COMPARING PHONOLOGICAL PROCESSES OF 4 TO 6-YEAR-OLD MONOLINGUAL BANGLA-SPEAKING TYPICALLY DEVELOPING CHILDREN AND CHILDREN WITH COCHLEAR IMPLANTS

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Abstract

Children often simplify adult speech when they start talking by using some sound error patterns known as Phonological Processes (PPs) and those are considered typical until the age of six. However, for some children, these processes do not follow the typical pattern, for example, children with Cochlear Implant (CI) start to hear and develop an understanding of speech sounds after their hearing devices are switched on. CI is known as the most effective sensory prosthesis in the world for Profound Sensory Neural Hearing Loss (SNHL). However, research on the phonological development or phonological processes used by children with CI in Bangladesh is limited. The purpose of this cross-sectional study was to compare the PPs of 4- to 6-year-old Bengali children with CI and TD children; and to find out the unique PPs pattern in children with CI. This study recruited 30 participants aged 4 to 6 years, including 15 children in both TD and CI groups. Data were collected in a twenty-minute recording session using a picture naming task. Then analyzed using Narrow Phonetic Transcription by undertaking the International Phonetic Alphabet (IPA). The results suggested that fewer PPs were found in the TD group than in the CI group, and the early implanted children with CI used fewer PPs than the later implanted peers. Also, three unique processes were found in the CI group- initial consonant deletion, medial consonant deletion, and weak syllable deletion, which were absent in their TD peer.

Keywords: Cochlear Implant, Children with Cochlear Implant, Typically

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Introduction

Phonological Processes' close relation with speech and language development is observed significantly during the initial stages of language acquisition (Roulstone et al., 2002). Examining the PPs provides descriptive-analytical information on the categories of speech errors that children generate (Asad et al., 2018). For children with standard development using PPs is natural and at a particular time they automatically eliminate them (Vollmer, 2020; Bernthal et al., 2017). PPs are assessed so that the language development of a child can be understood and measured. The single-word naming task or the picture naming task is the most used instrument for the assessment of PPs as it is simple and easy to conduct. It is a predetermined list of words so including phonemes of different places and manner of articulation that are the target of the researcher depending on the research interest is easy (Wolk, & Meisler, 1998).

For children with cochlear implants, their PPs may vary from the typical phonological process as they start hearing after their surgery. In SNHL damage to the inner ear or the nerve pathways is found and this creates difficulty in hearing both soft and loud sounds. Children with SNHL can benefit greatly from CI which is commonly utilized when conventional hearing aids are unable to restore the hearing ability of all phonemes (Bradham and Jones 2008). CI is surgically implanted to bypass the normal hearing pathway by directly stimulating the auditory nerve. The majority of deaf persons have had their hearing restored and their speech perception improved because of CI (Boisvert et al. 2020). Approximately 750,000 persons with CI can be found worldwide and about 12,000 children with SNHL receive CI annually in the United States (Cullington et al., 2022; CDC, 2019). Therefore, CI has been the focus of extensive study and development in recent years. Since 2000, there have been over 15,000 publications related to CI reflecting the increased research interest due to the devices' clinical effectiveness and scientific potential (Werfel & Hendricks, 2023). However, the lack of published research on a large number of children affected by speech, language, and other communication disorders in Bangladesh is evident (Nisha, 2019).

The purpose of this study is to determine the PPs of TD and CI 4- to 6-year-old Bangla-speaking children in single-word naming tasks. This is because the single-word naming task is a straightforward and efficient method for collecting speech sound production samples for identifying the PPs (Bernthal et al. 2017). It is hoped that a better understanding of the typical and atypical phonological performance of

Bangla-speaking children may provide a structural framework for the intervention of children with hearing aids.

Cochlear Implant (CI)

The human ear consists of three most defined portions: outer ear, middle ear, and inner ear which contain numerous hair cells. In normal hearing the acoustic signal travels through the ear, then auditory nerve to the brain (Loizou, 1999). The impairment in outer and middle ear is known as conductive hearing loss and mostly they can be compensated using non-surgical hearing aids but when problem occurs in the inner ear, particularly in the cochlea or the hair cells (known as SNHL) then CI is needed. CI is an electronic device that consists an internal and an external part. The internal part is surgically implanted along cochlea and an external part is placed behind the ear. The external part receives the sounds and converts them into electrical impulses, the auditory nerve receives the sound and the electrical impulse travels to the internal part via an electrode array, avoiding the middle and outer ears (Macherey & Carlyon, 2014). Dettman et al. (2016) suggested that the implementation of CI for children under 12 months old can enhance their speech perception, language acquisition, and speech production ability.

Phonological Processes (PPs)

Phonological processes are the phonetic or phonemic changes in the utterances or speech that are present in the classes of sounds or sound positions including substitution, syllable structure, and assimilation (Bernthal et al. 2017; & Vollmer, 2020). They involve breaking up words into phonemes or syllables, removing sounds, and combining single sounds (Stahl & Murray, 1994). Shortening a syllable through syllable structure processes creates an open syllable form (Parker, 2005) such as in Bengali deletion of final consonant ([m̪a.kʰon̪] → [m̪a.kʰo]), cluster reduction ([m̪uk̪.t̪a] → [m̪ub̪.t̪a]), reduplication ([ɦa.d̪u.d̪u] → [ɦa.d̪u.d̪u.d̪u]), and weak syllable deletion. The process of adapting one word sound to become similar to another is known as assimilation ([t̪or.m̪uɻ] → [t̪om̪.m̪uɻ]). In phoneme substitution, a targeted sound in a word is replaced with a different sound that differs in the location or style of articulation (Parker, 2005), for example- gliding of liquids, stopping, and velar fronting. These classifications are important to determine children's progress in phonological development or expressive language development (Flipsen & Parker, 2008). The phonological disorder occurs when a child has not outgrown the PPs past the expected age (Stiene, 2001).

Phonological Processes of TD Children

Children begin to develop non-verbal communication skills before developing verbal communication. They use prelinguistic skills such as pointing and eye contact to communicate with others (Goldin-Meadow, 2014). Children's prelinguistic communication skill acquisition is closely dependent on lexical development and phonemic understanding of language. Most produce words by the age of one year and their phonemic awareness emerges (Childers & Tomasello, 2002). The phrase "Phonemic Awareness" can be used when the phoneme is the level of analysis. The ability to break down words into their phonological forms, manipulate sounds within words, or differentiate one sound from another is a common way to assess phonological awareness (Werfel & Hendricks, 2023). Children learn to understand each phonological unit separately and catch the smallest units of sound (word-syllables-phonemes) as they are growing up (Anthony & Francis, 2005). Thus, PPs emerge through phonological awareness and phonological memory which stores phonemic information and helps to retrieve or use that phonemic information. Common PPs that are produced by young TD children with typical hearing include cluster reduction, reduplication, and final consonant deletion (Bernthal et al. 2017). During the first year of age, children favor low, nonrounded vowels ([i], [e], [ɑ]), and the differences in height in vowels present before the differences of fronting and backing (Asad et al. 2018). This leads production of more nonrounded vowels despite front-back vowels and changes the way of their sound production ultimately resulting in PPs. According to Bowen (1998), children acquire 50%-75% phonological pattern within the age of 3 years and all PPs should have disappeared by 6 years. Vehkavuori et al. (2021), analyzed the connection between early understanding and usage of language of Finnish-speaking TD children with their later expressive and receptive language abilities and pre-literacy skills. They tested the early lexical skills including PPs in children aged 1.6 and 2 years using the FinCDI-SF infant version and toddler version then used the Boston Naming Test to assess the lexicon, phonology, morphology, and pre-literacy skills at age 5 years. The results showed a significant association between PPs with later language abilities and pre-literacy skills. Which emphasizes the significance of PPs in the development of overall verbal language skills.

Phonological Processes and Speech Characteristics of CI Children

Individuals with severe to profound hearing loss use CI to leverage an improved understanding of speech sounds that enable the development and use of linguistic features and increase communication skills (De Vel et al., 2005). CI enhances

children's capability to perceive their speech formulation and acquire a mature phonological scheme (Warner-Czyz et al., 2010) but evidence found that children with CI have systematic phonological systems that include PPs which are present even after the expected age of their omission (Moeller et al., 2010). It is generally agreed upon that children with hearing disorders who obtain early access to hearing aids have a higher chance of developing speech at a similar rate to their typically developing peers (Eriks et al., 2013; Ertmer & Goffman, 2011). Though these investigations suggest improvement in the expressive language of children with auditory difficulties, the phonological development of these children tends to be poorer than that of children with typical hearing (Flipsen & Parker, 2008). Most of the studies revealed that stopping, fronting, final consonant deletion, gliding, weak syllable deletion, and cluster reduction as the most found PPs in CI users (Eriks-Brophy et al., 2013). Also, backing, deletion of the initial consonants, glottal substitution, and errors of vowels were commonly found in CI-using children (Buhler et al., 2007; Doble, 2006). Young children with different degrees of hearing loss (15 to 26 months) have been shown a delayed pattern of vocalizations to those produced by younger typically growing infants (Parker, 2005). Some visible articulatory gestures of speech sounds, like labiodentals, are easier to produce when compared with backstage sounds, like- alveolars for children with hearing impairment (Parker, 2005). Children suffering from severe to profound degrees of hearing loss have poor voice quality, prolongations, substitutions, distortions, hypernasality, and abnormal suprasegmental features (Smith, 1975). Hudgins and Numbers (1942) also found the following errors by studying 192 children aged 8 to 20 years old with hearing loss: vowel insertion, substitutions, and neutralization; initial consonant deletion; final consonant deletion; cluster reduction; denasalization; consonant substitutions; simplification of diphthongs; devoicing of stops. These findings are also similar to recent studies (Huttunen, 2001). The speech intelligibility of the children using CI is better with prolonged use of the hearing device (Tobey et al., 2003). Receiving CI as early as possible helps children acquire expressive language abilities that are often near normal (Chin et al., 2003). Children who had CI implanted before two years of age develop verbal communication skills more accurately (Hammes et al., 2002).

The present study aims to identify and compare the PPs between TD children and children with CI. It places specific emphasis on the difference in PPs used by CI children regarding their cochlear implant time. The following research questions were formulated:

- Which PPs are found in TD children and children with CI between 4 to 6

years old?
- Is there any difference in PPs between TD children and children with CI?
- Is there any difference in PPs regarding CI time?

Methodology

Participants

In total thirty children (15 children with CI and 15 TD children) aged 4 to 6 years participated in this study. To ensure an accurate comparison, children in the TD group were age- and gender-matched with those in the CI group. CI participants were taking speech therapy at Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh; and the National Institute of Ear, Nose, and Throat (ENT), Bangladesh for at least three months. Speech and Language Pathologists (SLPs) as well as the parents of the children provided information regarding the severity of their hearing impairment. All the TD participants were attending Shishutosh Kindergarten & High School in Dhaka city and were fluent in Bangla as their mother tongue. The participant's demographic information is included in Table 1.

Table 1: ***Gender and age of TD children and children with CI***

CI			TD	
Gender	CA	Age at CI	Gender	CA
M	5.5	4.6	M	6.0
M	6.0	4.0	M	4.5
M	5.5	3.6	M	4.5
M	6.0	3.7	M	4.5
M	5.0	3.4	M	4.0
M	5.0	3.0	M	4.5
M	6.0	3.6	M	4.0
F	5.0	3.6	F	5.5
F	6.0	4.0	F	5.5
F	5.0	3.7	F	6.0
F	4.5	3.7	F	6.0
F	5.0	3.0	F	5.0
F	6.0	4.0	F	6.0
F	4.5	2.5	F	4.0

**Note: F=female, M=male, CA=chronological age.*

The considered inclusion criteria for TD participants were: no evidence of speech and language disorders; no evidence of hearing difficulty; monolingual in Bangla; and absence of any kind of significant medical or neurological condition. For CI participants following inclusion criteria were considered: had a congenital hearing impairment (prelingually deaf); were full-time cochlear implant users; were monolingual Bangla speakers; had no cognitive, visual, or developmental delay; had participated in Auditory Verbal Therapy (AVT) sessions at least weekly soon after the switch on of their CI devices and this history was confirmed by their SLPs and their documents that were provided during their assessment. The participants who showed disinterest toward the picture naming task, or were inattentive, and did not answer within ten minutes were excluded from both groups.

Instrumentation and Recording

The researchers used the Picture Naming Task (Annex 1) for data collection. 50 pictures were selected by choosing 16 consonants in Bangla alphabet (/k/,/kʰ/, /g/,/gʱ/, /ɟ/, /ɟʱ /, /c/, /cʰ/, /ʃ/, /t/, /tʰ/, /d/, /dʱ/, /r/, /l/, /t̪ʰ/) in the initial, medial, and final position of words; and three cluster productions (/mukt̪a/, /bʱromɔr/, /gɔndar/). There is no standard tool available in Bangla language to assess the phonological processes of Bangla-speaking children. Therefore, the researchers developed this picture stimulus including 16 phonemes that vary in place and manner of articulation so that insights into the utterance of different places and manner of articulation can be found. All samples were collected in twenty-minute recording sessions and "Sony UX570" voice recorder was used to record the utterances and a diary was maintained to note the unintelligible utterances.

Procedure

Picture naming task (Annex 1) was used in this study and the data were collected from participants in a tranquil setting at the hospital and school in the presence of their parents or SLPs. Each participant was prompted to name the selected pictures shown and the participant's utterances were audio recorded. The whole process was described to the participants and their parents previously. If any child faced any problem recognizing the target pictures, then meaningful cues were provided to enhance the child's responses. Small breaks were allowed if the child wanted to take a break or get bored. A diary was maintained to take short notes about the start and ending time of the data collection, to record significant reactions or impressions that occurred during the data collection, to record the duration and frequency of breaks provided, and most importantly the unintelligible utterances of the

participants. Consent from the participants' SLPs or teachers or parents was taken for audio recording but the children who participated were not informed because that information could make them self-aware or limit their natural way of speaking.

Data Transcription

The data from the single-word naming task were analyzed using narrow transcription relying on standard adult perceptual realization for the targeted stimuli (Wells, 1994), to make a typical and atypical phonetic inventory. The focus was on the analysis of consonant production and the target words were transcribed using the International Phonetic Alphabet (IPA). Before that narrow transcription, broad transcription had already been done. The notes about unintelligible utterances from the diary that were maintained during data collection were helpful in the transcription.

Data Analysis

This study followed a cross-sectional study design. To identify the occurrences of PPs percentage was analyzed and then comparison testing (paired t-test) was run through to check the comparison between the two groups. The Differences in PPs of CI Children regarding CI Time were also compared through paired t-tests. In both tests $p < 0.05$ was the significance level.

Reliability test

The first author initially transcribed the data. To assess the intra-judge reliability of the transcriptions the sample of speech sound productions was re-transcribed by the first author. For inter-judge reliability, the second author transcribed the same speech sample, and the transcription of the first and second authors were compared. The intra-judge agreement was found to be 97%, and the inter-judge agreement was 95%. Huttunen (2001) followed the same procedure for intra and interjudge reliability tests in his study on the phonological development of children with hearing disorders.

Findings

The findings of the current study demonstrated that the percentages of different PPs varied between the participants with CI and TD participants. The results also suggested that the implant age affected the language development of children with CI.

Table 2: ***Percentages of Phonological Processes of TD and CI Children***

Phonological Process	TD Children	CI Children
Alveolarization	0.4%	1.73%
Labialization	0.53%	7.07%
Assimilation	18.8%	21.33%
Denasalization	0.53%	2.13%
Voicing	0.53%	1.07%
Devoicing	5.47%	5.2%
Palatalization	0.4%	2%
Cluster Reduction	2.4%	6.27%
Final Consonant Deletion	0.8%	9.2%
Vowel Deletion	1.6%	1.73%
Dentalization	6.13%	8.27%
Gliding	0.13%	4.27%
Depalatalization	0.53%	4.27%
Reduplication	0.13%	0.93%
Initial Consonant Deletion	0	7.73%
Medial Consonant Deletion	0	4.4%
Weak syllable Deletion	0	1.47%

Table 2 demonstrates that a total of fourteen phonological processes were produced by TD monolingual Bangla-speaking children and seventeen processes were demonstrated by CI children under the chronological age of 4 to 6 years old. In both groups, the highest phonological process was assimilation. For TD the lowest phonological process was both alveolarization and deaffrication and for CI it was the reduplication. Different performances are demonstrated by these groups. CI group showed a high percentage in almost all of the PPs whereas the TD group showed a high percentage only in 1 process (devoicing), and 3 PPs (initial consonant deletion, medial consonant deletion, and weak syllable deletion) are absent in the TD group.

Table 3: ***Comparison between TD and CI regarding PP***

Mean		Paired Differences					t	df	Sig. (2-tailed)
		Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference					
				Lower	Upper				
Pair 1	CI - TD	2.6493	2.4817	.6633	1.2164	4.0822	3.994	13	.002

Notes: *TD= typically developing, CI= cochlear implant*

*. The mean difference is significant at the 0.05 level – Paired T-test

From Table 3, a significant difference ($p < 0.002$) regarding PPs has been found between TD and CI. That means PPs in CI were significantly higher than the TD.

Table 4: ***Differences in Phonological Processes of CI Children regarding CI Time***

Mean		Paired Differences					t	df	Sig. (2-tailed)
		Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference					
				Lower	Upper				
Pair 1	G2 - G1	2.4035	1.6524	.40079	1.5539	3.2532	5.997	16	.000

Notes: G1= Group 1, G2= Group 2

*. The mean difference is significant at the 0.05 level – Paired T-test

Table 4 demonstrates the comparison of PPs between the two groups of CI children regarding cochlear implant age where in G1 participants got their CI at the age of 2.0 to 3.35 years, in G2 participants got their CI at the age of 3;6 to 4;0 years. G1 and G2 show significantly different performances ($p < 0.000$) suggesting that G1 showed fewer PPs whereas G2 showed more PPs defining early implanted participants use less PPs than late implanted participants.

Discussion

Phonological Processes in Monolingual Bangla-Speaking TD Children

In total fourteen PPs were found in the TD group- assimilation, dentalization, devoicing, cluster reduction, deletion of vowel, cluster reduction, final consonant deletion, devoicing, labialization, denasalization, voicing, alveolarization, palatalization, depalatalization. These are considered normal for TD children

and are expected to be omitted by 6 years (Bowen, 2011; Dodd et al., 2003). TD children produced assimilation, dentalization, and devoicing very frequently until six years of age. But in English-speaking children assimilation, dentalization, and devoicing process eliminate after 3 years (Vollmer, 2020; Bernthal et al., 2013; Peña-Brooks & Hedge, 2007; Stiene, 2001). Then processes like cluster reduction and deletion of vowels were found. Cluster reduction, final consonant deletion, and devoicing were also reported in monolingual English and Spanish speakers (Goldstein & Iglesias, 1999) but these were eliminated under four years of age in TD children (Vollmer, 2020; Bernthal et al. 2013; Bowen, 2011; Stiene, 2001). The percentage of deletion of the final consonant, labialization, denasalization, voicing, alveolarization, and palatalization was low. According to Bowen (2011), final consonant deletion was expected until 3 years. The result for labialization is similar with English-speaking TD children as labialization was expected to present until the age of 6 (Bernthal et al. 2013; Peña-Brooks & Hedge, 2007). Also, denasalization, and voicing are expected at or under the age of 3, and depalatalization, alveolarization, and palatalization should be expected at or under the age of 5 years in children's speech (Bernthal et al. 2013; Bowen, 2011; Peña-Brooks & Hedge, 2007).

Phonological Processes in Monolingual Bangla-Speaking Children with CI

In this study, the most prominent PPs was assimilation in the CI participant's speech sample. CI children use bilabials more than they use fricatives, glides, and liquids which ultimately results in assimilation (McCarthy & Smith, 2003). For making speech easier children with hearing impairment tend to do so. In the picture naming task, some other most commonly present processes were final consonant deletion, dentalization, cluster reduction, devoicing (initial, medial, and final), gliding, and depalatalization. Then denasalization, palatalization, alveolarization, voicing, deletion of the weak syllable, deletion of vowel, reduplication, and devoicing process were also identified in the speech production of TD children. Grogan et al. (1995), suggested assimilation, medial consonant deletion, final consonant deletion, dentalization, and cluster reduction as the four most common processes observed in children with CI. The final consonant errors as the deletion of the final consonant is common to them which ultimately increases the production of words with final consonant deletion than the initial consonant deletion (Dodd, 2013). In English-speaking children with CI stopping is considered as one of the most common PPs (Moeller et al., 2010; Flipsen & Parker, 2008; Eriks-Brophy et al., 2013). Consonant deletion specifically final consonant deletion and final cluster reduction or cluster simplification were observed among the processes reported in Doble (2006) & Buhler et al. (2007).

Comparison of Phonological Processes between TD and CI Children

The PPs in the CI group tended to happen more frequently than in the TD group. Unlike the CI group, three processes were absent in the TD group- initial consonant deletion, medial consonant deletion, and weak syllable deletion. Children with profound SNHL who used CI demonstrated more PPs than age-matched TD children with typical hearing (Asad et al. 2018). The most frequent PPs observed in the CI group (assimilation, dentalization, cluster reduction, devoicing) were also found among the most frequently reported processes in the TD group with normal hearing. Following implantation, the mean rate of language development in deaf children was quite similar to that of hearing children (Svirsky et al. 2000). Relative to expectations for processes used by TD children, the findings suggest that children with CI may have demonstrated continuing speech delay. This reflects prior findings for CI user children relative to intelligibility (Flipsen & Colvard, 2006) and pronunciation features (Lenden & Flipsen, 2007) that showed a slower rate of development than normal hearing peers (Eriks-Brophy et al., 2013).

Differences in Phonological Processes of CI Children regarding their Cochlear Implant Time

From the comparison of PPs of CI children regarding implant time, children in group 1 (implanted before 3.5 years of age) had produced fewer PPs than children in group 2 (implanted after 3.5 years of age). Thus, the performance of the children in group 1 was better than children in group 2. Tye-Murrayet al., (1995) reported that children who are profoundly deaf and who receive a cochlear implant at an early age may show greater benefit in terms of speech acquisition than children who receive a cochlear implant later, which is consistent with the current study. Children implanted before 3.5 years of age appeared to demonstrate a faster rate of improvement in their speaking skills than children implanted after 3.5 years of age (Tye-Murray et al. 1995). The percentage of PPs was high in group 2 indicating speech production accuracy and speech intelligibility were low in the participants in group 2. Therefore, children who have implantation before three years develop expressive communication skills more coequal with typical children of the same age (Novak et al., 2002). This early implanted group of CI users provides an outstanding landscape to assess auditory perceptual and production impacts the development of utterance validity (Warner Czyz, and Davis, 2008). Comparison of early-implanted children with typical peers supports understanding of influences on the acquisition of speech in the single-word period (Warner Czyz, and Davis, 2008). Colvard (2002), also found that the child identified with hearing impairment

of the inner ear at birth and implanted with CI had the most consistent PP just like a TD child.

Strengths and Limitations

This study will assist in understanding the characteristics of how phonological development occurs in Bangla-speaking children and how it varies from another language. It gives insights into the phonological development in children with cochlear implants which has not been studied in Bangla context. This helps the SLPs to plan and provide more specific and evidence-based practices. However, some limitations of this study should be considered: the present study used single-word picture naming test rather than a connected speech assessment. Prior findings show that young participants demonstrate more phonological errors on connected speech tasks than on single-word naming tasks (Ertmer, 2010). The researcher selected a total of 30 participants (15 TD and 15 CI) as the study sample. A larger sample size should consider conducting further research on the development of PP.

Clinical Implications

According to Higgins et al. (1996) assessing children with cochlear implants may provide different challenges than assessing children with regular hearing. The findings of the current work can be effective in the therapeutic field such as assessment and intervention of phonological processes, speech sound disorders, and other language and hearing-related difficulties. This research can assist SLPs in providing assessment tools specialized for children with CI. Besides this, it also intends to help the SLPs and caregivers comprehend the developmental process of phonology among 4- to 6-year-old typical and implanted children. The result of this research study can be useful to SLPs for providing an efficient intervention program to children having delays and difficulties in speech and language development.

Conclusion

Children with CI produce more phonological processes than TD peers. However, children receiving CI at early years produce fewer phonological processes compared with those who received CI at an older age. These processes could not be eliminated before 6-year-olds in Bangla-speaking children and compared with English-speaking children, the development and elimination systems of phonological processes are different in Bangla-speaking peers. If the normal phonological production is understood then the atypical phonological production can easily be identified. To understand the phonological process of development

and elimination, most of the SLPs in our country rely on the normative data of the English language. The results of this study can be useful to evaluate the accuracy of children's phonological development.

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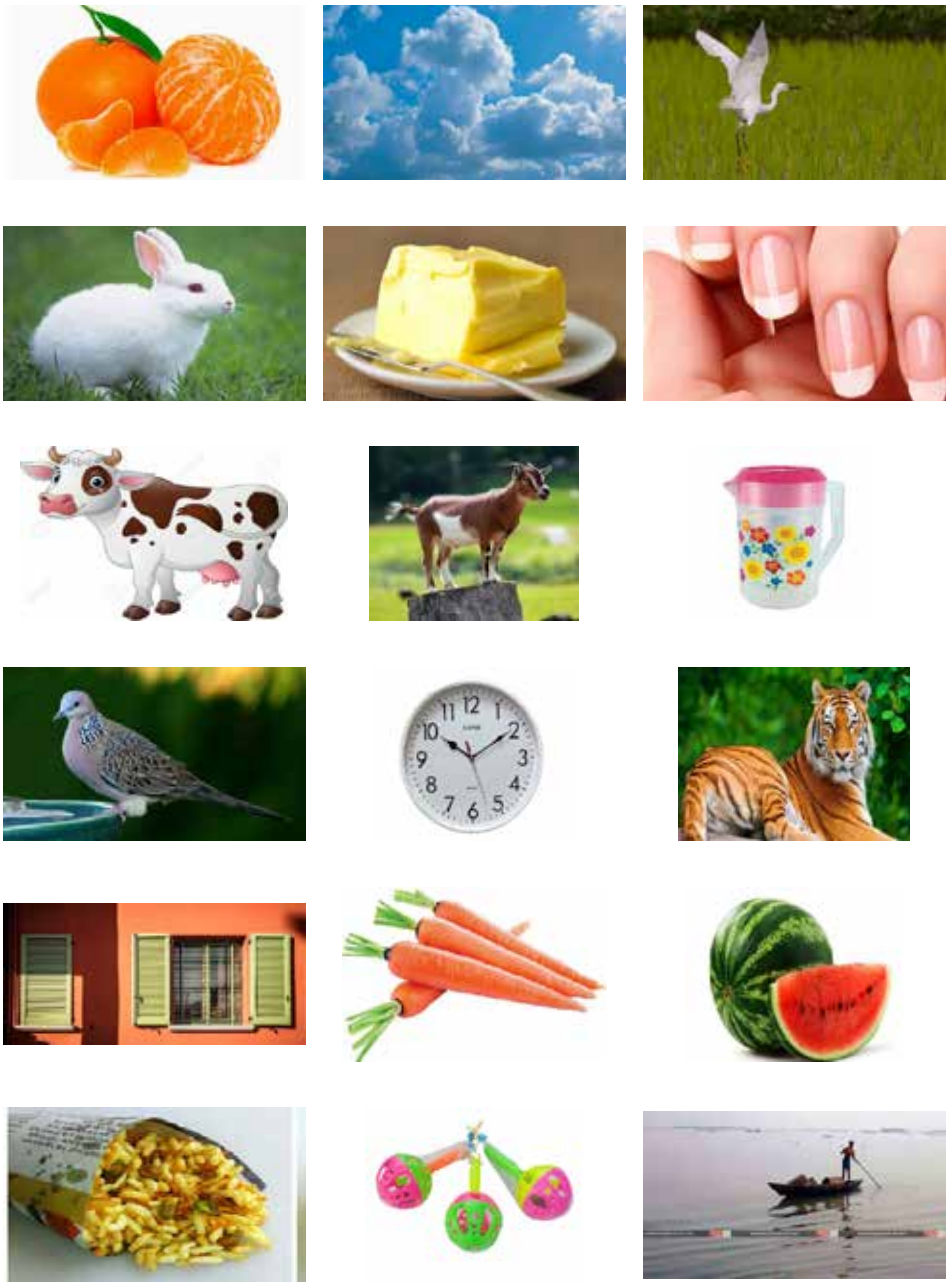
Annex 1: The Picture Naming Task





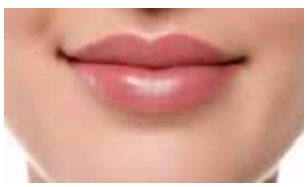




























Number of Words	Sounds	Selected Words	Responses (Bangla)	Broad Transcription	Narrow Transcription	PPs Type
1	ক /k/	কমলা /kɔmɔla/				
2		আকাশ /akaʃ/				
3		বক /bɔk/				
4	খ /kʰ/	খরগোশ /kʰɔrgoʃ/				
5		মাখন/makʰon/				
6		নখ /nɔkʰ /				
7	গ /g/	গরু /goru/				
8		ছাগল /cʰagol/				
9		জগ / ɟɔg/				
10	ঘ /gʱ/	ঘড়ি / gʱoɽi /				
11		ঘুঘু /gʱugʱu/				
12		বাঘ / bagʱ /				
13	জ /ɟ/	জানালা /ɟanala/				
14		গাজর /gaɟor /				
15		তরমুজ /t̪ormuɟ /				
16	ঝ /ɟʱ /	ঝালমুড়ি / ɟʱalmuɽi/				
17		ঝুনঝুনি /ɟʱunɟʱuni/				
18		মাঝি /maɟʱi/				
19	চ /c/	চশমা /cɔʃma/				
20		চানাচুর /canacur/				
21		লিচু /licu/				
22	ছ /cʰ/	ছাতা /cʰat̪a/				
23		কাছিম /kacʰim/				
24		মাছ /macʰ/				

25	শ /ʃ/	শাপলা /ʃapla/				
26		রসুন /roʃun/				
27		হাঁস /hãʃ/				
28	ট /t/	টমেটো /tɔmeto/				
29		লাটিম /latim/				
30		রুটি /ruti/				
31	ঠ /tʰ/	ঠোঁট /tʰõt/				
32		কাঁঠাল /kãtʰal/				
33		লাঠি /latʰi/				
34	ড /d/	ডালিম /dalim/				
35		হাড়ুডু /hadu-du/				
36		লুডু /ludu/				
37	ঢ /dʱ/	ঢাকনা /dʱak-na/				
38		ঢুলুঢুলু /dʱu-ludʱulu/				
39	র /r/	রঙপেন্সিল / rɔŋpensil/				
40		ঢেঁড়স /dʱẽɽoʃ/				
41		ময়ূর /mɔɪur/				
42	ল /l/	লেবু /lebu/				
43		বেলুন /belun/				
44		বল /bɔl/				
45	থ /ʈʰ/	থালা /ʈʰala/				
46		মাথা /maʈʰa/				
47		পাথর /paʈʰor/				
		Cluster Production				
48		মুক্তা /mukʈa/				
49		ভ্রমর/bʱromɔr/				
50		গণ্ডার /gɔndar/				