of the stimuli by each participant was noted for all the vowel contexts.

3.5.2 *Articulation Therapy*

For all participants only a single phoneme was targeted at a time. Therefore, therapy began with unvoiced velar /k/ followed by voiced velar /g/.

Two to three, individual 40-minute therapy sessions were provided to each of the participants in a week. The total number of sessions attended by the participants varied depending on their learning skills.

The stages of therapy were as follows:

a. Verbal modelling or imitation was the prime means of stimuli presentation. The orthographical form of the non-word was also used to help elicit the correct response, when required.

b. In order to determine the facilitating vowel context, the child was made to repeat the non-word stimuli of the target phoneme, beginning with the vowel harmonized set.

c. A rating sheet was used to mark the correct/ incorrect production of the child. Correct production was indicated by a tick mark (✓) and an incorrect production with a cross mark (✗). A sample of the rating sheet is provided in table 3.3. The complete rating sheet is provided in Appendix 2.

Table 3.3

Sample of rating sheet used for articulation therapy

Vowel harmonized - Set I		**Vowel non-harmonized** - Set II			
	Session		Session		Session
/ka/- /pa/		/ka/- /pi/		/pi/- /ka/	
/ka/- /pi/		/ka/- /pu/		/pu/- /ka/	
/ka/- /pu/		/ka/- /po/		/po/- /ka/	
/ka/- /pe/		/ka/- /pe/		/pe/- /ka/	
/ka/- /po/					

d. Reinforcement (verbal, social, tangible reinforcement) was provided for every correct production of the child.

e. If the child was able to achieve motor production of target phoneme in seven out of nine stimuli for a particular vowel context, then that vowel context was documented as the facilitating vowel context.

f. If no facilitating vowel contexts were observed, the participant was taught to produce the target phoneme through phonetic placement (beginning with the vowel harmonized set).

g. The facilitating vowel context was identified by rating the child's production as explained in the above steps.
h. The vowel context in which the child was able to achieve production of a target phoneme was noted as the most facilitating context. The first two facilitating vowel contexts were documented.

3.5.3 *Mid-therapy assessment*

The two sets of stimuli were presented in a random order to the participants (beginning with the vowel harmonized set) for mid-therapy assessment. Participants had to achieve motor production of the target phoneme (7 out of 9 correct productions) in at least one vowel contexts in order to shift therapy to the next target phoneme.

3.5.4 *Post-therapy assessment*

Following therapy, each of the participants was made to repeat the stimuli items in each vowel context and the same was noted. Initially, the harmonized set was presented followed by the non- harmonized set.

3.5.5 *Intelligibility scores*

A pre-therapy assessment was performed to evaluate the speech intelligibility of the participants. Articulation ability of the children was assessed using Malayalam Articulation Test- Revised (Neenu, Vipina, Vrinda & Sreedevi, 2011) through repetition mode or picture naming task. Only four words (2 words each for /k/ and /g/) were taken from MAT-R. The assessment was audio recorded using Sony MP3

recorder (I CD- UX81F) and the misarticulated phonemes were documented and transcribed using International Phonetic Alphabet (2015).

For calculating the percentage of intelligibility, first, the recorded audio sample of MAT-R of each participant was presented individually to three Malayalam speakers who were unfamiliar with the MAT-R wordlist. They were asked to note the number of words intelligible from the words presented. Speech intelligibility was calculated using the following formula:

$$Intelligibility\ \% = \frac{Total\ number\ of\ words\ identified}{Total\ number\ of\ words\ presented} X\ 100$$

Average percentage of three judges served as speech intelligibility score for each of the participant.

In a similar manner, a post therapy assessment of intelligibility scores were carried out and percentage of intelligibility was calculated. The pre-test and post-test scores for the percentage of speech intelligibility were compared.

3.6 Statistical Analysis

The results across the sessions for each participant are presented graphically. SPSS software (version 17) was used for statistical analysis. Descriptive statistics was performed for each of the participants. In order to determine the facilitating vowel context, Friedman test was performed across each vowel context in pre-therapy, mid-therapy and post-therapy productions of the participants for each target phoneme. Subsequently, Wilcoxon signed rank test was carried out to determine pair wise significance across vowel contexts. Articulation therapy outcome was determined by statistically analyzing the pre-therapy, mid-therapy and post-therapy productions of

participants across various vowel contexts for each target phoneme using Friedman and Wilcoxon signed rank test.

Chapter 4

Results and Discussion

The study aimed at identifying vowel contexts facilitating the production of velar cognates /k/ and /g/ in Malayalam speaking children with hearing impairment. The study is first of its kind as facilitative contexts for correct production of velars in disordered population has not been explored particularly in the Indian context. The current investigation involved six children, 4 boys and 2 girls in the age range of 3-to-7 years as participants. The results are discussed under the following headings:

4.1 Facilitative vowel contexts of velar phonemes

4.1.1 Unvoiced velar /k/

4.1.2 Voiced velar /g/

4.2 Statistical analysis of facilitative vowel contexts for velars

4.2.1. Velar production across vowel contexts

4.2.2. Velar production across articulation therapy sessions

4.3 Percent Intelligibility scores

4.1 Facilitative vowel contexts of velar phonemes

The facilitative contexts of unvoiced velar phoneme /k/ and voiced velar phoneme /g/ are documented in the following sections. A pre-therapy assessment was carried out in the first session and intervention was initiated in the second session for all the participants. Criterion for mid-therapy assessment was when the child correctly produced seven out of nine stimuli in at least one vowel context. A mid-therapy assessment was performed in the subsequent session. Further progress of the production of target phoneme in various vowel contexts was documented in the successive sessions following which articulation therapy was terminated. A post-

therapy assessment was performed in the last session. All the six participants who were recruited for the therapy program misarticulated unvoiced (/k/) and voiced velar (/g/). The participants substituted unvoiced dental /t/ for /k/ and voiced dental /d/ for /g/. Session details of each participant are provided in tables 4.1 and 4.3.

4.1.1 Unvoiced velar /k/

Figures 4.1, 4.2, 4.3, 4.4 and 4.5 depict the acquisition of phoneme /k/ in participants P1, P2, P3, P4, P5, and P6 respectively, across various sessions in the context of vowels /a/, /i/, /u/, /e/, and /o/ respectively. From visual inspection of the figures, vowel /a/ was observed to be the most facilitating context for the acquisition of /k/ in all the participants and vowel /e/ was the least facilitating context for all the participants except P5. Interestingly the second most facilitating context varied across participants and the details are given in table 4.2. For P1, P2, and P6 vowel /i/ was observed to be the second most facilitating context, whereas vowel /o/ for P3 and P4 and vowel /e/ for P5.

Another significant observation was that vowel harmonized set seemed to facilitate the easier production of /k/ than the vowel non- harmonized set.

Table 4.1

Details of participants and session number of mid-therapy and post-therapy assessment for phoneme /k/

Participant No.	**Age/gender**	**Session number**	
		Mid-therapy	**Post-therapy**
P1	5.3 years/Male	5	9
P2	4.5 years/Female	2	6

P3	4.7 years/Male	5	8
P4	7 years/Male	2	6
P5	5 years/Male	3	6
P6	5years/ Female	1	4

Table 4.2

Depicts the facilitating vowel contexts for velar /k/ in different participants

Participant number	Most facilitating context	Second most facilitating context	Least facilitating context
P1	/a/	/i/	/e/
P2	/a/	/i/	/e/
P3	/a/	/o/	/e/
P4	/a/	/o/	/e/
P5	/a/	/e/	/i/
P6	/a/	/i/	/e/

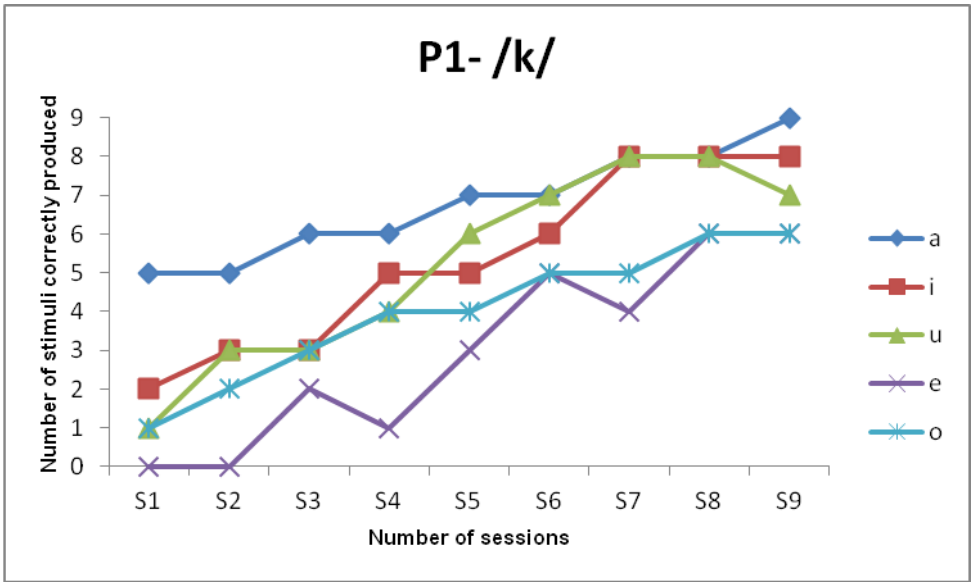

Figure 4.1. Acquisition of /k/ across sessions in the context of five vowels for participant 1

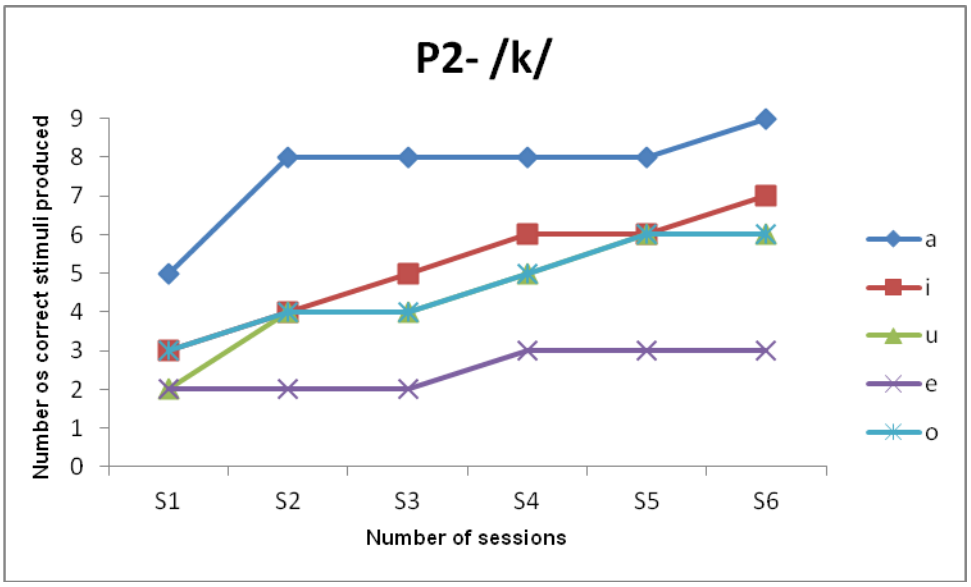

Figure 4.2. Acquisition of /k/ across sessions in the context of five vowels for participant 2

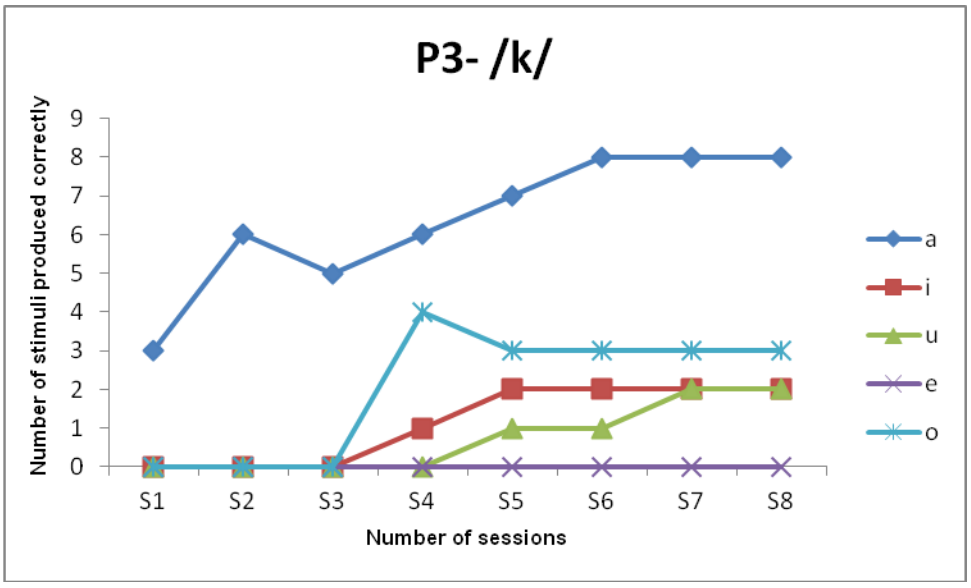

Figure 4.3. Acquisition of /k/ across sessions in the context of five vowels for participant 3

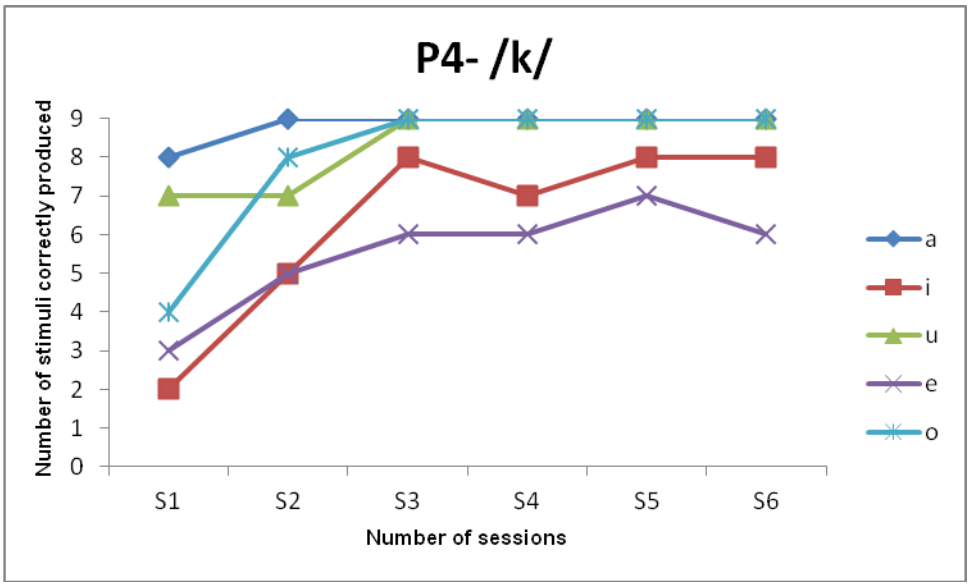

Figure 4.4. Acquisition of /k/ across sessions in the context of five vowels for participant 4

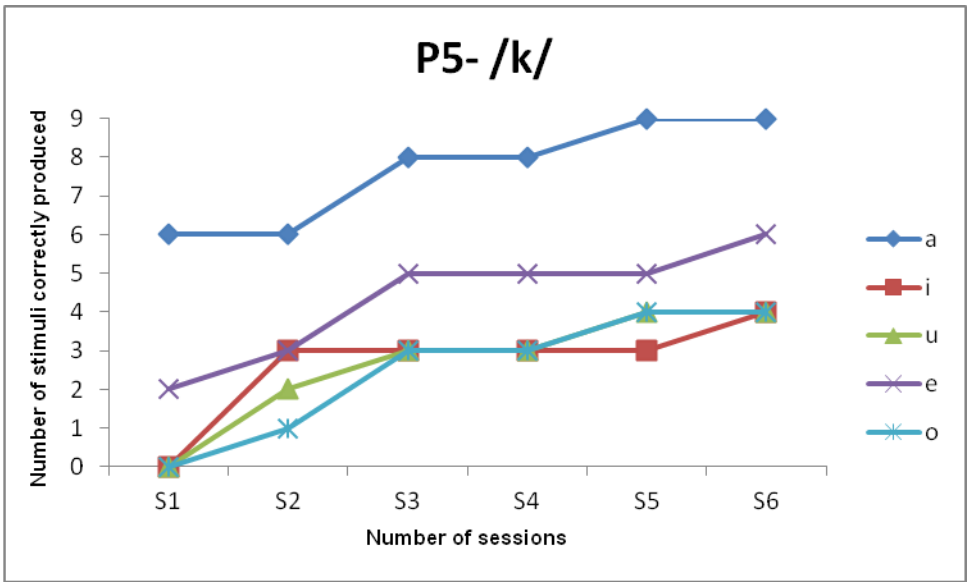

Figure 4.5. Acquisition of /k/ across sessions in the context of five vowels for participant 5

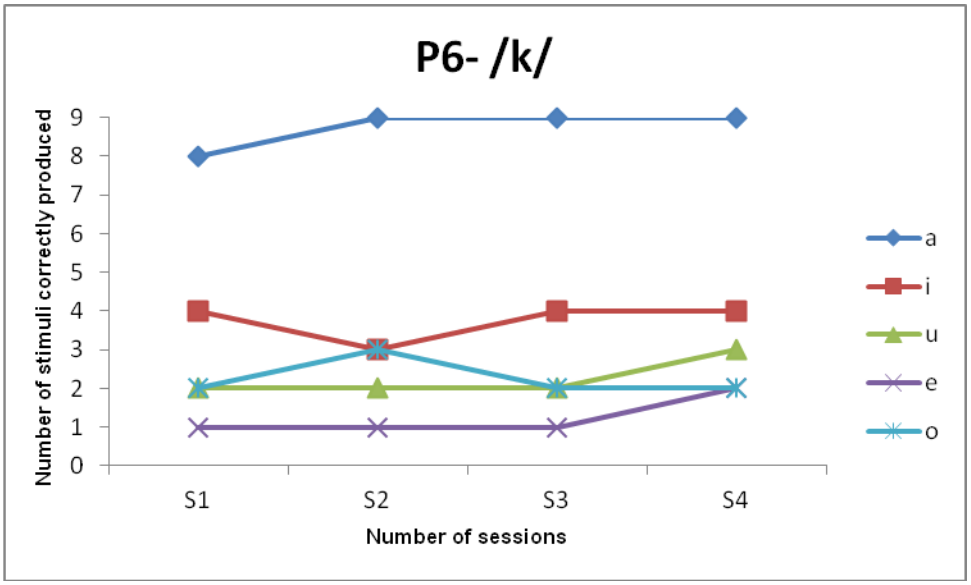

Figure 4.6. Acquisition of /k/ across sessions in the context of five vowels for participant 6

4.1.2 Voiced velar /g/

Visual examination of the Figures 4.7, 4.8, 4.9, 4.10, 4.11 and 4.12, revealed that vowel /a/ was the most facilitating key environment for the acquisition of /g/ also. The second most facilitating context was observed to be vowel /i/ for P1, P2, P6 and vowel /o/ for P3 and P5. Participant 4 had both vowel /u/ and vowel /o/ as second most facilitating context. The details are provided in table 4.4. Vowel /e/ was observed to be least facilitating in all the participants for the acquisition of velar /g/. Similar to target phoneme /k/, velar /g/ was also produced with ease in vowel harmonized set in contrast to non- harmonized set by all participants.

Table 4.3

Details of participants and session number of mid-therapy and post-therapy assessment for phoneme /g/

Participant No.	**Age/gender**	**Session number**	
		Mid-therapy	**Post-therapy**
P1	5.3 years/Male	5	9

P2	4.5 years/Female	5	8
P3	4.7 years/Male	10	12
P4	7 years/Male	4	8
P5	5 years/Male	6	9
P6	5years/ Female	7	9

Table 4.4

Depicts the facilitating vowel contexts for velar /g/ in all participants

Participant number	Most facilitating context	Second most facilitating context	Least facilitating context
P1	/a/	/i/	/e/
P2	/a/	/i/	/e/
P3	/a/	/o/	/e/
P4	/a/	/u/, /o/	/e/
P5	/a/	/o/	/e/
P6	/a/	/i/	/e/

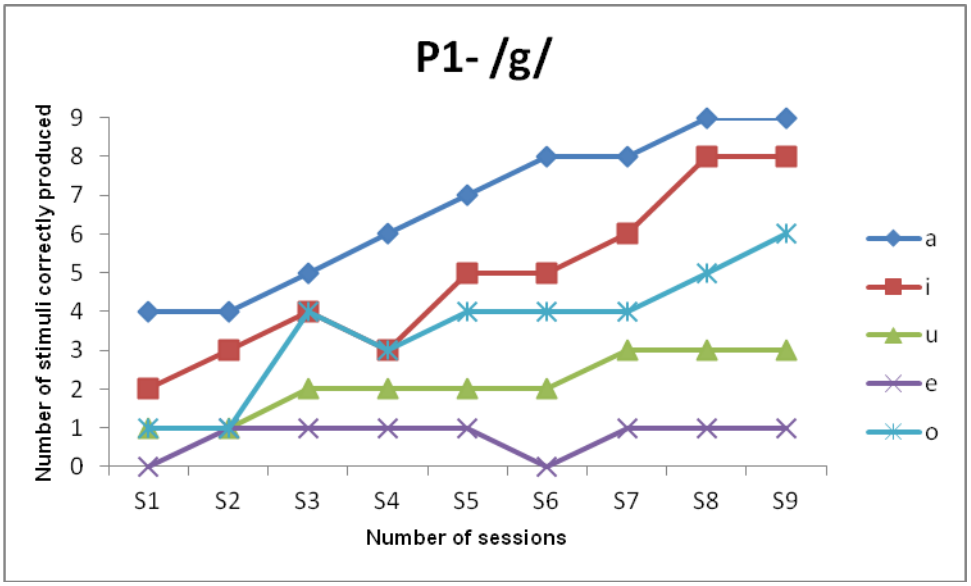

Figure 4.7. Acquisition of /g/ across sessions in the context of five vowels for participant 1

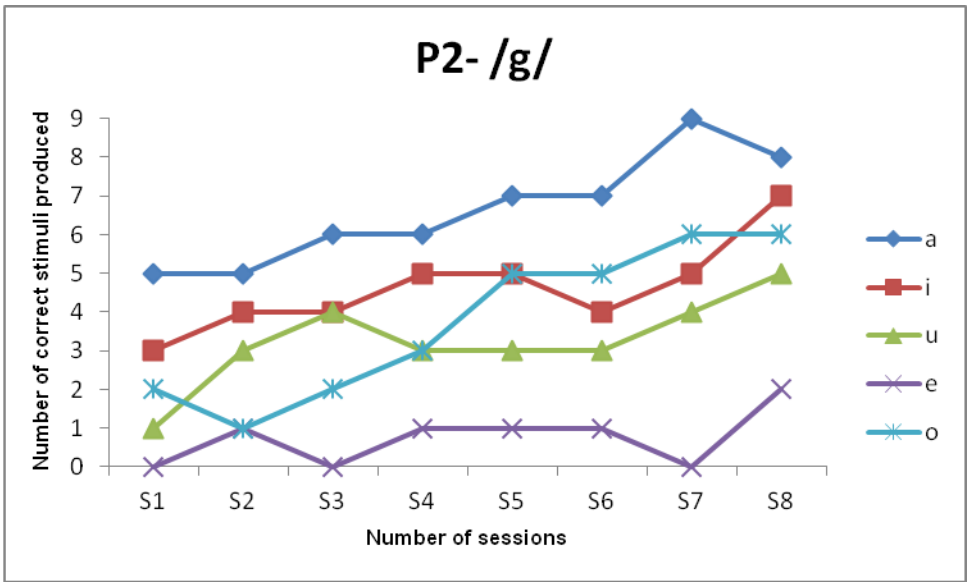

Figure 4.8. Acquisition of /g/ across sessions in the context of five vowels for participant 2

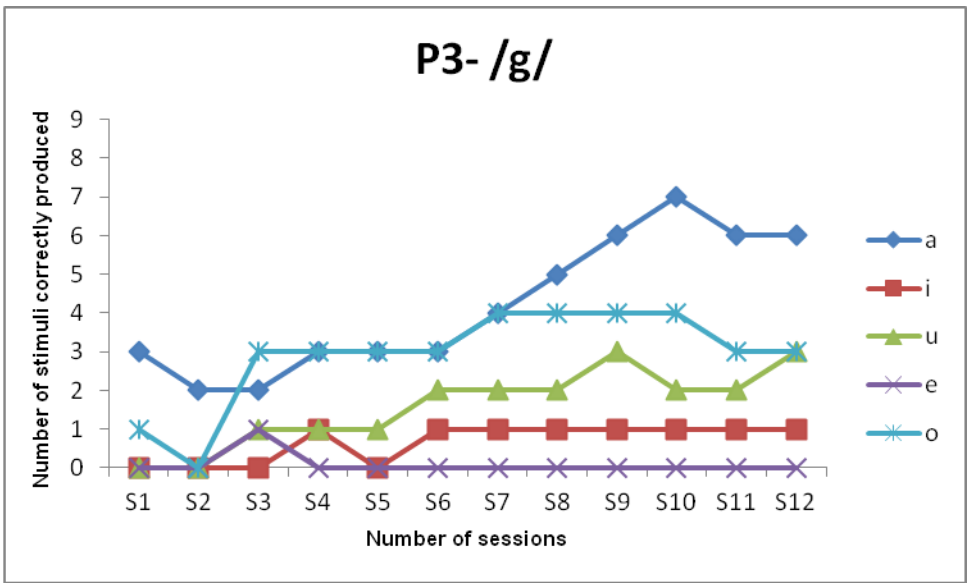

Figure 4.9. Acquisition of /g/ across sessions in the context of five vowels for participant 3

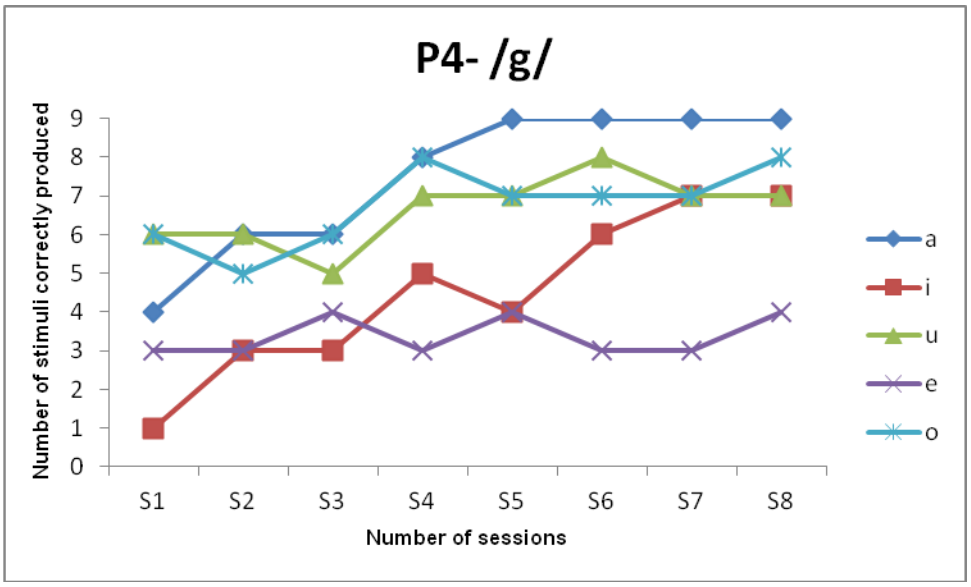

Figure 4.10. Acquisition of /g/ across sessions in the context of five vowels for participant 4

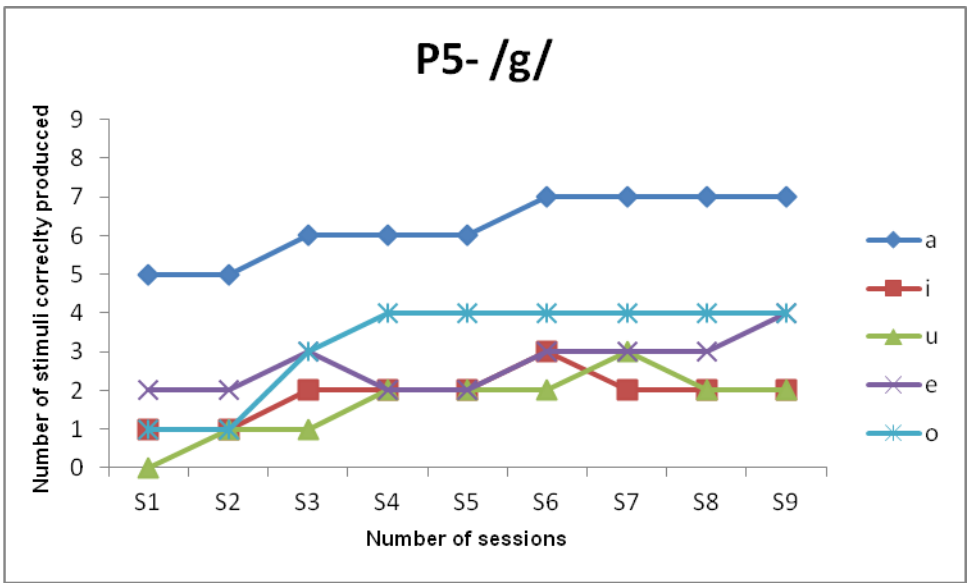

Figure 4.11. Acquisition of /g/ across sessions in the context of five vowels for participant 5

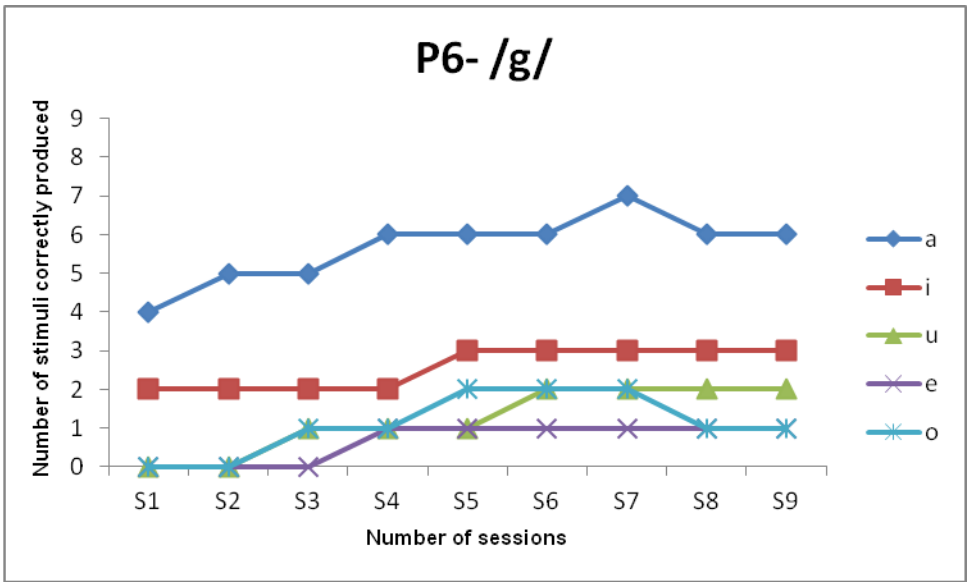

Figure 4.12. Acquisition of /g/ across sessions in the context of five vowels for participant 6

To conclude, a similar trend was observed in the acquisition of both velar phonemes with /a/ being the most facilitating context for both the target phonemes /k/ and /g/. This is reasoned on the physiological evidence that /a/ provides least coarticulation resistance with velars in Malayalam using ultrasound imaging of the tongue (Irfana, 2017). Earlier Kent (1982) also supported this view stating, a context may be facilitating if it minimally interferes with the error sound. Vowel /a/ is also a frequently occurring phoneme in many of the Dravidian language such as Kannada and Malayalam and it is one of the first vowels to be acquired by an infant. Furthermore, high occurrence of velar-central vowel (VC) associations have been observed in the early babbling period of typically developing children in Swedish and American English (De Boysson- Bardies, 1993), Kannada (Shyamala & Basanthi, 2003; Anjana & Sreedevi, 2008; Shishira & Sreedevi, 2013) and in Malayalam and Hindi (Reeny, 2017).

Vowel /e/ was observed to be the least facilitating context in all participants except for P5. This may be because vowel /e/ occurred in a much reduced frequency in conversational Malayalam compared to vowel /a/ (4% vs 13%), as reported by Sreedevi and Irfana (2013).

The second most facilitating context varied across participants. For few participants, velars were facilitated by high front and high back vowels followed by vowel /a/. Kent (1982) reported that a similarity between error sound and its neighbour might facilitate the production of the misarticulated sound. Such velar-front and velar- back vowel combinations are observed in babbling stages of English speaking typically developing children by Davis and MacNeilage (1990, 2004). Similar findings were present in other languages for instance, Korean (Lee, Davis and MacNeilage, 2007), Yoruba (De Boysson-Bardies, 1993) and Tunisian and Dutch (Kern et al, 2011).

Clinical observations by Bauman-Wangler (2012) suggest the use of high back vowels for ease of production of velar /k/ in children with speech sound disorders. However in an ongoing research in Kannada by Amulya (2017) on children with speech sound disorders, velar productions were facilitated by vowel /a/ in two children, vowel /i/ and /u/ in one child each respectively.

In general, all the participants required more number of sessions to acquire voiced velar /g/ than voiceless velar /k/. This is probably because /k/ is the most occurring consonant in conversational Malayalam as reported by Sreedevi and Irfana (2013) and hence children will have more exposure to /k/.

Participants had better production of target phonemes in vowel harmonized set in contrast to vowel non- harmonized set. This is possibly because of the greater coarticulatory impact of the same vowels in the harmonized set.

4.2 Statistical analysis of facilitative vowel contexts for velars

4.2.1. Velar production across vowel contexts

Descriptive statistics (only median) was applied for each target phoneme (/k/ and /g/) for different assessments (pre-therapy, mid-therapy and post-therapy) across various vowel contexts (/a/, /i/, /u/, /e/ and /o/). The standard deviation was high and skewed, hence, median based tests (non- parametric tests) were used for elaborating the results. From the median values in table 4.5 it was observed that vowel /a/ was more facilitating than the other vowels /i/, /u/, /e/ and /o/ in pre-therapy, mid-therapy and post-therapy assessments.

Table 4.5

Median scores across the five vowels in pre-therapy, mid-therapy and post-therapy assessments for /k/ and /g/

Phoneme	**Assessments**	**Vowels**				
		/a/	**/i/**	**/u/**	**/e/**	**/o/**
/k/	Pre-therapy	5.50	2.00	1.50	1.50	1.50
	Mid-therapy	8.00	4.00	3.50	3.50	4.00
	Post-therapy	9.00	5.50	5.00	4.50	5.00
/g/	Pre-therapy	4.00	1.50	0.50	0.00	1.00
	Mid-therapy	7.00	3.50	2.50	1.00	4.00
	Post-therapy	7.50	5.00	3.00	1.50	5.00

In order to determine statistical significance, Friedman test was used. The test compared the overall significance of all the vowels in all three assessments. Analysis of table 4.6 revealed significant effects across all the vowel contexts in pre-therapy, mid-therapy and post-therapy assessments ($p < 0.05$).

Table 4.6

Comparison of median scores across the five vowel contexts in pre-therapy, mid-therapy and post-therapy assessments for /k/ and /g/ using Friedman test

Phonemes	Assessments	χ^2 (4)	p value*
/k/	Pre-therapy	15.216	0.004
	Mid-therapy	11.348	0.023
	Post-therapy	14.259	0.007
/g/	Pre-therapy	11.193	0.024
	Mid-therapy	17.138	0.002
	Post-therapy	16.522	0.002

Note. *p<0.05

As there was a statistical significance revealed in Friedman test, Wilcoxon signed rank test was employed to establish pair wise comparison of vowel contexts in all three assessments for each of the target phonemes. Results revealed there is statistical significance across vowel pairs /a/-/i/, /a/-/u/, /a/-/e/ and /a/-/o/ with level of significance set at p<0.05 for both /k/ and /g/ except for the pair /ga/-/go/ in pre-therapy assessment (Table 4.7). There were no significant effects observed across other pairs of vowel contexts, for example /i/-/u/, /u/-/e/, etc. for both the target phonemes in the three assessments. Hence, only those pairs with statistical significance are listed in table 4.6.

Table 4.7

Pair wise comparison of median scores across vowel contexts in pre-therapy, mid-therapy and post-therapy assessments for /k/ and /g/using Wilcoxon signed rank test

Assessments	Pairs for /k/	|Z|	p value	Pairs for /g/	|Z|	p value*
Pre-therapy	/ka/-/ki/	2.214	0.027	/ga/-/gi/	2.232	0.026
	/ka/-/ku/	2.214	0.027	/ga/-/gu/	2.003	0.045

	/ka/-/ke/	2.214	0.027	/ga/-/ge/	2.214	0.027
	/ka/-/ko/	2.214	0.027	-	-	-
Mid-therapy	/ka/-/ki/	2.207	0.027	/ga/-/gi/	2.232	0.024
	/ka/-/ku/	2.032	0.042	/ga/-/gu/	2.003	0.024
	/ka/-/ke/	2.207	0.027	/ga/-/ge/	2.214	0.027
	/ka/-/ko/	2.032	0.042	/ga/- /go/	1.903	0.027
Post-therapy	/ka/-/ki/	2.214	0.027	/ga/-/gi/	2.214	0.027
	/ka/-/ku/	2.032	0.042	/ga/-/gu/	2.207	0.027
	/ka/-/ke/	2.226	0.026	/ga/-/ge/	2.214	0.027
	/ka/-/ko/	2.041	0.041	/ga/- /go/	2.226	0.026

Note. *p<0.05

Therefore, to summarize, a significant effect of vowel context was present when comparing vowel /a/ with other vowels across pre-therapy, mid-therapy and post-therapy assessments for the velar cognates except for the pair /a/-/o/ for /g/ in pre-therapy assessment. This led to the conclusion that /a/ was the most significant facilitating vowel context for the target phonemes /k/ and /g/. The statistical significance of vowel /a/ is evident in Figures 4.1 and 4.2 for P1, Figures 4.3 and 4.4 for P2, Figures 4.5 and 4.6 for P3, Figures 4.7 and 4.8 for P4, Figures 4.9 and 4.10 for P5 and Figures 4.11 and 4.12 for P6. Visual inspection of graphical representation of participants also revealed vowel /a/ as the most facilitating vowel context (Section 4.1).

4.2.2. Velar production across articulation therapy sessions

Median scores determined for pre-therapy, mid-therapy and post-therapy assessments across the vowel contexts for the target phonemes /k/ and /g/ revealed that there was an improvement observed across the therapy assessments (Table 4.5).

Overall significant difference across pre-therapy, mid-therapy and post-therapy assessments was made for all the five vowels and target velars using Friedman test. Analysis of results from table 4.8 revealed a significant difference across the three assessments for both the target phonemes at $p<0.05$.

Table 4.8

Comparison of median scores across pre-therapy, mid-therapy and post-therapy assessments for the five vowels for /k/ and /g/ using Friedman test

Phonemes	**Vowel contexts**	$\chi^2(2)$	**p value***
/k/	/a/	11.143	0.004
	/i/	9.333	0.009
	/u/	8.273	0.016
	/e/	8.818	0.012
	/o/	10.571	0.005
/g/	/a/	11.200	0.004
	/i/	11.143	0.014
	/u/	10.182	0.004
	/e/	8.588	0.004
	/o/	11.143	0.006

Note. *$p<0.05$

Subsequently, Wilcoxon signed rank test was performed to determine pair wise significant effects for pre-therapy, mid-therapy and post-therapy. The results are represented in table 4.9. Significant effects were observed for pre-therapy vs mid-therapy and pre-therapy vs post-therapy pairs for all the vowel contexts for both the target phonemes except for vowel /u/ and vowel /e/ for phoneme /k/ ($p<0.05$). For mid-therapy vs post-therapy, statistical significance was present only for vowels /i/,

/e/ and /o/ for target phoneme /k/ ($p<0.05$). No significant effects were present for any of the vowel contexts for mid-therapy vs post-therapy for target phoneme /g/.

Table 4.9

Pair wise comparison of median scores across pre-therapy, mid-therapy and post-therapy assessments for the five vowels for /k/ and /g/ using Wilcoxon signed rank test

Phoneme	**Vowel context**	**Pre-therapy vs mid-therapy**		**Mid-therapy vs post-therapy**		**Pre-therapy vs post-therapy**	
		|Z|	**p value ($p<0.05$)**	**|Z|**	**p value ($p<0.05$)**	**|Z|**	**p value ($p<0.05$)**
/k/	/a/	2.214	0.027	1.633	0.102*	2.214	0.027
	/i/	2.003	0.045	2.041	0.041	2.041	0.041
	/u/	1.826	0.068*	2.070	0.038	2.214	0.027
	/e/	1.604	0.109*	2.236	0.025	2.032	0.042
	/o/	2.220	0.026	1.414	0.157*	2.041	0.041
/g/	/a/	2.232	0.026	1.414	0.157*	2.232	0.026
	/i/	2.271	0.023	1.732	0.083*	2.232	0.026
	/u/	2.232	0.026	1.134	0.257*	2.226	0.026
	/e/	2.000	0.046	1.732	0.083*	2.070	0.038
	/o/	2.232	0.026	1.633	0.102*	2.207	0.027

Note. *No significant difference

4.3 Percent Intelligibility Scores

Intelligibility scores were calculated before initiation of therapy and on termination of therapy. Four real words (2 each for /k/ and /g/) from Malayalam Articulation Test- Revised (Neenu, Vipina, Vrinda & Sreedevi, 2011) were used to calculate intelligibility scores. Recorded samples of the participants were provided to three judges for rating intelligibility. The production of these real words by the six

participants was rated by three judges who were unfamiliar with the test words. Average percentage of the three judges served as intelligibility score for each of the participant. It was apparent from Figure 4.13 that there was a difference across pre-therapy and post-therapy intelligibility scores in all the participants except P3.

The difference in intelligibility was only marginal across the pre and post-therapy assessments. This is because the test words used for intelligibility rating are real words wherein the participants had misarticulation of other phonemes in the same word. For example, there was error production of retroflex/ clusters etc. Also complexity of the real words reduced the scope for large gain in post-therapy intelligibility scores. The current study targeted only the velars with bisyllabic non-words. These non words included only the bilabial /p/ in addition to the target velar cognates. Bilabial /p/ is an early acquiring visible consonant with least restriction to the movement of the tongue.

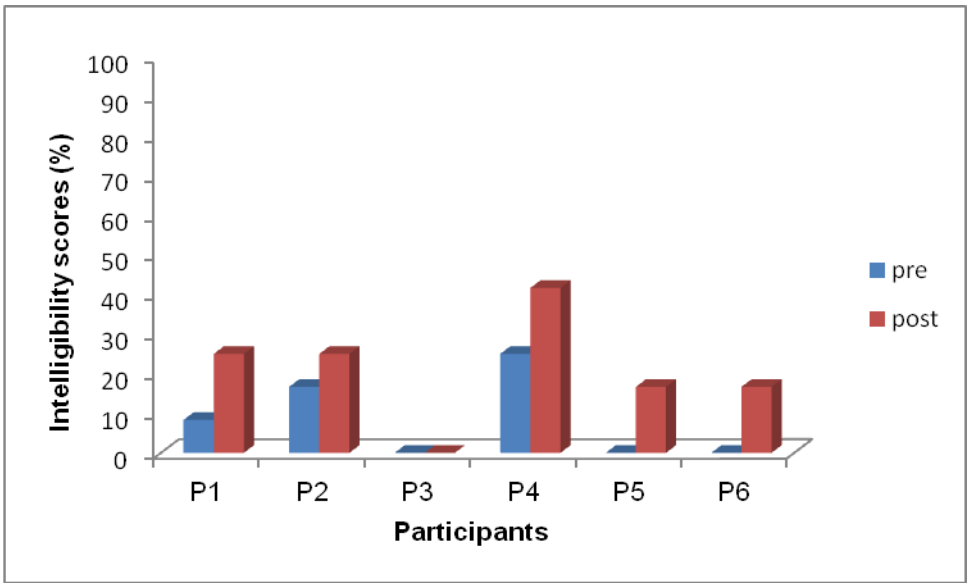

Figure 4.13. Comparison of Intelligibility scores in percentage for pre-therapy and post-therapy assessment

To summarize, vowel /a/ was observed to be the most facilitating vowel context for the acquisition of target velar phonemes /k/ and /g/ in children with hearing impairment. Additionally, children were able to correctly produce velar cognates better in vowel harmonized environment compared to non- harmonized set. Also, the participants learnt /k/ more easily than its voiced cognate /g/.

Chapter 5

Summary and Conclusions

Intelligible speech is vital for effective communication. Misarticulations present in individuals with hearing impairment compromises their speech intelligibility severely. Literature reports of various key environments for effective production of erred sounds. However, only few studies have reported the use of such facilitative contexts (Krishna & Manjula, 1991; Stringfellow & McLeod, 1994; Bauman-Wangler, 2012). Much of the research focuses majorly on facilitatory effects of phoneme position. There is dearth of research in this area in the Indian context, particularly in hearing impairment. Hence, the present study aimed at identifying the facilitatory vowel contexts for correct production of velar cognates /k/ and /g/ in Malayalam speaking children with hearing impairment.

Six participants in the age range of 3-to-7 years with hearing impairment and misarticulations of velars /k/ and /g/ were recruited for the study. Phonetic placement was utilized for intervention. The stimuli used were bisyllabic non-words (vowel harmonized and non- harmonized). The children were assessed three times. Pre-therapy assessment was conducted before initiation of articulation therapy, a mid-therapy assessment during therapy and a post-therapy assessment on termination of therapy. The results were subjected to statistical analysis and also graphically illustrated. The intelligibility scores were also calculated pre and post-therapy using real words from Malayalam Articulation Test- Revised (Neenu, Vipina, Vrinda & Sreedevi, 2011).

The velar phonemes /k/ and /g/ were acquired in the context of vowel /a/ in all the six participants leading to a conclusion that vowel /a/ was the most facilitating context. This was reasoned out through a physiological study by Irfana (2017) in

Malayalam, vowel /a/ provided least coarticulation resistance with velars. Also, it is a frequently occurring phoneme in Malayalam (Irfana & Sreedevi, 2013) and is acquired very early by typically developing children. Statistical analysis across the vowel contexts in three assessments also revealed vowel /a/ to be the most facilitating context. Vowel /e/ was observed to be the least facilitating context. The second most facilitating context was found to be different across participants and it varied from vowel /i/ to vowel /o/.

All the participants were able to produce the target phoneme with ease in the vowel harmonized set in contrast to non-harmonized set. This may be due to the better coarticulatory influence of same vowels in the harmonized set. Also, the participants learnt /k/ easier than /g/, the reason possibly being that /k/ is the most frequently occurring phoneme in Malayalam (Irfana & Sreedevi, 2013).

The intelligibility scores showed only minor improvement across pre-therapy and post-therapy assessments. The real words used for scoring intelligibility had phonemes which were misarticulated by the children. Furthermore, the complexity of the words also compromised the intelligibility scores.

Studies exploring facilitative contexts for correct speech production can effectively guide speech language pathologists to carry out effective intervention for children with various communication disorders. This can also help device a systematic procedure for articulation therapy which can reduce the duration of intervention and ensure speedy improvement.

Limitations of the study

1. The stimuli considered for intervention of participants were non-words.
2. The intelligibility scores are based on less number of words.

3. Findings cannot be generalized to all children with hearing impairment

Future directions

1. Future research can consider real words for intervention.
2. Generalization from non-words to real words can be researched upon.
3. Post-intervention measures can be carried out few months after termination of therapy to ensure maintenance of the target phoneme acquired in real words.
4. Similar study can be carried out in other child language disorders and different languages.

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Appendix 1

Set 1- Vowel Harmonized

Vowel Harmonized set for /k/	Vowel Harmonized set for /g/
/ka/- /pa/	/ga/- /pa/
/ki/- /pi/	/gi/- /pi/
/ku/- /pu/	/gu/- /pu/
/ke/- /pe/	/ge/- /pe/
/ko/- /po/	/go/- /po/
Total = 5	**Total = 5**

Set 2- Vowel Non –Harmonized

Vowel Non-Harmonized set for /k/	
Vowel- /a/	
/ka/- /pi/	/pi/- /ka/
/ka/- /pu/	/pu/- /ka/
/ka/- /po/	/po/- /ka/
/ka/- /pe/	/pe/- /ka/
Vowel- /i/	
/ki/- /pa/	/pa/- /ki/
/ki/- /pu/	/pu/- /ki/
/ki/- /po/	/po/- /ki/
/ki/- /pe/	/pe/- /ki/
Vowel- /u/	
/ku/- /pa/	/pa/- /ku/
/ku/- /pi/	/pi/- /ku/

/ku/- /po/	/po/- /ku/
/ku/- /pe/	/pe/- /ku/
Vowel- /e/	
/ke/- /pa/	/pa/- /ke/
/ke/- /pi/	/pi/- /ke/
/ke/- /pu/	/pu/- /ke/
/ke/- /pe/	/pe/- /ke/
Vowel- /o/	
/ko/- /pa/	/pa/- /ko/
/ko/- /pi/	/pi/- /ko/
/ko/- /pu/	/pu/- /ko/
/ko/- /pe/	/pe/- /ko/
Total = 8 x 5 = 40	
Total = 45 stimuli for /k/ phoneme	

Vowel Non-Harmonized set for /g/	
Vowel- /a/	
/ga/- /pi/	/pi/- /ga/
/ga/- /pu/	/pu/- /ga/
/ga/- /po/	/po/- /ga/
/ga/- /pe/	/pe/- /ga/
Vowel- /i/	
/gi/- /pa/	/pa/- /gi/
/gi/- /pu/	/pu/- /gi/
/gi/- /po/	/po/- /gi/
/gi/- /pe/	/pe/- /gi/

Vowel- /u/		
	/gu/- /pa/	/pa/- /gu/
	/gu/- /pi/	/pi/- /gu/
	/gu/- /po/	/po/- /gu/
	/gu/- /pe/	/pe/- /gu/
Vowel- /e/		
	/ge/- /pa/	/pa/- /ge/
	/ge/- /pi/	/pi/- /ge/
	/ge/- /pu/	/pu/- /ge/
	/ge/- /pe/	/pe/- /ge/
Vowel- /o/		
	/go/- /pa/	/pa/- /go/
	/go/- /pi/	/pi/- /go/
	/go/- /pu/	/pu/- /go/
	/go/- /pe/	/pe/- /go/
Total = 8 x 5 = 40		
Total = 45 stimuli for /g/ phoneme		

Appendix 2

Vowel harmonized for /k/- Set I

/ka/- /pa/
/ka/- /pi/
/ka/- /pu/
/ka/- /pe/

Vowel non-harmonized for /k/- Set II

/ka/- /pi/	/pi/- /ka/	/ki/- /pa/	/pa/- /ki/
/ka/- /pu/	/pu/- /ka/	/ki/- /pu/	/pu/- /ki/
/ka/- /po/	/po/- /ka/	/ki/- /po/	/po/- /ki/
/ka/- /pe/	/pe/- /ka/	/ki/- /pe/	/pe/- /ki/

Vowel non-harmonized for /k/- Set II

/ku/- /pa/	/pa/- /ku/	/ke/- /pa/	/pa/- /ke/
/ku/- /pi/	/pi/- /ku/	/ke/- /pi/	/pi/- /ke/
/ku/- /po/	/po/- /ku/	/ke/- /pu/	/pu/- /ke/
/ku/- /pe/	/pe/- /ku/	/ke/- /pe/	/pe/- /ke/

Vowel harmonized for /k/- Set II

/ko/- /pa/	/pa/- /ko/
/ko/- /pi/	/pi/- /ko/
/ko/- /pu/	/pu/- /ko/
/ko/- /pe/	/pe/- /ko/

Vowel harmonized for /g/- Set I

/ga/- /pa/
/gi/- /pi/
/gu/- /pu/
/ge/- /pe/

Vowel non-harmonized for /g/- Set II

/ga/- /pi/	/pi/- /ga/	/gi/- /pa/	/pa/- /gi/
/ga/- /pu/	/pu/- /ga/	/gi/- /pu/	/pu/- /gi/
/ga/- /po/	/po/- /ga/	/gi/- /po/	/po/- /gi/
/ga/- /pe/	/pe/- /ga/	/gi/- /pe/	/pe/- /gi/

Vowel non-harmonized for /g/- Set II

/gu/- /pa/	/pa/- /gu/	/ge/- /pa/	/pa/- /ge/
/gu/- /pi/	/pi/- /gu/	/ge/- /pi/	/pi/- /ge/
/gu/- /po/	/po/- /gu/	/ge/- /pu/	/pu/- /ge/
/gu/- /pe/	/pe/- /gu/	/ge/- /pe/	/pe/- /ge/

Vowel non- harmonized for /g/- Set II

/go/- /pa/	/pa/- /go/
/go/- /pi/	/pi/- /go/
/go/- /pu/	/pu/- /go/
/go/- /pe/	/pe/- /go/