



Development and standardization of Assamese photo articulation test

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Abstract

The articulation development follows an orderly sequence and it advances with the increase in age. Developmental articulation errors like simplification of one sound by another may occur and be accepted with the developmental period. Articulatory abilities and speech sound acquisition in Assamese has not been studied so far as per available literature and also there is no standard measure to evaluate articulation skills in Assamese-speaking children thus there is a need to develop and standardize articulation test in Assamese.

The present study aimed to develop and standardize the Photo Articulation Test in Assamese by establishing norms of mastery of phonemes in typically developing Assamese-speaking children in the age range of 3-7 years. A total of 240 typically developing Assamese-speaking children were considered participants in this study from different districts of the state of Assam in North-Eastern India.

Participants were equally divided into 8 age groups with equal gender distribution and with an age interval of six months in each group. The tool was

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developed in six stages i.e., Selection of words, Familiarization of the words, Preparation of the final list, Selection of pictures, Test administration, Scoring, and Statistical Analysis. Mastery of the respective phonemes was determined by 100% accuracy using PCC (Percentage Correct Scores), age and gender effect, error patterns, acquisition of clusters were also inquired into. The collected data were analyzed descriptively to find out the Mean Articulatory Score, Mean Score, and statistical analysis was done by using SPSS version 25.0.

It may be concluded that among the phonemes of the Assamese language, the stops, glides, bilabials, and velars were the sounds achieved at a very early age along with glottal fricatives and affricates. Comparing the present study with the Western and Indian studies, most of the findings are well correlated and agrees with the findings of the present study. Thus, it may be inferred that the developed Photo Articulation Test may be a useful clinical tool for the assessment and therapeutic management of speech sound disorders (articulation and phonological disorders) in the Assamese population.

Keywords: articulation test, language, development, Assamese, children

1. Introduction

Human communication is the process of interaction among people using various ways or methods and humans can communicate complex ideas, information using verbal and non-verbal information. Language is also a system in which rules or regularities guide which coded symbols may be combined with other symbols and in what order and what symbols can be used in what situations. Speech is a system in the sense that it consistently and usefully relates the meanings of a language with the sounds by which the language is communicated. More formally, language may be described as an arbitrary system of signs or symbols used according to prescribed rules to convey meaning within a linguistic community. An important point is that language is the code, whereas speech is the sensorimotor production of that code. Speech is the oral expression of language involving the sensorimotor processes by which language users reproduce the coded symbols that are stored in their central nervous systems so that others can hear the symbols. The respiratory system contributes greatly to the production of speech. Speech acquisition is a complex process, one that involves learning a language (its syntax, semantics, and phonology)—a speech code that relates meaning to sound, and a motor skill by which the speech organs are controlled to produce rapid and overlapping movements. Speech sound development involves a time-dependent mastery of the motor responses (Winitz, 1969). A speaker's intelligibility can be affected by articulatory, phonological, suprasegmental, and other linguistic features.

There are factors, i.e. socio-economic status, intelligence, gender, structural, physiologic, and neurological factors, and organic factors which cause articulation disorder that needs to rule out by using a sufficient assessment battery or articulation test. Careful assessment is essential to understand phonological development and its disorder. Articulation errors may be depending on types and phoneme combinations. To rule out abnormal articulation from normal articulation, it is important to know the stages of normal development in the acquisition of phonological skills. There are different types of articulation tests to elicit responses from speech



samples recorded or collected. Four types of articulation tests are mainly administered for ruling out articulation and phonological disorders, i.e., 1. Screening test, 2. Diagnostic Articulation Test, 3. Deep Test of Articulation, 4. Predictive Screening Test.

Misarticulation occurs due to various factors, which hindered the correct production of speech sounds deviating from the normal developmental pattern. The most common misarticulated sounds hindered the correct production of speech sounds deviating from the normal developmental pattern.

Language is always a determining factor in articulation assessment and it is always best to use the L1 or first language for assessing skills such as articulation especially when estimating development trends. Despite similarities in their phonological systems, languages differ in the level of phonetic implementation. Since each language has its phonological system as well as phonological rules, assessment tools should be language specific to correctly reflect articulation and phonological patterns in each language. In a multilingual country like India, a greater necessity arises for articulation tests in various Indian languages.

Over the years, many investigators have tried to determine approximate ages of individual sound mastery in specific groups of children. Wellman (1931) reported norms on 204 children ranging from 2-6 years of age and found mastery of sounds was assigned to the age levels at which at least 75% of the children mastered them in all three positions in words.

Sander (1972) reported that the articulatory development can be presented according to “the age of customary production” (the age at which 50 % of the children tested produced the sound correctly in at least two positions) and “age of mastery production” (the age which 90% of the children produced correctly in all three positions).

Prather, Hendrick and Kern (1975) were among the one who studied the articulation skills of 147 children in age range of 24 to 48 months by using the Sequential Inventory of Communication Development (SIDC) and reported that mastery of sound was obtained by correct usage of 75% or more in two positions.

MacNeilage and Davis (1990) conducted a study on vowel acquisition and reported that despite a relatively precious rate of vocabulary acquisition over the period from 14 to 20 months, the subjects studied produced less than 60% of vowels correctly according to the evidence from phonetic transcriptions.

Levelt et al. (2000) examined syllable structure development in longitudinal data from 12 children learning Dutch (1.0 – 1.11 years at the outset of their study) and found that nine of the children acquired CVCC syllable structures before CCVC structures, while the remaining three children showed the reverse order of acquisition.

Thirumalai (1972) has described some aspects of acquisition of Tamil phonology of a boy who was 4.4 years. The study indicated that the child had acquired all the stop consonants, nasals and laterals present in adult Tamil phonology.

Sreedevi (1976) studied the acquisition aspects of Kannada on four children (two boys and two girls) in the age range of 2 - 3.5 and 2 - 11.5

years. The results indicated that among the consonants, the stop consonants were acquired more fully than sibilants, trills and laterals.

Banik (1988) conducted a study on screening test of articulation and discrimination on 165 Bengali speaking school going children in the age range of 2 - 8 years and conclude that results indicated that there was a definite pattern in the acquisition of articulation. All the vowels were acquired by 2.5 years. Most of the consonants were acquired by 3 years except fricative /ʃ/, flap /r/, trill /r/ and some of the clusters like /kr/, /ksha/, /sra/, /gl/, /bra/, /st/, /skr/.

Divya (2010) studied the articulatory acquisition in Malayalam to obtain the current norms for the Malayalam Articulation Test (Maya, 1990) in the age range of 2 -3 years and to establish the ages at which 75% and 90% of the children produced the phonemes of Malayalam correctly and concluded that the vowels tested were found to be acquired by the age of 2.3 years itself. The exception was /u/ and /u:/ which reached 90% criteria by the age of 2.6 years. Consonants such as /ŋ/, /n/, /b/, /m/, /p/, /-nt/, /-t/, /-nth/, /-cj/, /-nd/ and /ʃ/ were acquired by 90 % of the children in all the positions tested by the age of 2.3 years itself. By the age of three years, the phonemes /k/, /dʒ/, palatal nasal /ɲ/, /g/, /v/, /-t̪v/, /l/, /t/, /d/, /t/, /d̪/, /j/, /ʃh/, /-nk/, /t̪h/ and /t̪/ were also acquired in all the positions tested by 90% of the children. None of the clusters reached the 75% criteria by the age of 3 years however one boy in the age range of 2.9 to 3 years produced /t̪ra/, /s̪ta/ and /ska/ correctly in the medial position.

Raj (2012) developed the Hindi Photo-articulation Test by administering it on 120 typically developing native Hindi speaking children of 3-7 years and concluded that the vowels and consonants like /k/, /kh/, /g/, /ʃ/, /dʒ/, /dʒh/, /t/, /d/, /ŋ/, /t̪/, /d̪/, /n/, /p/, /b/, /m/, /j/, /l/, /w/, /h/, and /gj/ were mastered by children of 3 - 4 years of age.

Chanu (2013) developed Manipuri Picture Articulation test by administering it on 160 typically developing Manipuri speaking children in the age range of 3-7 years divided in 8 groups with the age interval of six months. It was found that vowels were acquired by 3 years of age and consonantal phonemes such as /h/, /j/, /w/, /m/, /n/ and /b/ were easiest and had accuracy of 90% or even more in the age group of 3-4 years of age.

There is no standardized measure to evaluate articulatory skills and phonemic acquisition in Assamese. Hence, there is a great need to develop and standardize articulation test in Assamese and also to develop norms for acquisition of Assamese phonemes.

The present study aimed to develop and standardize the Photo Articulation Test in Assamese by establishing norms of mastery of phonemes in typically developing Assamese-speaking children in the age range of 3-7 years consisting of all Assamese phonemes and establish the age of acquisition of Assamese phonemes in the respective population.

2. Methodology

2.1. Participants

The participants of the study consisted of 240 children typically developing Assamese children in the age range of 3-7 years belonging to



middle socio-economic status. All the participants attended preschool and primary schools situated in rural and urban areas of Assam. The inclusion criteria of the study are the inclusion of children from middle socio-economic status, adequate speech and language stimulation received by the parents, absence of any structural or functional oro-motor deformity or abnormality, and all the developmental aspects of the children were normal when assessed with a developmental and cognitive checklist.

Participants were equally divided into eight age groups with an age range of six months intervals in each group. Participants consisted of children within the following age ranges: Group I: 3.1-3.6 years, Group II 3.7-4 years, Group III: 4.1-4.6 years, Group IV:4.7-5 years, Group V:5.1-5.6 years, Group VI:5.7-6 years, Group VII:6.1-6.6 years, Group VIII:6.7-7 years. Each group consisted of 30 participants with equal gender distribution (15 girls and 15 boys).

2.2. Data collection and processing

Data were collected from the Assamese-speaking children of pre-schools and primary schools from the urban and rural areas of different districts of Assam from middle socio-economic status were included based on the scores of modified Kuppuswamy Socio-Economy Scale taken from the parents, which revealed background information regarding family income and socio-economic status of the children. Inclusion criteria were set as age-adequate speech and language skills, no observable functional or structural deficits in the articulators or facial structures.

The articulation tool was developed in the following six steps; that is, selection of words, familiarization of words, preparation of final list, selection of picture (culturally sensitive), test administration by scoring (1=correct response, 0=no response/incorrect response) the responses in typically developing children in Assamese population.

2.2.1. Selection of words

Corpora of 500 words were selected from Assamese textbooks belonging to kindergarten and pre-primary classes to represent These words needed to have the target phoneme's initial, medial, and final position within the limits of Assamese Language.

2.2.2. Familiarization of the words

These words were given to 10 native Assamese speakers and 1 Assamese Linguist and 5 Assamese Speech Language Pathologists to check the familiarity of the words. They were asked to rate the words as familiar or unfamiliar based on the familiarity rating scale of "0" as not familiar, "1" as familiar, and "2" as most familiar. These words were further given to two Assamese linguists for selection and analysis of the words based on their frequency of occurrence in the language to which the children were maximally exposed in daily living activities and the surrounding environment. These words contained all the Assamese phonemes in initial, medial, and final positions based on the position of occurrence as permitted by the language. Those words having a familiarity rating of 80% or more as

per native speakers and linguists were included as a part of the final word list.

2.2.3. Preparation of the final list

From the total of 500 words, a familiarity assessment was carried out. A total of 5 teachers were involved in it. The words were provided to teachers for assessment by rating the words in terms of their familiarity on a three-point rating scale of 0, 1 and 2 referring to unfamiliar, fairly-familiar, and most-familiar respectively. Word-wise total score was calculated based on the teachers' ratings and converted into percentage. The words scoring more than 90% were selected and listed separately resulting in an accumulation of 114 words. The list consisted of the words for all consonants, vowels, diphthongs at an initial, medial, and final position as per the language constraint, familiar consonant clusters was also included as per familiarity rating. Consonants, out of which 33 consonants (/k/, /kh/, /g/, /gh/, /ʃ/, /ʃh/, /dʒ/, /dʒh/, /t/, /th/, /d/, /dh/, /n/, /t̪/, /t̪h/, /d̪/, /d̪h/, /n/, /p/, /ph/, /b/, /bh/, /m/, /j/, /r/, /w/, /l/, /v/, /ʃ/, /ʃ/, /x/, /h/, /kʃh/). Out of 33 consonants, 23 consonants were tested in all three positions, and three consonants were tested in only initial and medial (/dʒh/, /bh/, /ʃ/) positions, and one sound (/n/) on initial and final positions. Two consonants, that is, /w/ and /j/ were tested in the medial position and /d/ and /dh/ only in the initial positions and only one consonant /z/ in the final position respectively. Twelve clusters were /-pr-/, /-bl-/, /-tʃ-/, /-dm-/, /-tr-/, /-kr-/, /-ʃk-/, /-chʃ-/, /-ʃl-/, /-rg-/, /-kl-/, /-ʃk-/.

2.2.4. Selection of pictures

Coloured pictures were selected for a word in the final list by standardizing it during the familiarization of the words by the Assamese linguist and SLPs by selecting the most appropriate picture depicting the exact meaning of the words selected and which is culturally sensitive. A total of 114 words for different phonemes at the initial, medial, and final position were prepared for the stimuli which yield 3 cards for each picture card of dimension 3 X 6 inches. All the pictures were selected based on clarity and visibility.

2.2.5. Test Administration

Picture cards were shown to the participants individually in one-to-one situations in a quiet room. The child was asked to name the picture on the card spontaneously. Each card was shown approximately for the duration of 10 seconds. Additional cues were provided when the child failed to respond. The child was asked to repeat the word after the clinician examine it when they failed to name the target picture again. Administration time was approximately 20-25 minutes for each child. Instruction: "I will show you some picture cards; you have to name them spontaneously" 6. Scoring: The data obtained from all the participants were recorded on a phone (iPhone XR) and then transcribed using broad and narrow IPA transcription. All the responses of 65 each subject were analyzed sound-by-sound on a response sheet. Correct responses (CR) as well as other kinds of articulatory errors such as substitution, omission, distortion, and addition were also noted



down. A score of "1" was given to each correct response and a score of "0" was given to the error. Finally, the total score for each age group was calculated. Mastery of the phonemes was determined by 100% accuracy and the age at which it reached was also noted down for all the phonemes.

2.3. *Statistical analysis*

The data obtained from the participants of the study were arranged in MS-Excel sheets and further analysed by SPSS version 25.0. 80 % criteria were considered for calculating the mastery of the vowels, consonants and clusters in the respective positions (initial, medial and final). The articulation scores of the participants were represented as Mean (+SD) in the respective age groups for males and females. Representation of the same was done in percentages and bar graphs. One-way ANOVA was performed to check if the mean scores of articulatory acquisitions differed significantly across age and gender. Reliability was assessed by re-administration of the test in the interval of 2 weeks and further finding the product-movement co-relation of the newly obtained scores with previous scores. Validity was checked by applying independent t-test to check the significant difference between the mean articulatory scores of speech and hearing-impaired group to the control group. Reliability and validity of the test was also performed.

The developed Photo Articulation Test in Assamese consisted of 32 consonants (/k/, /kh/, /g/, /gh/, /ʃ/, /ʃh/, /ɟ/, /ɟh/, /t/, /th/, /d/, /dh/, /ŋ/, /tʃ/, /tʃh/, /dʒ/, /dʒh/, /n/, /p/, /ph/, /b/, /bh/, /m/, /j/, /r/, /l/, /v/, /ʃ/, /ʃ/, /s/, /h/, /kʃh/). Out of 32 consonants, 24 consonants were tested in all three positions, and three consonants were tested in only initial and medial (/ɟh/, /bh/, /ʃ/) positions, and two sounds (/ŋ/) on initial and final positions. Two consonants, that is, /w/ and /j/ were tested in medial position and /d/ and /dh/ only in the initial positions respectively. Twelve consonantal clusters were tested respectively. These clusters were /-pr-/, /-bl-/, /-ts-/, /-dm-/, /-tr-/, /-kr-/, /-ŋf-/, /-chʃ-/, /-sl-/, /-gr-/, /-kl-/, /-sk-/.

3. Findings

Descriptive statistical analysis was undertaken to find out the mean scores and standard deviation (SD) values for vowels, consonants, and clusters.

The summary of mean articulation scores for typically developing Assamese-speaking children in the age range of 3-7 years old using the developed test is presented in the graph which can be inferred from the graph that the mean articulation scores increase with an increase in the age.

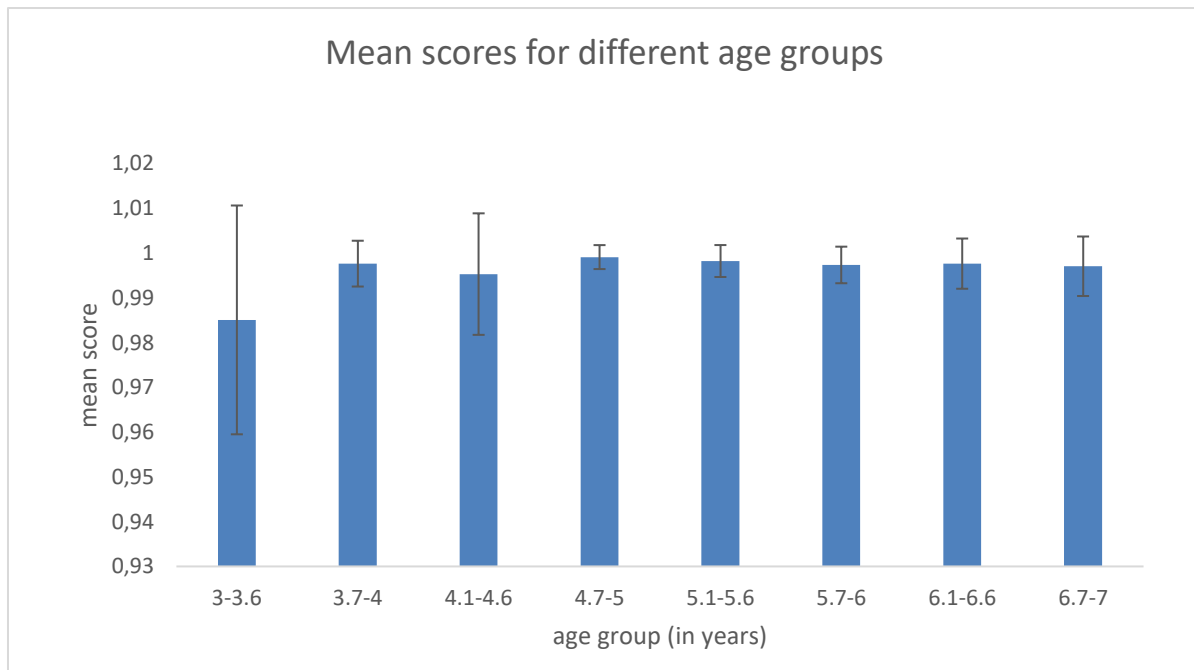


Figure. 1. Mean Articulatory Scores for different age groups (in years)

3.1. Age of acquisition of each phoneme

The performance for each phoneme was analyzed across the groups to investigate the age ranges for the acquisition of different phonemes. The minimum level at which acquisition was thought to start was the level at which the children could produce the phonemes with eighty percent or greater accuracy, and the phonemes were taken to be acquired at the age when the group's phonemes were produced with complete accuracy of 100% correct score, across all word positions. The results are further discussed under vowel acquisition, consonants acquisition and consonants clusters acquisition heading.

3.1.1. Vowel Acquisition

In the present study, Photo Articulation Test in Assamese tests seven vowels i.e., /ə/, /a/, /I/, /i/, /u/, /ε/, /o/. Out of seven vowels, /a/, /I/, /U/, and /ə/ were studied in all three positions. Two vowels /e/ and /o/ were studied in initial and medial. The results indicated that all the vowels had reached 100% criteria by 3 years to 3 years 6 months of age. Similar findings have been reported by Divya (2010). She found that all the vowels in Malayalam were acquired by 90% of children at the age of 3 years. Studies on various Indian languages (Banu, 1977; Usha, 1986; Padmaja, 1988; Banik, 1988; Maya, 1990; Prathima, 2009; Divya, 2010; Usha, 2010; Deepa, 2010) have reported that all the vowels are mastered by three years itself.

3.1.2. Consonant acquisition

The developed test consisted of thirty-three consonants. Out of 32 consonants, 24 consonants were tested in all three positions, and three consonants were tested in 72 only in initial and medial positions and two sounds in initial and final positions. Three consonants were tested in the



medial position and two only in the initial positions and one sound only in the final position respectively. The percentage correct score(PCC) for the 32 consonants (/k/, /kh/, /g/, /gh/, /ʃ/, /ʃ h/, /dʒ/, /dʒh/, /t/, /th/, /d/, /dh/, /n/, /t̪/, /t̪ h/, /d̪/, /d̪ h/, /n/, /p/, /ph/, /b/, /bh/, /m/, /z/, /r/, /l/, /w/, /ʃ/, /ʃ/, /x/, /h/, /kʃ h/, /j/) varied in each group. The voiced unaspirated stops (/b/, /d/, /g/) and the voiced aspirated stops (/bh/, /dh/, /gh/) were found to have an overall accuracy of 100% in all the groups which indicated that the phoneme was already acquired by the age of 3 years. The accuracy of voiced unaspirated and aspirated stops for all the word positions was present by the age of 3 years. The PCC scores of the unvoiced unaspirated stops (/p/, /t/, /k/) in Group-I was 100% which indicates that these phonemes were in the acquisition phase before the age of 3 years and were completely acquired by the age of 3 years respectively. Whereas it was seen that the PCC scores of unvoiced aspirated stops (/ph/, /th/, /kh/) was 100% by the age of 3 years i.e., the unvoiced aspirated stops were acquired by the age of 3 years in all the respective positions. The PCC scores of voiceless alveolar fricative (/ʃ/) in Group 1 was 73.33% which indicates that the acquisition of the respective phoneme was started by the age of 3 years and then only acquired by the age of 4 years as the PCC scores in the Group 2 was 100% in all the respective positions except in final position with 86.67% but it achieved the criterion of 80%. The PCC scores of the voiced alveolar fricative (/z/) and voiced glottal fricative (/h/) were 100% by the age of 3 years concluding that the 32 respective phonemes were already acquired by the age of 3 ½ years in all the positions respectively. The acquisition of the aspirated stop (/kʃ h/), PCC score was 100% indicating that the acquisition began before the age of 3 years and was acquired by the age of 3 ½ years in all the positions. For the liquid /l/, 100% accuracy was observed in all the eight groups and it was completely achieved 100% by the age of 3 ½ years concerning all the positions. For the trill /r/, the acquisition began at an early age of 3 years and was completely achieved by the age of 3 ½ years as the PCC score was 100%. For the glides (/j/, /w/), the PCC scores were 100% in all the age groups and the acquisition was already completed by the age of 3 years in all the positions. The dental (/t̪/, /d̪/, /d̪ h/), PCC scores were present at the age of 3 years with an accuracy of 100% which concludes that the acquisition of the dental sounds started by the age of 3 years was acquired by the age of 3 ½ years in all the positions. In the case of nasal sounds, /m/, /n/, and /ŋ/ (which occur independently of homographic consonants in Assamese but do not occur in word-initial position), PCC scores were present at the age of 3 years with the accuracy of 100%. The acquisition of all the nasal sounds started by the age of 3 years and the ceiling effect was seen for all the groups i.e., the sounds were acquired before the age of 3 years 6 months in all the positions. For the affricates (/ʃ/, /ʃ h/, /dʒ/, /dʒh/), it was observed that the mastery of these phonemes was observed by the age of 3 years as the PCC scores were 100% in all the respective positions, thus concluding that the acquisition completed by the age of 3 ½ years. For glottal fricative /h/, the age of acquisition is 3 years because the PCC scores across all the age groups were 100% in all the age groups and acquisition began by the age of 3 years. It may be concluded that among the phonemes of the Assamese language, the

stops, glides, bilabials, velars were the sounds easily achieved at a very early age along with glottal fricative /h/ and affricates. The phoneme /x/ is exclusively present in the Assamese language. The acquisition of /x/ begins before 3 years of age and it is completely acquired by the age of 3 ½ years with the accuracy of 100%. The voiceless and voiced fricatives were achieved at an early age but it was evident from the data that the acquisition was better in the older age groups.

Table 1

Age-wise acquisition of different consonants in Assamese based on PCC

Sound	3-3½ years %	3yrs. 7mths-4-yrs %	4yrs. 1mth-4½yrs %	4yrs 7 months-5years	5yrs1m-5 ½ years %	5.7yrs-6 Years %	6yrs1m-6 ½ years %	6yrs7m-7 years %
Stops								
/k/	100	100	100	100	100	100	100	100
/kh/	100	100	100	100	100	100	100	100
/g/	100	100	100	100	100	100	100	100
/gh/	100	100	100	100	100	100	100	100
/t/	100	100	100	100	100	100	100	100
/th/	100	100	100	100	100	100	100	100
/d/	100	100	100	100	100	100	100	100
/dh/	100	100	100	100	100	100	100	100
/p/	100	100	100	100	100	100	100	100
/ph/	100	100	100	100	100	100	100	100
/b/	100	100	100	100	100	100	100	100
/bh/	100	100	100	100	100	100	100	100
/t̪/	100	100	100	100	100	100	100	100
/th̪/	100	100	100	100	100	100	100	100
/d̪/	100	100	100	100	100	100	100	100
/dh̪/	100	100	100	100	100	100	100	100
/d/	100	100	100	100	100	100	100	100
Fricatives								
/f/	100	100	100	100	100	100	100	100
/ʃ/	73.33	100	100	100	100	100	100	100
/x/	100	100	100	100	100	100	100	100
/h/	100	100	100	100	100	100	100	100
Affricates								
/tʃ/	100	100	100	100	100	100	100	100
/dʒ/	100	100	100	100	100	100	100	100
/dʒh/	100	100	100	100	100	100	100	100
Nasals								
/m/	100	100	100	100	100	100	100	100
/n/	100	100	100	100	100	100	100	100
/ŋ/	100	100	100	100	100	100	100	100
Lateral								
/l/	100	100	100	100	100	100	100	100
Trill								
/r/	100	100	100	100	100	100	100	100
Glide								
/j/	100	100	100	100	100	100	100	100
/w/	100	100	100	100	100	100	100	100
Compound consonants								
/kʃh/	100	100	100	100	100	100	100	100



3.1.3. Acquisition of clusters

The acquisition of cluster sounds was not analyzed in detail as the acquisition of clusters was not part of the objective of the present study. However, the twelve most commonly occurring clusters were tested in different positions, that is, /-pr-/, /-bl-/, /-ts-/, /-dm-/, /-tr-/, /-kr-/, /-nj-/, /-chj-/, /-sl-/, /-gr-/, /-kl-/, /-sk-/. It was observed that all these clusters were achieved fully by the age of 3 years except /-pr-/, /-bl-/, /-tr-/, /-kr-/, /-sk-/ which were achieved by the age of 4 years and was also observed that the dialectical variation also contributed to the production of the clusters.

3.2. Error Patterns

The error patterns across the respective age groups when analyzed found that the error pattern seen in younger children was mostly distortion and omission which was primarily present in the final position of the word. Considering the error pattern across the phoneme positions, it was found that the sounds were first acquired in the initial and medial positions and then acquired in the final position. Final consonant deletion, epenthesis, fronting, and devoicing were observed as the most commonly occurring phonological processes. None of the children exhibited any other kind of errors but in the case of clusters, the presence of distortion was dominant in the lower age groups and there were dialectical influences in some clusters.

3.3. Age and Gender Effect

One-way ANOVA was carried out to see the age and gender effect concerning the articulatory acquisition. In terms of age, the p-value was found to be 0.000, which showed a significant difference {df=7, F=5.017, (p < 0.05)} across different age groups. Result of one-way ANOVA indicated a significant difference between the mean articulatory scores for males and females of different age groups, p-value 0.001 {df=15, F=2.805, (p < 0.05)}, depicting that there is a significant difference between the mean articulatory scores among the participants of different groups when age and gender are considered together as base of categorization.

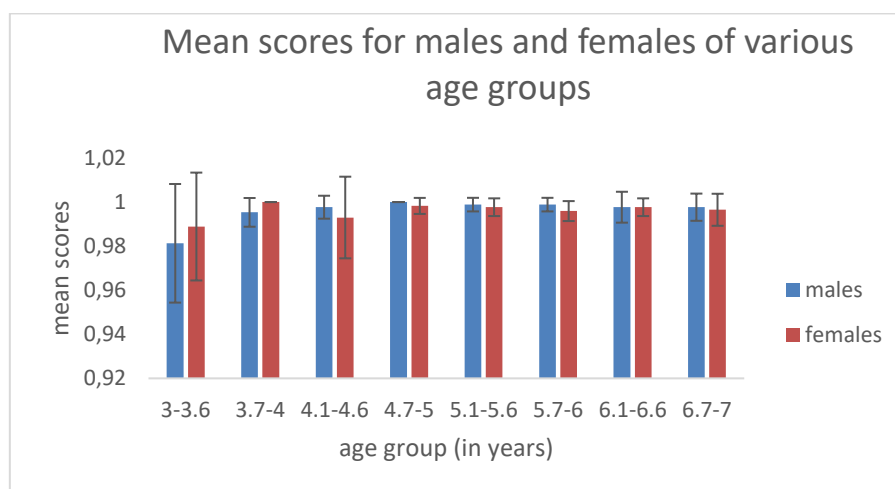


Figure2. Mean Articulatory Scores for different age groups of males and females

3.4. Reliability

The test was re-administered with the interval of 2 weeks on 8 males and 8 females from each group (N=128) and the mean scores were correlated with the mean scores obtained previously. The Product-moment correlation between the scores was found to be $r=0.39$ ($p<0.01$). Furthermore, the average mean score of the subjects from the first and re-administered scores obtained were 0.996 and 0.995 respectively and the t-test conducted showed that there was no significant difference between the first and second trials ($p=0.721$ or $p>0.05$) and thus concluding the developed Assamese Photo Articulation Test to be reliable.

3.5. Validity

The developed test was administered to five participants with bilateral severe hearing loss of age ranging from 5 to 7 years. The mean score for these children was significantly different ($p=0.002$ or $p<0.05$) from the normal participants concluding that this test could successfully discriminate between normal and Hearing Impaired populations, thus establishing the validity of the test.

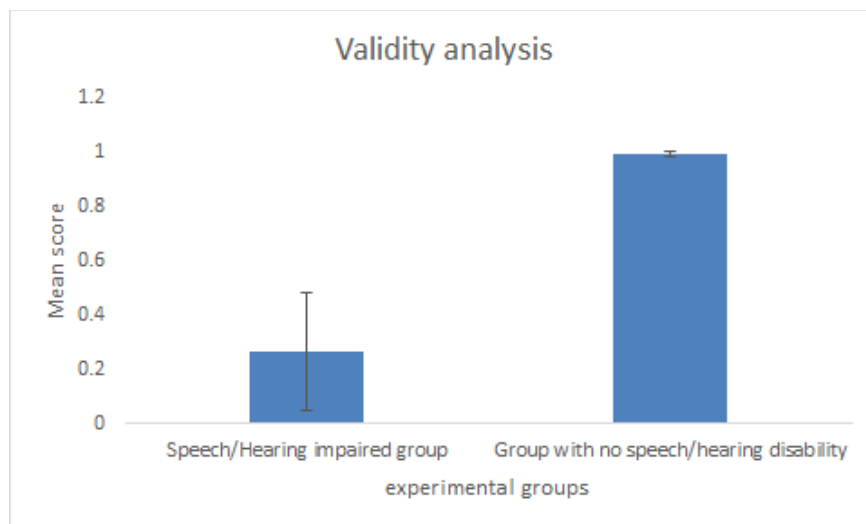


Figure 3. Comparison of Mean Articulatory Scores of Normal children and Hearing Impaired Children

4. Discussion

The result of the present study revealed that the acquisition of speech sounds starts occurring before 3 years of age but almost all the sounds are acquired by 3 years and 6 months of age in Assamese-speaking children. It was also found that the acquisition of the phonemes increases with age and some sounds are acquired before others certain factors like stimulation from the environment, socio-economic status, dialectical variation along with the educational aspects of the children, exposure to gadgets and multi-lingual peers in school and environment; which in turn may facilitate the development of the language. The results of the present study agree with the findings suggested by Wellman (1931); Poole (1934); Templin (1957) & Shankar (1998). Fudala and Reynolds (1986) also suggested that 90% of all



phonemes were achieved by 6 years of age. The cross-linguistic findings of McLeod and Crowe across 27 languages conclude that most consonants were acquired by the age of 5 years but many studies specifically considering the consonant acquisition of typically developing 2-year-old children show their seemingly precocious capacity compared with current benchmarks (McLeod et al., 2001; Nelson & Stoeckel-Gammon, 1985; Watson & Terrel, 2012) which establishes accordance with the present study. Neuromuscular maturity of all motor skills increases as the age advanced as also the articulation skills. The present study of the acquisition of phonemes in the Assamese population indicated an overall age effect which is evident in almost all the studies carried out previously as presented in Table 2. However, no significant difference in age was seen except for Group -1, as the acquisition starts from 3 years of age and is achieved by a 4 years of age with an accuracy of about 90%. Therefore, the ceiling effect was found in the groups except Group-I and Group II.

Table 2
 Comparison of acquisition of speech sounds in different languages

Speech sounds	Banu (1977) Kannada	Minakshi (1997) Kashmiri	Banik (2003) Odia	Raj (2012) Hindi	Chanu (2013) Manipuri	The present study, Assamese (3-7 years) 100% Age in years
/k/	3	3.8	2-3	3-4	3-5	3
/k ^h /		3.8	2-3	3-4	3.5-5.5	3
/g/	3	3.2	4-5	3-4	3-5	3
/g ^h /			4-5	4-5	4.5-6.5	3
/ʃ/	3.7	3.8	3-4	3-4	4-6.5	3
/ʃ ^h /		3.8	3-4	4-5		3
/ɖ/		3.8	4-5	3-4	3.5-6.5	3
/ɖ ^h /			5-6	3-4	5-7	3
/t/		3.8	3-4	3-4	3-4.5	3-4
/t ^h /	3	3.8	3-4	4-5	4-7	3-4
/d/	3.8	3.8	3-4	3-4	3-5.5	3
/d ^h /			3-4	4-5	5-7	3
/ŋ/	-		3-4	3-4	3-5	3
/t̪/		3.2	3-4	3-4		3
/t̪ ^h /	-	3.8	3-4	3-4		3-4
/d̪/			3-4	3-4		4-5
/d̪ ^h /	-	-	-	3-4		3
/n/	3	3.2	3-4	3-4	3-4	3
/p/	3	3.2	3-4	3-4	3-4.5	3-4
/p ^h /		3.2	4-5	4-5	4-6.5	3.6
/b/	3	3.2	2-3	3-4	3-4	3
/b ^h /		4.4	3-4	4-5	4.5-7	4

/m/	3	3.2	2-3	3-4	3-4	3
/j/	3	3.2		3-4	4.5-7	3
/r/	4.6	4.4	7-8	4-5	4-6.5	3-4
/l/	3	3.2	5-6	3-4	3-5	3
/w/				3-4	3-3.5	3
/ʃ/	5.1	4.8	4-5	6-7		3-4
/ʒ/			4-5	6-7		3
/s/or	3	4.8	4-5	5-6	3.5-6	3
/x/						
/h/	-	3.2	4-5	3-4	3-3.5	3
/kʰ/			4-5	6-7		4

5. Conclusion

We may conclude that among the phonemes of the Assamese language, the stops, glides, bilabials, and velars were the sounds achieved at a very early age along with glottal fricative /h/ and affricates. The Assamese language has unique phonemic features i.e., unvoiced velar fricatives /x/ which was acquired at an early age with an accuracy of 100%. The voiceless and voiced fricatives were achieved at an early age but it was evident from the data that the acquisition was better in the older age groups. The results from the present study also provide normative age of articulatory acquisition of speech sounds in Assamese-speaking children in the age ranges of 3-7 years. This data can be further utilized as a baseline for the assessment of articulation and phonological disorders in Assamese-speaking individuals and is an effective clinical tool for accessing articulation skills

Declaration of Competing Interest:

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Conflict of interest

None.

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Appendix

Vowels of Assamese in their respective Initial, Medial and final positions
 Note: A picture representing each word given in the table was used during data elicitation but the pictures are not included here for copyright restrictions. English translation of the same words are provided in the brackets

Vowel sounds	Initial	Medial	Final
/ə/	--	/bəl/(ball)	--
/a/	/am/(mango)	/hah/(duck)	/dʒoʈa/(shoe)
/ɪ/	/Ita/(brick)	/dʒɪb ^h a/ (tongue)	/haɪ̯/(elephant)
/i/	/igl/(eagle)	--	/mak ^h ɪ/ (house fly)
/U/	/Ut/(camel)	/mekUri/(cat)	/gərU/(cow)
/e/	/ek/(one)	/pet/(stomach)	--
/O/	/Oʊʃod ^h / (medicine)	/xOn/(gold)	/ɪOh/(iron)

Consonants of Assamese in their respective Initial, Medial and final positions

Consonants	Initial	Medial	Final
/k/	/kan/(ear)	/bUkU/(chest)	/nak/(nose)
/k ^h /	/k ^h o wa/ (eating)	/mak ^h n/(butter)	/nok ^h /(nail)
/g/	/gərU/(cow)	/bəgOɪ/(stork)	/bəg/(bag)
/g ^h /	/ghorɪ/(watch)	/əgharO/(eleven)	/bag ^h /(tiger)
/ŋ/	/dɪŋɪ/(neck)	--	/lan/(clove)
/tʃ/	/tʃUɪ/(hair)	/p ^h əʈʃa/(owl)	/kəʃɪ/(scissor)
/tʃ ^h /	/tʃ ^h agOɪ/(goat)	/gamOʃ ^h a/(towel)	/mOʃ ^h /(beard)
/dʒ/	/dʒɪb ^h a/(tongue)	/gadʒr/(carrot)	/tərmUdʒ/ (water melon)
/dʒ ^h /	/dʒ ^h arU/(broom)	--	/madʒ ^h ɪ/ (fisherman)
/t/	/tUpOnɪ/(sleep)	/Ita/(brick)	/kaɪt/(fishbone)
/t ^h /	/t ^h əɛla/(hand cart)	/mɪt ^h aɪ/(sweets)	/at/(eight)
/d/	/dawr/(fog)	--	--
/d ^h /	/d ^h Oɪ/(drum)	--	--
/n/	/nak/(nose)	/konɪ/(egg)	/kɪ ^h ɪn/(thin)
/t̪/	/t̪amOɪ/(betel nut)	/aɪ̯t̪a/(grandmother)	/d̪at̪/(teeth)
/t̪ ^h /	/t̪ ^h alɪ/(plate)	/prart̪ ^h na/(prayer)	/pət̪ ^h /(path)
/d̪/	/d̪at̪/(teeth)	/bad̪am/(peanut)	/rOd̪/(sunlight)

/d̪h/	/d̪hənU/(bow)	/xad̪hU/(saint)	/kand̪h/ (shoulder)
/p/	/pIt̪ha/(pie)	/kəpal/(forehead)	/kIt̪ap/(book)
/p ^h /	/p ^h UI/(flower)	/xOp ^h a/(sofa)	/barap ^h /(ice)
/b/	/baltI/(bucket)	/gUbar/(cow dung)	/garib/(poor)
/b ^h /	/b ^h ərI/(leg)	/nab ^h i/(navel)	--
/m/	/maj̪h/(fish)	/rUmal/ (handkerchief)	/am/(mango)
/z/	/zəamət̪I//bak̪f/	/xUr̪zja/	--
/r/	/ranI/(queen)	/t̪arOwal/(sword)	/g ^h ar/(house)
/l/	/larU/ (spherical sweet/ladoo)	/bIlahi/(tomato)	/gal/(cheek)
/w/	--	/dawr/(fog)	--
/ʃ/	/ʃIjal/(fox)	/əʃUr/(devil)	/akaʃ/(sky)
/ʒ/	/ʒar/(ox)	/bərʃUn/(rain)	/məʃ/(sheep)
/x/	/xat̪/(seven)	/t̪Uloxi/(basil)	/man̪xO/(meat)
/h/	/hat̪I/(elephant)	/pahar/(hill)	/t̪Ijah/ (cucumber)
/k̪h/	/k̪h̪in/(thin)	/nək̪h̪tra/(star)	/brik̪h̪ə/(tree)
/j/	--	/xarIja/(mustard)	--

12 consonantal clusters in their respective Initial, Medial and Final positions

Consonantal clusters	Initial	Medial	Final
/-pr-/	/prIt̪wi/(earth)	--	--
/-bl-/	/blaəde/(blade)	--	--
/-ʃw-/	--	/Ut̪ʃaw/(festival)	--
/-d̪m-/	--	--	/pad̪m/ (lotus)
/-tr-/	/traIn/(train)	--	--
/-kr-/	/krIxak/(farmer)	--	--
/-ʃk-/	/ʃkəl/(scale ruler)	--	--
/-nc ^h -/	--	/pənc ^h Il/(pencil)	--
/-chʃ-/	/chʃama/(eyeglasses)	--	--
/-ʃl-/	/ʃləat/(slate)	--	--
/-rg-/	--	/d̪Ur̪ga/(goddess Durga)	--
/-kl-/	/klaʃ/(classroom)	--	--