Phonetic and Phonological Features of Typical and Atypical Speech: Insights from Bangla Language



University of Dhaka

Department of Linguistics

A Dissertation Submitted in Fulfillment of the Requirements for the Degree of

Doctor of Philosophy (PhD) in Linguistics

Prepared by

Tanzia Siddiqua

Registration No. and Session: 13/2020-2021

Re-Registration No. and Session: 13/2024-2025

Supervisor

Syed Shahrier Rahman, PhD

Professor, Department of Linguistics,

Faculty of Arts, University of Dhaka

Date of Submission

July 06, 2026

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Declaration

I, Tanzia Siddiqua, PhD Researcher (Registration No. and Session: 13/2020-2021 and Re-Registration No. and Session: 13/2024-2025) of Department of Linguistics, University of Dhaka, hereby, declare that this PhD dissertation titled 'Phonetic and Phonological Features of Typical and Atypical Speech: Insights from Bangla Language' is being submitted in fulfillment of the requirements for the Degree of Doctor of Philosophy (PhD) in Linguistics. All of its contents are original and devised by the researcher and these have not been included or published elsewhere. I have added references and appendices to declare all the relevant sources.

Signature;

……

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Certificate of the Supervisor

I have the pleasure to certify that the PhD dissertation titled 'Phonetic and Phonological Features of Typical and Atypical Speech: Insights from Bangla Language' submitted by Tanzia Siddiqua, PhD Researcher (Registration No. and Session: 13/2020-2021 and Re-Registration No. and Session: 13/2024-2025) of Department of Linguistics, University of Dhaka, in fulfillment of the requirements for the Degree of Doctor of Philosophy (PhD) in Linguistics, is an original research work carried out under my supervision and guidance. The contents of this dissertation, in full or in parts, have not been submitted or published elsewhere. To the best of my knowledge, the researcher has added references and appendices to declare all the relevant sources.

Therefore, I recommend this dissertation to be submitted to the Office of the Controller of the Examinations at the University of Dhaka as part of the requirements for the degree of Doctor of Philosophy (PhD) in Linguistics.

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Syed Shahrier Rahman, PhD

PhD Supervisor

Professor, Department of Linguistics,

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Acknowledgements

It is an honor to thank Professor Syed Shahrier Rahman, of the Department of Linguistics, Faculty of Arts, University of Dhaka, for his supervision, guidance, and generosity from the initial to the final level in developing the dissertation.

I am heartily thankful to Dr Monira Begum, Associate Professor and Chairperson, of the Department of Linguistics, Faculty of Arts, University of Dhaka for fostering a remarkable research environment and for facilitating the resources necessary to carry out this work, the dissertation committee members for their thoughtful comments and constructive feedback, Prof. Dr. Md. Afzal Hossain, Former Professor and Chairperson, Department of Neuro Surgery, Bangladesh Medical University (BMU, formerly BSMMU), Prof. Dr. Dhiman Chowdhury, Professor and Chairperson, Department of Neuro Surgery, BMU, and Dr. Robert Ahmed Khan, Assistant Professor, Department of Neuro Surgery, BMU for their approvals, expertise, and encouragement for my data collection. I thank the residents and the administrative authorities of BMU for being hospitable and supportive during patients' observations and above all, I thank the patients' and their family members for being welcoming and co-operative during the surveys.

I wish to express my sincere gratitude and appreciation to my family and friends whose prayers, love, and best wishes were a constant source of inspiration, encouragement, and motivation for me as I was conducting the study.

Lastly, I offer my regards and blessings to all of those who supported in any respect during the completion of this research.

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Abstract

The present research provides statistical analyses of the phonetic and phonological features for Bangla typical and atypical speech. It identifies and categorizes the distinctive sound features and then devises necessary articulatory and acoustic tools to analyze the data for Bangla typical and typical speech. The study identifies presences and absences of sounds, along with alterations, and also newly identifiable features following the distinctive feature matrix theory. It also looks into the articulatory and acoustic properties, theories, mechanisms, characteristics and transcription of typical and atypical speech, a synopsis of the standard variety, dialectical variations and individual differences, cross-linguistic perspective on Bangla phonetics and integrating features, existing IPA, extIPA chart along with historical contexts of Bangla typical and atypical speech. Later on, it suggests revisions of principles which were used in transcribing atypical speech of Bangla language. In order to collect data, two Task-based Phonological Tests has been devised: (a) picture naming and (b) word naming. All atypical participants are diagnosed aphasic patients, primarily from Bangladesh Medical University (formerly BSMMU) and Metropolitan Medical Centre Ltd. The patients have suffered from Broca's Aphasia after cerebrovascular accident (CVA) with impressions of intracerebral haematoma in the cerebral hemisphere and are at the early stage of treatment and speech therapy, i.e., within 6 months to a year. The research was concluded by listing the most common features of atypical speech, along with affected organs. It identifies pre-palatalization /ʲ◌/, nasal release /◌ⁿ/, lip compression /◌̪/, fricative release /◌ˣ/ (and /◌ˢ/, /◌ᶠ/ as systematic release markers), strong articulation /◌̈/, weak articulation /◌̗/, inconsistent /O/, unaspirated /◌̄/ (often unmarked), unintelligible speech /◌/. pre-aspirated /ʰ◌/, partial devoicing /(◌̥)/, sliding articulation /◌◌̲/, double articulation /◌͡◌/, aspirated fricative /◌ʰˢ/ as newly identifiable symbols for atypical speech representation for Aphasic patients who speak Bangla as L1. Unintelligible speech /◌/ can also be suggested as new. Low tone (˩), Extra-Low Tone (˩̗), Weak Articulation (◌̗), Retracted Tongue-Root

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Position (◌̪) are prominent in most utterances. In a few cases, Post-Alveolar Clicks (◌!) and Palatal Clicks (◌ǂ) were observed. Various places of articulation include: /◌̼/ – linguolabial, /◌ʷ/ – labialized, /◌̪/ – dental, bidental /◌̪̪/, /◌ˠ/ – velarized, pre-palatalized /ʲ◌/, and manners of articulation include: /◌ˢ/ – sibilant, /◌̃/ – nasalized, nasal release /◌ⁿ/, /◌ʳ/ – trill/tap. As for organs, soft palate/Velum , back and the root of the tongue are mostly affected. Also, it finds that the highest form of atypical speech occurs due to velarization and nasal release/nasalization which can be considered under distortion. Other significant errors happen due to retracted tongue-root position, creaky-voice, rising-falling tone, nasal release/nasalization and no audible release. Creaky-voice and rising-falling tone can be considered as suprasegmental features, and retracted tongue-root position can cause phonological or acoustic errors which all leads to distortion. No audible release, on the other hand, can lead to omission. In addition, the research shows that in dialect variation, F1-F2 relationships shift in predictable and consistent ways. The research presents all the data in percentages. To summarize, the research aims to revisit and catalogue the articulatory and acoustic features of Bangla typical speech, devise necessary articulatory and acoustic tools to collect Bangla typical and atypical speech, and propose amendments to the existing extIPA for disordered speech in the context of Bangla atypical speech. Thus it provides a systemic analysis on speech production of atypical speech and bridges the gaps between the theoretical and practical applications. Hence, it provides culturally and linguistically appropriate research-based resources (e.g., pictographic tools, communication-ready materials) for speech-language pathologists (SLPs) dedicated towards Aphasic patients who speaks Bangla as their L1. In future, this shall add to the direct service to the patients and their families for assessment, therapy, support and build collaboration and capacity building among the professionals (speech-language therapists, health workers) through training, etc. Following this model, other disorders can also be explored.

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Chapter One
Introduction

The research aims to identify and compare the phonetic and phonological features for Bangla typical and atypical speech. It looks into the articulatory and acoustic properties as well as Bangla language specific phonological features for typical and atypical productions. The study identifies presences and absences of sounds, along with alterations, and also newly identifiable features. The research, hence, identifies the distinctive sound features of Bangla language for typical and atypical speech. In general, typical speech is the standard predictable patterns of speech sound production whereas atypical speech deviates from these norms due to various reasons such as neurological conditions or motor sensory development etc. For example, in the word কাঁঠাল, (IPA: [kɐ̃ʈʰɐl]), [ʈʰ] which appears in the middle of the word displays typical sounds such as consonants [k], [ʈʰ], [l], and vowels: [ɐ̃], [ɐ]. Here, [ʈʰ] is a pulmonic egressive, alveolar, voiceless sound which is of 0.09 seconds, 69 dB, 218 Hz. On the other hand, an atypical sound might display কাঁঠাল, (IPA: [kɐʈ̬ʰɐ˩˧]) with a voiced [ʈ̬ʰ] along with other features such as rising-falling [ɐ˩˧] weak articulation with low tone of [˩˧] for the entire word. Hence, it displays distortion. It could be display 0.15 seconds, 73 dB, 197 Hz. These, and many other prosodic features may appear during the analysis of atypical speech. Later on, the research looks into the existing features and suggests revisions of principles which could be used in transcribing atypical speech of Bangla language. This research contributes in characterizing and analyzing the atypical speech disorders.

1.1. Research Objectives

The main objectives of this research are to;

(a) revisit and catalogue the articulatory and acoustic features of Bangla typical speech,

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(b) devise necessary articulatory and acoustic tools to collect Bangla typical and atypical speech,

(c) propose amendments to the existing extIPA for disordered speech in the context of Bangla atypical speech.

1.2. Research Questions

The initial comparisons of this research have been based on the features of Bangla typical and atypical speech. The queries below add to its practicality.

(a) Which articulatory and acoustic features are most significant in the production of Bangla atypical speech? Which phonological errors are more prominent?

(b) How are these features different from Bangla typical speech?

(c) What type of modifications are required to develop transcription models for Bangla atypical speech?

1.3. Formulation of the Research

The research follows a quantitative method with added written explanations where necessary. It takes in fieldwork with electronic sources and provides linguistic analysis in relation to the literature review and received data to draw a conclusion. The study considers two separate studies; for typical and atypical and later on works on the analysis. In order to collect data, two Task-based Phonological Tests has been devised: (a) picture naming and (b) word naming. Also, a checklist has been devised to identify the articulatory and acoustic features of typical and atypical speech, along with the types of phonological errors made by the patients. For this research, distortions, omissions, substitutions, and insertions have been listed. The tests have been administered in person.

A pilot study has been administered to pre-test the tests and the checklist on a small number of people before it is used in earnest. PRAAT has been used for analyzing both typical and atypical speech for controlled groups. It processed the recorded audio, generated waveforms and spectrograms which assisted to visualize vocal data in a more printable and quantifiable format. The software further computed precise and aggregated values of all the prosodic features such as intensity, pitch patterns, formants, pulses, frequency, syllable break, labeled words,

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and individual phonemes. There were controlled (selective) and spontaneous (affable) speech analysis.

As for participants for typical speech, the study takes adult speakers, i.e., above the age eighteen, between age 18-60, who speak standard Bangla as L1 and also as mother tongue. There has not been any dialect variations within the participants; all were at least Secondary School Certified. To further reduce possible discrepancies, the participants with typical speech were selected based on the ages of the atypical participants. The research comprises of a total of 110 participants with a ratio of 10 typical per atypical participant (10:1). Type versus Token ratio is, 2 : 840, i.e. types of patients versus number of occurrences. As for sample, it is 2 : 168. All atypical participants are diagnosed aphasic patients, primarily from Bangladesh Medical University (formerly BSMMU) and Metropolitan Medical Centre Ltd. The patients have suffered from Broca's Aphasia after cerebrovascular accident (CVA) with impressions of intracerebral haematoma in the cerebral hemisphere and are at the early stage of treatment and speech therapy, i.e., within 6 months to a year. The patients are also divided into two stages: spasmodic and recurrent.

As the research includes spontaneous and natural responses from the participants, therefore, a number of feature detection observation checklists and a semi-structured survey and/or interview have been selected to reveal the facts. Considering the number and type of the participants, the timeline of the study, and the type of the investigation, the research design has been classified as cross-sectional/experimental study with stratified random sampling and it is semi-longitudinal.

1.4. Rationale

An explicit awareness of the sound structure is required to be able to transcribe any speech. Although the IPA provides a standardized set of symbols for representing speech sounds across languages, and the extIPA extends the systems to capture atypical speech, both remain insufficient in their current form to fully and accurately represent the range of typical and atypical speech sounds in Bangla. Moreover, since IPA and extIPA provide data on speech sounds in general for different languages, it is not specific to Bangla language. The literature on Bangla

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IPA and extIPA also varies due to theoretical debates. Moreover, there hasn't been an extensive and/or continuous research to find how Bangla language has changed over the period of time. In fact, a systemic analysis of atypical speech has not been conducted over the years. There has been research under the light of Clinical Linguistics and other related fields, however, not as much considering the Theoretical/Pure Linguistics. Thus, there remains a research limitation between the theoretical and practical applications. Hence, it is important to conduct this research in a large scale.

1.5. The Research Layout

Considering all these factors of the research, the layout has been formulated as below. The literature review chapter consists of the following categories.

(a) The Study of Articulatory and Acoustic Phonetics: The Articulatory Properties, as in, Speech Anatomy: respiration, phonation and articulation mechanisms, Articulatory Organs, Voicing and Sound Types, Places and Manners of Articulation, Articulation Procedures, Structure, Clusters, and Syllables; The Acoustic Properties, as in, Theories, Mechanisms, Measurements, Phonation Modes, Linguistic Rhythms, States of the Glottis, Voice Onset Time, Formats, and Harmonics, Speech Synthesis Systems, Spectrograms etc.

(b) The Study of Systematic Representation of Speech Sounds: The International Phonetic Alphabet and its Historical Context, Phonetic Transcription and Diacritics, Revisions of extIPA Chart and its Necessity, Characteristics and Transcription of Typical and Atypical Speech

(c) Bangla Phonetics and Phonology: Bangla as an Indo-European Language, A Synopsis of the Standard Varity, Dialectical Variations and Individual Differences, Cross-Linguistic Perspective on Bangla Phonetics and Integrating Features, Probable Bangla Consonant and Vowel Sounds

Given this criterion for finding a framework, this research provides critical overview of Bangla language. However, the research shows a few limitations which has been discussed in the next section.

1.6. The Limitations

The research has a few limitations. First of all, it focuses on Bangla community in order to retrieve data and hence has a local view rather than a worldview. It's because the official language of Bangladesh is Modern Standard Bangla (Literary Bengali/Bangla). However, the scale of speakers is much larger. It is because, within India, Bangla is the official language of the states of West Bengal, Tripura and the Barak Valley in the state of Assam, and is the most widely spoken language in the Andaman and Nicobar Islands in the Bay of Bengal, and is spoken by significant populations in other states including in Arunachal Pradesh, Delhi, Chhattisgarh, Jharkhand, Meghalaya, Mizoram, Nagaland and Uttarakhand. Bangla exhibits diglossia, according to some scholars it exhibits triglossia or even n-glossia or heteroglossia. In addition to that it has even wider phonemic varieties depending on all its dialects. Therefore, the research does not cover all the dialects of Bangla language either. It also has a smaller number of cases for typical and atypical speech sounds. It is because each Task-based Phonological Test (Picture and Word Naming) audio had to be cleared out through noise cancellation which generated Oscillograms (Sound Waves) having a beginning, middle, and ending, and later on those were analyzed with detailed acoustic data. As a result, the data was enormous and hence the number of participants had to be kept to a minimum. However, it is still a limitation to the study.

1.7. Summary

To summarize, the research aims to revisit and catalogue the articulatory and acoustic features of Bangla typical speech, devise necessary articulatory and acoustic tools to collect Bangla typical and atypical speech, and propose amendments to the existing extIPA for disordered speech in the context of Bangla atypical speech. Thus it provides a systemic analysis on speech production of atypical speech and bridges the gaps between the theoretical and practical applications.

Chapter Two
Reviewing Literatures on Phonetic and Phonological Features of Typical and Atypical Speech

The present chapter consists of the theoretical background of speech production and representation of typical and atypical speech.

2.1. Speech Production: Typical versus Atypical

The speech production can be studied in two folds: the articulatory and acoustic phonetics. The field of articulatory phonetics is a subfield of phonetics that investigates how human speech sounds are produced. The acoustic phonetics is the study of the physical properties of human speech sounds. These aspects are discussed in details below.

2.1.1. The Articulatory Properties: The segments of speech sounds involve the basic understanding of speech anatomy which includes the studies of respiration, phonation and articulation mechanisms. According to Ladefoged (2000), the respiratory system includes the lungs and the windpipe (Trachea) which performs in inhalation and exhalation. The lung air, as in, Pulmonic air goes up through the windpipe into the Larynx or voice box. It then passes between the vocal folds, then Pharynx, then into the oral cavity. The vibrating sounds are termed as voiced, as opposed to those in which the vocal folds are apart and do not necessarily vibrate are termed as voiceless. For example, [v] is voiced and [f] is voiceless. These respiratory sounds vary in terms of speech quality which is often created due to obstructions of two or more articulatory organs. The point of maximum obstruction is called the place of articulation, and the way the obstruction forms are called the manner of articulation which, of course, varies in different languages. The different Human Speech Organs include: Upper Lip and Upper Teeth (frontal incisors), Alveolar Ridge, Hard Palate, Soft palate or Velum (can cause Velic closure), Uvula, Lower lip, Lower Teeth, Tongue (tip, blade or front, center, back, root). There is also Larynx for Phonation, and the three cavities: Oral, Nasal, and

Pharyngeal. In articulatory phonetics, if a speech sound that is articulated with complete or partial closure of the vocal tract, is called a consonant sound.

Speech gestures using the lips are named as Labial articulations; if the tip or the blade of the tongue is used then they are called Coronal articulations; for the back of the tongue, the sounds are called Dorsal articulations. The fourth one is Laryngeal consonants, which are consonants with their primary articulation occurring in the larynx. Given below are the list of places of articulation followed by the Official IPA Chart, i.e., the consonant phonemes (the phonemes are abstract units used to write a language systematically and unambiguously) are represented next.

Labial: Labial consonants are those consonants in which one or both lips are used as active articulator(s).

i. Bilabial: using closing movement of both lips, e.g., [p] (e.g., pat in English), [b] (e.g., bat in English), [m] (e.g., mat in English), [w] (e.g., water in English)
ii. Labio-Dental: using lower lip and the upper teeth, e.g., [f] (e.g., fish in English) and [v] (e.g., vote in English)
iii. Linguolabial (or Apicolabial): consonants articulated by placing the tongue tip or blade against the upper lip, later it goes downwards to meet the tongue, e.g., [n̪] (e.g., n̪isi in Araki, IPA [n̪isi], meaning ‘still’)

Coronal: Coronals are consonants articulated with the flexible front part of the tongue.

i. Dental: the tip of the tongue is used between the teeth or close to the upper teeth, e.g., [θ] (e.g., thanks in English) and [ð] (e.g., that in English)
ii. Alveolar: the blade of the tongue is used here close to the Alveolar Ridge, e.g., [t] (e.g., time in English) and [d] (e.g., date in English), [s] (e.g., sea in English), [z] (e.g., zoo in English), [n] (e.g., never in English), [l] (e.g., letter in English)
iii. Palato-Alveolar or Post-Alveolar: the blade (or tip) of the tongue touches behind the Alveolar Ridge, e.g., [ʧ] (e.g., chair in English) and [ʤ] (e.g., jog in English), [ʃ] (e.g., ship in English) and [ʒ] (e.g., zip in English), [r] (e.g., river in English)

iv. Retroflex: the tongue has a flat, concave, or even curled shape, and is articulated between the Alveolar Ridge and the hard palate, e.g., [ɳ] (e.g., गुण in Hindi, IPA ['guɳa] meaning 'virtue')

Dorsal: Dorsal consonants are those consonants articulated with the back of the tongue (the dorsum).

i. Palatal: the front of the tongue is raised close to the palate, e.g., [j] (e.g., yes in English)
ii. Velar: the back of the tongue is used against the soft palate, e.g., [k] (e.g., kite in English), [ɡ] (e.g., gate in English) and [ŋ] (e.g., sing in English)
iii. Uvular: the back of the tongue against or near the uvula, that is, further back in the mouth than velar consonants, e.g., [ʁ] (e.g., Paris in French, IPA [paːˈʁiː], meaning 'Paris')

Laryngeal: Laryngeal consonants (a term often used interchangeably with guttural consonants) are those consonants which have their primary articulation in the larynx.

i. Pharyngeal/Epiglottal: the back of the tongue against the Pharynx, e.g., [ʕ] (e.g., عِلْم in Arabic, IPA [ʕilm], meaning 'knowledge')
ii. Glottal: the gap between the vocal cords is used here which helps to make audible friction, e.g., [h] (e.g., hat in English)

Given next are the Manners of Articulations.

i. Stop or Plosive: pulmonic consonant in which the vocal tract is blocked so that all airflow ceases, e.g., [p] (e.g., pat in English) and [b] (e.g., bat in English) (bilabial closure), [t] (e.g., time in English) and [d] (e.g., date in English) (alveolar closure), [k] (e.g., kite in English) and [g] (e.g., gate in English) (velar closure)

ii. Nasal (also called Nasal Occlusive or Nasal Stops): an occlusive consonant produced with a lowered velum, allowing air to escape freely through the nose, e.g., [m] (e.g., month in English) (bilabial closure), [n] (e.g., night in English) (alveolar closure), [ŋ] (e.g., sang in English) (velar closure)

iii. Fricative: a consonant produced by forcing the lung air through a narrow channel which is made by placing two articulators close together, [f] (e.g., fish in English), [v] (e.g., vote in English) (labio-dental closure), [θ] (e.g., think in English), [ð] (e.g., that in English) (dental closure), [s] (e.g., sing in English), [z] (e.g., zoo in English) (alveolar closure), [ʃ] (e.g., shut in English), [ʒ] (e.g., pleasure in English) (palate-alveolar closure); higher pitched sounds or hissing sound are sometimes called sibilants; thus, Fricatives could be sibilants and non-sibilants

iv. Approximant: here, one articulator is close to another, but the vocal tract isn't narrowed and a turbulent airstream is produced; there are two types of Approximants: Central – [w] (e.g., wish in English), [y] (e.g., yes in English), [r] (e.g., red in English) and Lateral – [l] (e.g., light in English)

v. Affricate: an affricate is a consonant that begins as a stop and releases as a fricative, e.g., [ʧ] (e.g., chair in English) and [ʤ] (e.g., jog in English)

vi. Additional Consonantal Articulations: Tap (often called Flap) is a type of consonantal sound, which is produced with a single contraction of the muscles so that one articulator (such as the tongue) is thrown against another, (e.g., latter in North American English, IPA [lærɚ]); and Trill (often called Roll) which is a type of consonantal sound produced by vibrations between the active articulator and passive articulator; (e.g., perro in Spanish, IPA [ˈpe̞ro̞], meaning 'dog')

As for the vowels, these are speech sounds which are articulated with the air-stream passing freely through the oral cavity without any obstruction, closure or narrowing. Jones (1993) says 'A vowel (in normal speech) is defined as a voiced sound in forming of which the air issues in a continuous stream through the pharynx and mouth, there being no obstruction and no narrowing such as would cause audible friction' (p.23).

Similarly, Verma and Krishnaswamy (1997) say ‘a vowel is a sound produced by the unobstructed passage of the air stream without the oral cavity being constricted enough to cause audible friction’ (p.34). The term ‘vowel’ is approached and defined variously by different linguists and phoneticians. The most common view is that ‘vowels are sounds in which there is no obstruction to the flow of air as it passes from the larynx to the lips’ (Roach, 1997; p.10). The vowel can best be understood from the description of its basic features of articulation. A vowel can be described on the basis of (i) air-stream mechanism, (ii) state of the glottis, (iii) state of the velum, (iv) stricture involved, (v) height of the tongue, (vi) position of the tongue, (vii) quality of vowels, (viii) position of the lips, and (ix) distribution in a word. These are briefly discussed next.

(i) Air-Stream Mechanism: Speech sound is the modification of air stream which is produced by airstream mechanism. There are three main air-stream mechanisms such as pulmonic, glottalic, and velaric air-stream mechanism. The pulmonic air-stream mechanism consists of the lungs and the respiratory muscles. The walls of the lungs act as the initiator which is moved by the respiratory muscles so that air is drawn into the lungs or pushed out of those. When the air-stream mechanism is used to push air out, it is called egressive and when it is used to draw air in, it is called ingressive. The second main type of air-stream mechanism is glottalic air-stream mechanism where closed glottis acts as the initiator and the air in the pharynx is used. The last main type of air-stream mechanism is velaric air-stream mechanism in which the back of the tongue is the initiator and the air in the mouth is set in motion.

(ii) State of the Glottis: The opening between the vocal cords is called Glottis. During the production of speech sounds, the vocal cords are either drawn wide apart or loosely held together. Sounds produced when the vocal cords are drawn wide apart are voiceless whereas sounds produced when the vocal cords are loosely held together are voiced.

(iii) State of the Velum: The sounds become oral or nasal or nasalized due to the function of the soft palate. If the soft palate is lowered, the lung air passes through the nasal cavity and nasal sounds are produced. If the soft palate is raised, the lung

air passes through the oral cavity and thus the oral sounds are produced. Sometimes, the soft palate assumes such a position that allows lung air to pass through both the oral and nasal cavities and produces the nasalized sounds.

(iv) Stricture Involved: The term ‘stricture’ refers to the ways lung air is modified by different organs of speech. During the production of vowels, the active articulator and passive articulator assume such a position that there is an opening between the two articulators through which the lung air passes freely without causing any audible friction.

(v) Height of the Tongue: As per the height of the tongue, vowels can be described and classified as high/close vowels, half/near-close vowels, close-mid, open-mid, half/near-open vowels and low/open vowels. Close vowels are those vowels in the production of which the tongue rises as close to the roof of the mouth as possible. Open vowels, on the other hand, are those vowels in the production of which the tongue is lowered as far away from the roof of the mouth as possible. Half-close vowels are those vowels in the articulation of which the tongue occupies a position about one-third of the distance from close to open whereas during the articulation of the half open vowels, the tongue occupies a position about two-thirds of the distance from close to open.

(vi) Position of the Tongue: During the articulation of vowels, the different parts of the tongue take part in action. Thus, based on the position of the tongue, vowels are described and classified as front vowels, central vowels and back vowels. Front vowels are those vowels in the production of which the front part of the tongue is raised towards the hard palate whereas in the production of back vowels, the back part of the tongue is raised towards the soft palate. Central vowels are those vowels in the articulation of which the central part of the tongue (i.e., between the front and the back of the tongue) is raised in the direction of the central part of the roof of the mouth (i.e., between the hard palate and the soft palate).

(vii) Quality of Vowels: In the production of vowels, the quality may change or remain unchanged due to the different positions assumed by the tongue. If the

quality remains unchanged, pure vowels or monophthongs are produced but if the quality changes, vowel glides or diphthongs are produced.

(viii) Position of the Lips: During the articulation of vowels, the lips may be neutral or spread and rounded. If the lips are neutral or spread, the vowels are unrounded whereas if the lips are rounded, the vowels are rounded.

(ix) Distribution in a Word: A vowel may occur in different positions in a word. However, there are some positions where a particular vowel may not occur due to the effect of neighboring sounds.

These mean that, in the production of vowel sounds, the articulators do not come very close together, and the passage of the airstream is relatively unobstructed. They are usually voiced and can be described in terms of three factors; 1. The height of the body of the tongue: high/close, mid (also have half/near-close, close-mid, open-mid, half/near-open), low/open, 2. The front-back position of the tongue: front, central, back, 3. The degree of lip rounding: rounded, unrounded. Based on the usage of units, there are three types of vowels: Monothong/Monophthong: a single vowel, Diphthong: a double vowel, Triphthong: a union of three vowels.

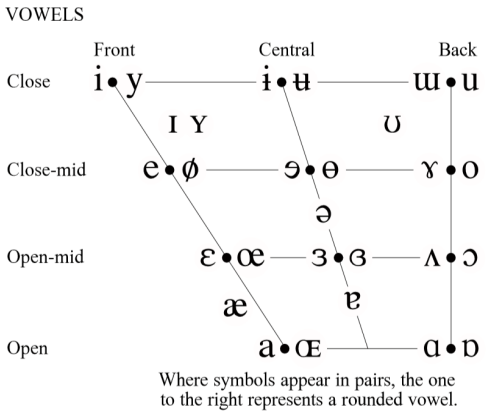


Figure 01: The Vowel Chart (IPA, 2020)

Given next are the list of high/close vowel sounds.

i. [i] = close front unrounded vowel, or high front unrounded vowel; often associated with length, e.g., free in English, IPA [fri:]

ii. [y] = close front rounded vowel, or high front rounded vowel, often associated with length, e.g., tu in French, IPA [t̪y], meaning ‘you’
iii. [ɨ] = close central unrounded vowel, or high central unrounded vowel, e.g., shí in Chinese, IPA [ʃɨ], meaning ‘ten’
iv. [ʉ] = close central rounded vowel, or high central rounded vowel, e.g., nu in Standard Northern Dutch, IPA [nʉ], meaning ‘now’
v. [ɯ] = close back unrounded vowel, or high back unrounded vowel, e.g., 空気 ‘kūki’ in Japanese, IPA [kɯːki], meaning ‘air’
vi. [u] = close back rounded vowel, or high back rounded vowel, often associated with length, e.g., ‘boot’ in English, IPA [buːt]

Given below are the list of half/near-close vowel sounds.

i. [ɪ] = near-close front unrounded vowel, or near-high front unrounded vowel; e.g., ‘him’ in English, IPA [hɪm]
ii. [ʏ] = near-close front rounded vowel, or near-high front rounded vowel, e.g., ‘lune’ in French, IPA [lʏn], meaning ‘moon’
iii. [ʊ] = near-close near-back rounded vowel, or near-high near-back rounded vowel, e.g., ‘তুমি’ in Bangla, IPA [ˈt̪ʊmiː], meaning ‘you’

Given next are the list of close-mid vowel sounds.

i. [e] = close-mid front unrounded vowel, or high-mid front unrounded vowel; e.g., ‘red’ in English, IPA [red]
ii. [ø] = close-mid front rounded vowel, or high-mid front rounded vowel; e.g., ‘peu’ in French, IPA /pø/, meaning ‘few’
iii. [ɘ] = close-mid central unrounded vowel, or high-mid central unrounded vowel; e.g., ‘mysz’ in Polish, IPA [mɘ̟ʂ], meaning ‘mouse’
iv. [ɵ] = close-mid central rounded vowel, or high-mid central rounded vowel; e.g., ‘je’ in French, IPA [ʒɵ], meaning ‘I’
v. [ɤ] = close-mid back unrounded vowel, or high-mid back unrounded vowel; e.g., ‘thoe’ in Thai, IPA [tʰɤː], meaning ‘you’
vi. [o] = close-mid back rounded vowel, or high-mid back rounded vowel; e.g,. ‘réseau’ in French, IPA [ʁezo], meaning ‘network’

Given next are the list of mid vowel sounds.

i. [ẹ] = mid front unrounded vowel; e.g.,‘ بيت/bēt’ in Arabic, IPA [bẹːt], meaning ‘home’
ii. [ø̹] = mid front rounded vowel; e.g., bleu in Romanian, IPA [bl̪ø̹], meaning ‘light blue’
iii. [ə] = mid central vowel; e.g., sofa in English, IPA [ˈsəʊfə]
iv. [ɤ̞] = mid back unrounded vowel; e.g., tờ in Vietnamese, IPA [tɤ̞˧˩], meaning ‘sheets’
v. [o̞] = mid back rounded vowel; e.g., 高/kò in Chinese, IPA [ko̞¹], meaning ‘tall’

Given below are the list of open-mid vowel sounds.

i. [ɛ] = open-mid front unrounded vowel, or low-mid front unrounded vowel; e.g., 天 /tiān in Chinese, IPA [tʰi̯ɛn˥], meaning ‘sky’
ii. [œ] = open-mid front rounded vowel, or low-mid front rounded vowel; e.g., 長/cheung in Chinese, IPA [tsʰœːŋ˩], meaning ‘long’
iii. [ɜ] = open-mid central unrounded vowel, or low-mid central unrounded vowel; e.g., bird in English, IPA [bɜːd]
iv. [ɞ] = open-mid central rounded vowel, or low-mid central rounded vowel; e.g., port in French, IPA [pɞːʁ] meaning ‘port’
v. [ʌ] = open-mid back unrounded vowel or low-mid back unrounded vowel; e.g., hut in English, IPA [hʌt]
vi. [ɔ] = open-mid back rounded vowel, or low-mid back rounded vowel; e.g., thought in English, IPA [θɔːt]

Given next are the list of half/near-open vowel sounds.

i. [æ] = near-open front unrounded vowel, or near-low front unrounded vowel; e.g., bat in English, IPA [bæt]
ii. [ɐ] = near-open central vowel, or near-low central vowel; e.g., পা/pa in Bangla, IPA [pɐ] meaning ‘leg’

Given next are the list of open vowel sounds.

i. [a] = open front unrounded vowel, or low front unrounded vowel; e.g., ‘أنا/anaa’ in Arabic, IPA [anaː] meaning ‘I - 1st person singular pronoun’

ii. [œ]= (near) open front rounded vowel, or (near) low front rounded vowel; e.g., ‘öra’ in Swedish, IPA [ˈœ̂ːra̲] meaning ‘ear’

iii. [ä] = open central unrounded vowel, or low central unrounded vowel; e.g., ‘塌／tā’ in Chinese, IPA [tʰä˥] meaning ‘collapse’

iv. [ɑ] = open back unrounded vowel, or low back unrounded vowel; e.g., ‘棒/bang’ in Chinese, IPA [pɑŋˊ] meaning ‘stick’

v. [ɒ] = open back rounded vowel, or low back rounded vowel; e.g., ‘fog’ in English, IPA [fɒg]

Based on the languages, there could be various structure of sounds, such as CVC = Consonant-Vowel-Consonant, e.g., cat, IPA /kæt/ has a CVC structure, CVCC = Consonant-Vowel-Consonant-Consonant, e.g., hunt, IPA /hʌnt/ has a CVCC structure etc. Often Consonant Clusters might be observed which is two or more consonant sounds within the same syllable. Vowels and consonants can be thought of as the segments of which speech is composed. Together they form the syllables, which go to make up utterances. Superimposed on the syllables are other features known as suprasegmental features. These include variations in pitch (frequency, Hz), loudness (intensity, dB), and length (duration, Sec). These phonetic details could be presented more specific symbols or by allophonic differences. The use of diacritics, small marks that can be added to a symbol to modify its value, is a means of increasing precision. In practice, it is difficult to represent all the details of the sounds involved. When writing down an unknown language or when transcribing a child or a patient not seen previously, one does not know what rules will apply. In these circumstances, the symbols indicate only the phonetic value of the sounds. This kind of transcription is called an impressionistic transcription. The way in which human beings hear a sound depends on its acoustic structure.

2.1.2. The Acoustic Properties: Linguists and speech pathologists need to explain why certain sounds are confused with one another. They can also give better descriptions of some sounds (such as vowels) by describing their acoustic structure rather than by describing the articulatory movements involved. A knowledge of acoustic phonetics is also beneficial for understanding how computers synthesize speech and how speech recognition works. To analyze speech, one has to work

from a recording. More information could be retrieved than is available from merely listening to a recording by making acoustic analyses of the sounds.

Sound consists of small variations in air pressure that occurs very rapidly one after another. These variations are caused by actions of the speaker's vocal organs that are (for the most part) superimposed on the outgoing flow of pulmonic air or lung air. In the case of voiced sounds, the vibrating vocal folds chop up the stream of lung air so that pluses of relatively high pressure alternate with moments of lower pressure. In fricative sounds, the airstream is forced through a narrow passage so that it becomes turbulent, with irregularity occurring peaks of pressure. The same principles apply in the production of other types of sounds. Variations in air pressure in the form of sound waves move through the air somewhat like ripples on a pond. When they reach the ear of a listener, they cause the eardrum to vibrate. A graph of the sound wave is very similar to a graph of the movements of the eardrum. The waveforms of speech sounds can be readily observed on a technological device.

The pitch of a sound depends on the rate of vibration of the vocal folds. In a sound with a high pitch, there is a higher frequency of vibration than in a sound with a low pitch. Because each opening and closing of the vocal folds causes a peak of air pressure in the sound wave, it can be estimated by looking into the rate of the peaks in the wave-form. In this way, frequency can be measured. Frequency is basically the number of complete repetitions (cycles) of variations in air pressure occurring in a second. The unit of frequency measurement is called Hertz, abbreviated as Hz. The frequency of the sound is 220Hzm if the vocal folds make 220 complete opening and closing movements in a second. The pitch of the sound is that auditory property that enables a listener to place it on a scale going from low to high, without considering its acoustic properties. In practice, when a speech sound goes up in frequency, it also goes up in pitch. It is possible to determine the frequency of a sound by counting the peaks of air pressure in a record of its waveform. By using a technological device, the graphical displays can be shown which correspond to the pitch. Voiceless sounds have no vocal fold pulses and therefore no pitch. The prominent frequencies in voiceless sounds are usually

above 2,000 Hz. In general, the loudness of a sound depends on the size of the variations in air pressure that occur.

The intensity is proportional to the average size, or amplitude, of the variations in air pressure. It is usually measured in decibels (abbreviated as dB) relative to the amplitude of some other sounds. Technically, to get to the dB difference one has to compare the power ratio, where the power is defined as the square of the mean amplitude (the mean variation in air pressure). The human ear can hear tolerate a range of about 120 dB. When one sound has an intensity 5 dB greater than another, then it is approximately twice as loud. The relation between pitch and frequency has been derived experimentally and used to form the Bark scale. Equal distances along the Bark scale correspond to equal changes in pitch. The mathematical relation between Hz and Bark is fairly complex. When dealing simply with the pitch of the voice, a straightforward linear plot of frequency is sufficient. Also, voice onset timing (VOT) is considered to measure the scales, which is a feature of the production of stop consonants, the length of time that passes between the release of a stop consonant and the onset of voicing, the vibration of the vocal folds. The relation between acoustic intensity and loudness is also nonlinear, but fortunately only slightly so. For all practical purposes one can consider differences in loudness to be simply related to differences in intensity, reported in dB. Each increase of 5 dB corresponds to a doubling of the perceived loudness.

Acoustic records are useful for studying various kinds of phonetic problems. Records of the waveform and the intensity provide a good way of studying variations in length. Hence, there must be a difference in quality. A set of vowel sounds provides a suitable starting point, since vowels can all be said on the same pitch and with the same loudness. The quality of a sound such as a vowel depends on its overtone structure. Putting this way, one can say that a vowel sound contains a number of different pitches simultaneously. There is a pitch at which it is actually spoken and there are the various overtone pitches that give it its distinctive quality.

There could be various phonation modes, based on the state of Glottis, namely: no voice, whisper, breathy voice, neutral (or modal), flow (or resonant), creaky-voice, pressed, falsetto, voiced, voiceless, etc. The vowels could have different pitches

based on the vowel types: 1. The height of the body of the tongue: high/close, mid (also have half/near-close, close-mid, open-mid, half/near-open), low/open, 2. The front-back position of the tongue: front, central, back, 3. The degree of lip rounding: rounded, unrounded. The characteristic overtones are called the formants of the vowels, the lower is called the first formants, and the higher the second formant. There is another characteristic overtone, the third formant, which is also present, but there is no simple way of demonstrating its pitch.

The formants that characterize different vowels are the result of the different shapes of the vocal tract. Any body of air, such as that in the vocal tract or that in a bottle, will vibrate in a way that depends on its size and shape. Smaller bodies of air, like smaller piano strings or smaller organ pipes, produce higher pitches. In the case of vowel sounds, the vocal tract has a complex shape so that the different bodies of air produce a number of overtones. A vowel has its own characteristic auditory quality, which is the result of the specific variations in air pressure due to its vocal tract shape being superimposed on the fundamental frequency produced by the vocal folds.

The general theory of formants was stated by the great German scientist Hermann Helmholtz (1863) almost 150 years ago. Even earlier, the English physicist Robert Willis (1829) had said, ‘A given vowel is merely the rapid repetition of its peculiar note.’ Willis was one of the first people to make an instrumental analysis of the acoustic structure of speech. But the notion of a single format (actually the second formant) had been observed several centuries earlier. Isaac Newton (1665/1730) wrote in his notebook: ‘The filling of a very deepe flagon with a costant streme of beere or water sounds ye vowels in this order w, u, ω, o, a, e, i, y.’ Spectrogram is used to analyze sounds and show their separate components. G. Oscar Rusell (1928), one of the pioneers in x-ray studies of vowels said, ‘Phoneticians are thinking in terms of acoustic fact, and using physiological fantasy to express the idea.’ In many cases, a consonant can be said to be a particular way of beginning or ending a vowel, and during the constant articulation itself there is no distinguishing feature.

The apparent point of origin of the formant for each place of articulation is called the locus of that place of articulation Evidence of voicing near the baseline during a consonant closure is called a voice bar. Wide-band spectrogram has been used in this case. When the vocal folds vibrate, they produce what are called harmonics of their fundamental frequency of vibration. Harmonics are vibrations at whole-number multiples if the fundamental frequency. Thus, when the vocal folds are vibrating at 100Hz, they produce harmonics at 200, 300, 400 Hz, and so on. Narrow-band spectrums are useful for determining the intonation, or tone, of an utterance. The most reliable measurements will be those of the length of the segments, for which purpose spectrograms are often even better than waveforms. Differences among vowels, nasals, and laterals can be seen on spectrograms, whereas it may be impossible to see these differences in the wave-forms.

Spectrograms are usually fairly reliable indicators of relative vowel quality. The frequency of the first formant certainly shows the relative vowel height quite accurately. The second formant reflects the degree of backness quite well, but there may be confusions due to variations in the degree of lip rounding. It is also possible to tell many things about the manner of articulation from spectrograms. For example, one can usually see whether a stop has been weakened to a fricative, or even to an approximant. Affrication of a stop can be seen on most occasions. Trills can be separated from flaps and voiced from voiceless sounds. One can also observe the relative rates of movement of different articulations. Spectrograms cannot be used to measure degrees of nasalization, nor are they much help in differentiating between adjacent places of articulations. For studying these aspects of speech, other techniques are more useful.

A speaker's speech habits are a significant factor in studying speech sounds. Spectrograms of a person's voice are sometimes called 'voice-prints' and they are said to be as individual as fingerprints. However, this is not the case. Nobody knows how many individuals share similar characteristics. Individual variation is also important from a general phonetic point of view. Spectrograms can show relative vowel quality. It is clearly true that one can use spectrograms to tell that the speaker has a higher vowel in 'three' than in the beginning of the vowel in 'here'. One can also use formant plots. But it is not easy to say if the vowel in a

given word as pronounced by one speaker is higher or lower than that of another speaker.

In general, when two different speakers pronounce sets of vowels with the same phonetic quality, the relative positions of these vowels on a formant chart will be similar, but the absolute values of the formant frequencies will differ from speaker to speaker. The simplest way to deal with this problem is probably to regard the average frequency of the fourth formant as an indicator of the individual's head size, and then express the values of the other formants as percentages of the mean fourth formant frequency. An alternative method is to assume that each set of vowels is representative of the complete range of a speaker's vowel qualities. Then one can express in that speaker's voice. Much of the work of the applied phonetician today is concerned with speech technology and are directed toward improving speech synthesis systems.

The greatest challenges in the field of speech synthesis are concerned with improvements in intonations and rhythm. Synthetic speech often sounds unnatural because the intonation is too stereotyped. In order to get the correct pitch changes, one must know the speaker's attitude to the world in general and to the topic under discussion, In addition, the syntax of the utterance must be taken into account, as well as various higher level pragmatic considerations, such as whether the word or a synonym of it has been used in previous sentence. In order to describe the various languages of the world, one needs to consider the total range of the phonetic capabilities of humans.

Rhythmic properties of speech and language have been a matter of long-standing debates, with both traditional production and perception studies delivering controversial findings. For decades, this seemingly simple but profoundly important question that connects language with other aspects of human cognition has been controversially debated (Cummins, 2012; Roach, 1982). Early accounts of linguistic rhythm suggest that it relies on some acoustic isochrony in spoken language—either at the level of syllables or inter-stress intervals (Abercrombie, 1967). However, this idea did not stand up to acoustic measurement as no temporal analyses of speech have ever provided any evidence for an isochrony-based rhythm

(Dauer, 1983; Fowler & Tassinary, 1981; Pointon, 1980; Roach, 1982; Uldall, 1971; van Santen & Shih, 2000). The failure to find isochrony in speech has led to the development of alternative approaches.

One of the most prominent proposals has suggested that linguistic rhythm may be ascribed to the durational variability present in consonantal and vocalic intervals, with languages being more or less variable and thus sounding rhythmically different. Initially appealing and fueling much research into the cross-linguistic study of rhythm, this approach has been recently critiqued as empirically inadequate and misrepresenting the issue at heart (Arvaniti, 2009, 2012; Arvaniti & Rodriquez, 2013; Barry, Andreeva, & Koreman, 2009; Kohler, 2009; Rathcke & Smith, 2015a, 2015b; Wiget et al., 2010). The latest attempts at capturing rhythmic properties of spoken language involve analyses of the prosodic hierarchy and its temporal signatures, i.e., durational implementation of the hierarchical structure of linguistic utterances (Rathcke & Smith, 2015a; White, Payne, & Mattys, 2009), though this proposal has also seen some counterevidence (Mairano, Santiago, & Romano, 2015).

Other recent approaches are less theoretically than acoustically driven, and rely on signal analyses such as properties of the amplitude envelope to capture some rhythmic properties in language (Goswami et al., 2002; Port, Cummins, & Gasser, 1995; Šturm & Volín, 2016; Tilsen & Arvaniti, 2013). Following on from these diverse and controversial accounts of rhythm, ideas have been put forward that language has a scale of rhythmicity (Kohler, 2009), is only occasionally rhythmic (White, Mattys, & Wiget, 2012), or even anti-rhythmic (Nolan & Jeon, 2014). Durational intervals in the linguistic input is to be measured in this case.

The Source-Filter Theory, also known as one of the major acoustic theories of speech production, explains how speech sounds are produced. It posits that speech production involves two main stages: a source of sound (vocal fold vibrations) and a filter (vocal tract) that shapes that sound. It was Fant (1942) who built off the work of Tsutomu Chiba and Masato Kajiyama (1941), to show the relationship between a vowel's acoustic properties and the shape of the vocal tract. For voiced sounds, it's the vibration of the vocal folds, creating a complex glottal tone. For

voiceless sounds, it can be turbulent airflow created by constrictions in the vocal tract. The vocal tract (mouth, throat, and nose) acts as a filter, modifying the sound's spectrum. The shape and size of the vocal tract determine which frequencies are amplified and attenuated, shaping the sound into different speech sounds. This theory focuses on the physical modeling of speech sounds distinguishes between different phonemes (vowels, consonants). Fricatives, such as [s] and [f], have at least one source due to turbulent noise produced in the oral cavity or pharynx and for [z] and [v], there are two sources, one at the glottis and one at the supra-glottal constriction. It also measures pitch, duration, intensity.

Distinctive Feature Theory (1968) distinguishes one sound from another within a language. For example, the feature [+voice] distinguishes the two bilabial plosives: [p] and [b] (i.e., it makes the two plosives distinct from one another as one is voiceless and the other is voiced). Since the inception of the phonological analysis of distinctive features in the 1950s, features traditionally have been specified by binary values to signify whether a segment is described by the feature; a positive value, [+], denotes the presence of a feature, while a negative value, [−], indicates its absence. Thus, [b] is [+V], and [p] is [-V]. After the first distinctive feature theory was created by Russian linguist Roman Jakobson in 1941, it was assumed that the distinctive features are binary and this theory about distinctive features being binary was formally adopted in ‘Sound Pattern of English’ by Noam Chomsky and Morris Halle in 1968. Jakobson (1941) saw the binary approach as the best way to make the phoneme inventory shorter and the phonological oppositions are naturally binary.

In recent developments, phonologists have proposed the existence of single-valued features. Major Class Features include: [+/− syllabic]: functions as a nucleus of a syllable: [+syllabic] designates all vowels, while [−syllabic] designates all consonants, [+/− consonantal]: produces significant blockage of airflow for consonants but not vowels, [+/− sonorant]: produces continuous turbulent airflow: for vowels and voiced consonants. Laryngeal Features are [+/-voice]: vocal colds vibration for voiced consonants, [+/-spread glottis]: vocal folds are spread for aspiration: consonants, specifically voiceless plosives like [p], [t], and [k], that are released with a noticeable puff of air, [+/-constricted glottis]: glottis is constricted

as in glottal stops which could be most sounds. Manner Features are [+/-continuant]: air flows continuously through oral cavity such as +:[v], [s] or -:[b], or [d], [+/-nasal]: air flows through nasal cavity, [+/-lateral]: air flows through the sides of the tongue, [+/-delayed release]: stops followed by a fricative release, [+/-strident]: high intense sounds such as fricatives and affricates. Place Features are [+/-labial]: involves lips, [+/-rounded]: lips are rounded, [+/-coronal]: tongue blades raised such as +: [t], [d] and -: [p], [m], [+/-anterior]: blockage at the front of the oral cavity such as +: [t], -: [k], [+/-distributed]: blockage spread over a larger area such as +: [ʃ], [ʒ] and -: [t], [d], [+/-high]: tongue's body raised such as +: [k], -: [m], [+/-low]: tongue's body lowered such as +: [ɑː], -: [k], [+/-back]: tongue's body retracted such as +[k], -:[e], [+/-tense]: greater articulatory effort such as +[i:], -: [ɪ]. This theory is useful for segmental analysis and phonological features for places, manners, voicing, cavity etc., for preparing feature matrix. It provides efficient description of phonological rules, assists to prepare cross-linguistic comparisons, and can be used as a foundation for speech technology.

The major class features can be identified with their descriptions. Such as if there is a peak in intensity showing clear formant structure, it is showing vowels. In that case, it will be [+syllabic]. Thus, Syllabic feature is identified. Reduced or absent formant structure, increased constriction, often with noise or silence identifies Consonants. Clear formant structure without aperiodic noise identifies Sonorants. For Voicing: regular glottal pulses, Spread Glottis: aspiration and high-frequency aperiodic energy, Constricted Glottis: irregular or creaky voicing, Continuant: continuous airflow with no closure, Nasal: voicing with low-frequency energy and nasal murmur around, Lateral: voiced segments with a drop in F2 and dark zones due to side-channel airflow, Delayed Release: a burst followed by fricative noise, visible in the spectrogram, Strident: shows intense high-frequency noise, Labial: displays weak formant transitions, especially flat F2, and show a lower burst, Rounded: lowering of F2, a cue for lip rounding, Anterior: have concentrated energy in the higher frequency region, indicating front articulations, Coronal: higher F2 transitions, bursts may appear more concentrated in the mid-frequency range, Distributed: shows broader spectral energy, High: shows low F1, indicating a high tongue position, Low: shows high F1, reflecting a low tongue position, shows low F2, signaling tongue retraction, Back/Retracted: shows low F2,

indicating back tongue placement, Tense: typically have higher F2 and longer duration.

Following the feature detection theory, phonological features can also be identified. For example, Labialized /◌ʷ/ shows lowered F2, rounding/backing effect, Nasalized /◌̃/shows (~250–300 Hz), higher formants, Dental /◌̪/ energy shifted lower, Bidental /◌̼/ irregular friction, low-frequency energy with broad, indistinct pattern, Palatalized /◌ʲ/shows raised F2, due to fronted tongue position, Velarized /◌ˠ/ shows lowered F2, reflects tongue body retracted toward velum, Pharyngealized /◌ˤ/shows lowered F2, raised F1 due to tongue root retraction, Apical /◌̺/ shows peaks, higher-frequency, Laminal /◌̻/shows broader spectral shape due to flat tongue, Devoicing /◌̥/ shows low voicing, Unaspirated /◌⁼/ shows that voicing begins quickly after stop release, Reiteration /p/p/p/shows repeated closure-release bursts, Double Articulation /◌͡◌/ shows overlapping energy patterns, Unintelligible Speech /¤/ shows that spectral noise, interruptions, or distortions, and also formants not clearly visible, Low Tone (˩) shows lower F0 contour in pitch, Breathy Voice (◌̤) may shows high frequency noises, weaker harmonics, Weak Articulation (◌̗) may show lower intensity, blurred formants, and many.

Gestural Phonology (Browman and Goldstein,1992) views speech sounds as sequences of articulatory movements, or ‘gestures,’ rather than abstract units like phonemes, provides a motor-based perspective on phonology and explains speech sound changes. Phonetic Underspecification Theory (Halle, 1970) suggests that only the most necessary (or distinctive) features can be stored, and the rest are filled in based on context or default rules during speech production, reduces the amount of information needed to store in the lexicon and facilitates phonological processing by simplifying phonological rules. Experimental Phonetics has three core branches which are, Articulatory Phonetics: focuses on the physical movements of the vocal organs (lips, tongue, etc.) during speech , Acoustic Phonetics: studies the physical properties of speech sounds, including frequency, amplitude, and duration, and Auditory Phonetics: investigates how listeners perceive and interpret speech sounds.

2.2. The Systematic Representation of Speech Sounds

According to Prof Handke (2020), a central question in phonology concerns the basic elements of sound structure, i.e., the phonemes. A systematic representation of the phonemes is necessary to document a language accurately.

2.2.1. The International Phonetic Alphabet and its Context: The alphabetic system of phonetic notation is called the International Phonetic Alphabet (IPA) which displays all the possible characteristics of the identified human speech sounds. Notes from International Phonetic Association **i**ncludes the IPA symbols, Consonants, Vowels, Clusters, Stress, Conventions, Prosody, Orthographic representation along with the broad and narrow transcriptions, Romanization, Tone, Geminating, Assimilations. It also includes the principles of the International Phonetic Association, Computer Coding of the IPA System, phonetic Diacritic and Suprasegmental symbols, symbols for Tones, Accents, Delimitations, Extended IPA Chart. Following the IPA chart, given next are the places and manners of articulation.

i. Bilabial: using closing movement of both lips, e.g., [p] (e.g., pat in English), [b] (e.g., bat in English), [m] (e.g., mat in English), [w] (e.g. water in English)
ii. Labio-Dental: using lower lip and the upper teeth, e.g., [f] (e.g., fish in English) and [v] (e.g., vote in English)
iii. Dental: the tongue tip is used either between the teeth or close to the upper teeth, e.g., [θ] (e.g., thanks in English) and /ð/ (e.g., that in English)
iv. Alveolar: the blade of the tongue is used close to the Alveolar Ridge, e.g., [t] (e.g., time in English) and [d] (e.g., date in English), [s] (e.g., sea in English), [z] (e.g., zoo in English), [n] (e.g., never in English), [l] (e.g., letter in English)
v. Palato-Alveolar or Post-Alveolar: the blade (or tip) of the tongue is used just behind the Alveolar Ridge, e.g., [ʧ] (e.g., chair in English) and [ʤ] (e.g., jog in English), [ʃ] (e.g., ship in English) and [ʒ] (e.g., zip in English), [r] (e.g., river in English)

vi. Retroflex: the tongue has a flat, concave, or even curled shape, and is articulated between the Alveolar Ridge and the hard palate., e.g., [ɳ] (e.g., गुण in Hindi, IPA [guɳa], meaning 'virtue')

vii. Palatal: the front of the tongue is raised close to the palate, e.g., [j] (e.g., yes in English)

viii. Velar: the back of the tongue is used against the soft palate, e.g., [k] (e.g., kite in English), [g] (e.g., gate in English) and [ŋ] (e.g., sing in English)

ix. Uvular: the back of the tongue against or near the uvula, that is, further back in the mouth than velar consonants, e.g. /ʀ/ (e.g. Paris in French, IPA [paːˈʀiː], meaning 'Paris')

x. Pharyngeal/Epiglottal: the back of your tongue against the Pharynx, e.g., [ʕ] (e.g., عِلْم in Arabic, IPA [ʕilm], meaning 'knowledge')

xi. Glottal: the gap between the vocal cords is used to make audible friction, e.g., [h] (e.g., hat in English)

Given next are the Manners of Articulations.

i. Stop or Plosive: pulmonic consonant in which the vocal tract is blocked so that all airflow ceases, e.g., [p] (e.g., pat in English) and [b] (e.g., bat in English) (bilabial closure), [t] (e.g., time in English) and [d] (e.g., date in English) (alveolar closure), [k] (e.g., kite in English) and [g] (e.g., gate in English) (velar closure)

ii. Nasal (also called Nasal Occlusive or Nasal Stops): an occlusive consonant produced with a lowered velum, allowing air to escape freely through the nose, e.g., [m] (e.g., month in English) (bilabial closure), [n] (e.g., night in English) (alveolar closure), [ŋ] (e.g., sang in English) (velar closure)

iii. Fricative: a consonant produced by forcing air through a narrow channel made by placing two articulators close together, [f] (e.g., fish in English), [v] (e.g., vote in English) (labio-dental closure), [θ] (e.g., think in English), [ð] (e.g., that in English) (dental closure), [s] (e.g., sing in English), [z] (e.g., zoo in English) (alveolar closure), [ʃ] (e.g., shut in English), [ʒ] (e.g., pleasure in English) (palate-alveolar closure); higher pitched sounds with a

more obvious hissing sound are sometimes called sibilants, thus, Fricatives could be sibilants and non-sibilants

iv. Approximant: an articulation in which one articulator is close to another, but without the vocal tract being narrowed to such an extent that a turbulent airstream is produced; there are two types of Approximants: Central – [w] (e.g., wish in English), [y] (e.g., yes in English), [r] (e.g., red in English) and Lateral – [l] (e.g., light in English)

v. Affricate: an affricate is a consonant that begins as a stop and releases as a fricative, e.g., [ʧ] (e.g., chair in English) and [ʤ] (e.g., jog in English)

vi. Additional Consonantal Articulations: Tap (often called Flap) is a type of consonantal sound, which is produced with a single contraction of the muscles so that one articulator (such as the tongue) is thrown against another, (e.g., latter in North American English, IPA [læɾɚ]); and Trill (often called Roll) which is a type of consonantal sound produced by vibrations between the active articulator and passive articulator; (e.g., 'perro' in Spanish, IPA [ˈpe̞ro̞], meaning 'dog')

In the production of vowel sounds, the articulators do not come very close together, and the passage of the airstream is relatively unobstructed. They are usually voiced and can be described in terms of three factors; 1. The height of the body of the tongue: high/close, mid (also have half/near-close, close-mid, open-mid, half/near-open), low/open, 2. The front-back position of the tongue: front, central, back, 3. The degree of lip rounding: rounded, unrounded. Based on the usage of units, there are three types of vowels: Monothong/Monophthong: a single vowel, Diphthong: a double vowel, Triphthong: a union of three vowels.

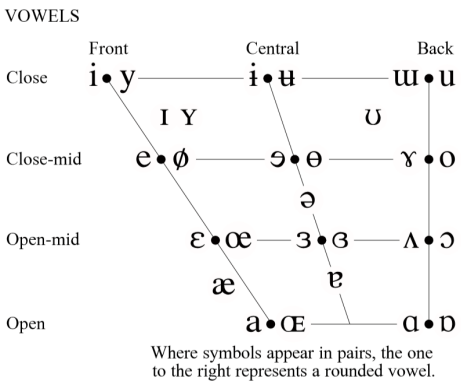


Figure 02: The Vowel Chart (IPA, 2020)

Given below are the list of high/close vowel sounds.

i. [i] = close front unrounded vowel, or high front unrounded vowel; often associated with length, e.g., free in English, IPA [fri:]
ii. [y] = close front rounded vowel, or high front rounded vowel, often associated with length, e.g., tu in French, IPA [t̪y], meaning ‘you’
iii. [ɨ] = close central unrounded vowel, or high central unrounded vowel, e.g., shí in Chinese, IPA [ʃɨ], meaning ‘ten’
iv. [ʉ] = close central rounded vowel, or high central rounded vowel, e.g., nu in Standard Northern Dutch, IPA [nʉ], meaning ‘now’
v. [ɯ] = close back unrounded vowel, or high back unrounded vowel, e.g., ‘**空気** /kūki’ in Japanese, IPA [kɯːki], meaning ‘air’
vi. [u] = close back rounded vowel, or high back rounded vowel, often associated with length, e.g., boot in English, IPA [bu:t]

Given next are the list of half/near-close vowel sounds.

i. [ɪ] = near-close front unrounded vowel, or near-high front unrounded vowel; e.g., him in English, IPA [hɪm]
ii. [ʏ] = near-close front rounded vowel, or near-high front rounded vowel, e.g., lune in French, IPA [lʏn], meaning ‘moon’
iii. [ʊ] = near-close near-back rounded vowel, or near-high near-back rounded vowel, e.g., ‘তুমি’ in Bangla, IPA [ˈt̪ʊmiː], meaning ‘you’

Given next are the list of close-mid vowel sounds.

i. [e] = close-mid front unrounded vowel, or high-mid front unrounded vowel; e.g., ‘red’ in English, IPA [red]
ii. [ø] = close-mid front rounded vowel, or high-mid front rounded vowel; e.g., ‘peu’ in French, IPA [pø], meaning ‘few’
iii. [ɘ] = close-mid central unrounded vowel, or high-mid central unrounded vowel; e.g., mysz in Polish, IPA [mɘ̟ʂ], meaning ‘mouse’
iv. [ɵ] = close-mid central rounded vowel, or high-mid central rounded vowel; e.g., ‘je’ in French, IPA [ʒɵ], meaning ‘I’
v. [ɤ] = close-mid back unrounded vowel, or high-mid back unrounded vowel; e.g., thoe in Thai, IPA [tʰɤː], meaning ‘you’

vi. [o] = close-mid back rounded vowel, or high-mid back rounded vowel; e.g., réseau in French, IPA [ʁezo], meaning ‘network’

Given below are the list of mid vowel sounds.

i. [ə] = mid central vowel; e.g., sofa in English, IPA [ˈsəʊfə]

Given below are the list of open-mid vowel sounds.

i. [ɛ] = open-mid front unrounded vowel, or low-mid front unrounded vowel; e.g., ‘天/tiān’ in Chinese, IPA [tʰi̯ɛn˥], meaning ‘sky’
ii. [œ] = open-mid front rounded vowel, or low-mid front rounded vowel; e.g., ‘長/cheung’ in Chinese, IPA [tsʰœːŋɻ], meaning ‘long’
iii. [ɜ] = open-mid central unrounded vowel, or low-mid central unrounded vowel; e.g., ‘bird’ in English, IPA [bɜːd]
iv. [ɞ] = open-mid central rounded vowel, or low-mid central rounded vowel; e.g., ‘port’ in French, IPA [pɞːʁ] meaning ‘port’
v. [ʌ] = open-mid back unrounded vowel or low-mid back unrounded vowel; e.g., ‘hut’ in English, IPA [hʌt]
vi. [ɔ] = open-mid back rounded vowel, or low-mid back rounded vowel; e.g., thought in English, IPA [θɔːt]

Given below are the list of half/near-open vowel sounds.

i. [æ] = near-open front unrounded vowel, or near-low front unrounded vowel; e.g., bat in English, IPA [bæt]
ii. [ɐ] = near-open central vowel, or near-low central vowel; e.g., ‘পা/pa’ in Bangla, IPA [pɐ] meaning ‘leg’

Given below are the list of open vowel sounds.

i. [a] = open front unrounded vowel, or low front unrounded vowel; e.g., أنا/anaa in Arabic, IPA [anaː] meaning ‘I - 1st person singular pronoun’
ii. [ɶ] = (near) open front rounded vowel, or (near) low front rounded vowel; e.g., ‘öra’ in Swedish, IPA [ˈɶːra̠] meaning ‘ear’
iii. [ɑ] = open back unrounded vowel, or low back unrounded vowel; e.g., ‘棒/bang’ in Chinese, IPA [pɑŋ˧˥] meaning ‘stick’

iv. [ɒ] = open back rounded vowel, or low back rounded vowel; e.g., fog in English, IPA [fɒg]

The Non-Pulmonic Consonants, on the other hand, can be categorized into three distinct features. These are; (a) Clicks, which are obstruents articulated with two closures (points of contact) in the mouth, one forward and one at the back, (b) Implosives – which are a group of stop consonants (and possibly also some affricates) with a mixed glottalic ingressive and pulmonic egressive airstream mechanism, and (c) Ejectives – which are usually voiceless consonants that are pronounced with a glottalic egressive airstream. The clicks could be Velar (Tenuis, Voiced, Nasal) or Uvular (Tenuis Lateral, Voiced Lateral, Nasal Lateral). Clicks could be Labial (ʘ) or (ɋ) or (pc), Dental (ǀ) or (ɬ) or (c) , Alveolar (!) or (ǃ) or (ᶝ) or (q), Slapped (!ˌ), Retroflex (ǃ̣) or (ψ), Domed (ǂʲ), Palatal (ǂ) or (Ↄ a) or (v ç tc qc b) or (ǀ́), Lateral (ǁ) or (ʖ) or (x), Labiolingual (ǀ̪), Velar (ɧ).

There are also complex clicks, such as, epiglottal release (ǂ͡kx’) or (ǂᴴ/), velar release (ɡ͡ʘ, ɡ͡ǀ, ɡ͡ǃ, ɡ͡ǂ, ɡ͡ǁ) and uvular release (ɢ͡ʘ, ɢ͡ǀ, ɢ͡ǃ, ɢ͡ǂ, ɢ͡ǁ). Implosives are indicated by modifying the top of a letter (voiced stop) with a rightward-facing hook: (ɓ, ɠ, ɗ, ᶑ, ɠ, ƒ, ᶂ, ʃ, ƈ, ɠ, ƙ, ɠ͡ɓ, ƙ͡ɠ, ƈ, ɋ) or occasionally (p’↓, t’↓, ʈ’↓, c’↓, k’↓) or often with a superscript left pointer, (p<, t<, ʈ<, c<, k<). Ejective consonants are marked with (p’, pʷ’, pˤ’, t’, ʈ’, ʈ’, tʷ’, t͡p’, c’, ʔ’ k’, ɡ͡k’/g’, k͡p’, kʲ’, kʷ’, q’, qʲ’, qʷ’, qˤ’, qˤʷ’, ɢ͡q’/ɢ’= Stops), (ɸ’, f’, θ’, s’, ʃ’, ʃʷ’, ʂ’, ɕ’, ç’, x’, χ’, xʷ’, χʷ’ = Fricatives), (p̪f’, t̪θ’, ts’, d͡ts’/dz’, tʃ’, d͡tʃ’ (dʒ’), ʈʂ’, t͡ʂ’ t͡sʷ’, t͡ʃʷ’, tʃ’, tɕ’, t͡ɕ’, t͡ɕʷ’, cç’, c͡ʎ̝̊’, k͡ʟ̝̊’, k͡ʟ̝̊ʷ’, kx’, ɡ͡kx’/gɣ’, qχ’, ɢ͡qχ’/ɢʁ’ = Affricates), (l’, ɬ’, tɬ’, c͡ʎ̝̊’, k͡ʟ̝̊’ = Lateral), and (r’ = Approximant).

There is also a possibility of Trill (ʀ̥’) and Nasal sounds (m’, n’, ŋ’) theoretically. An apostrophe indicates weak ejection and an exclamation mark strong ejection, such as k̓ , k! or k’’. Often double letters are used such as in case of (t’, k’, q’, tɬ’, ts’), (tt, kk, qq, ttl, tts) to be used sequentially. Co-articulated consonants are also observed, such as Labial–Alveolar Nasal (n͡m), Labial–Velar Nasal (ŋ͡m), Labial–Alveolar Plosive (t͡p, d͡b), Labial–velar Plosive (k͡p, ɡ͡b), Uvular–Epiglottal Plosive (q͡ʡ), Labial–Palatal Fricative/Approximant (ɥ̊, ɥ), Labial–Velar Fricative/Approximant (ʍ, w), Sj-sound Fricative/Approximant (ɧ), Velarized-

Alveolar Lateral Approximant (ɬ). The IPA Chart also lists symbols for the Suprasegmental features such as possible tones and accents by using Diacritics, and other listed/selected symbols.

Given next, is the IPA Chart (Revised Version: 2020).

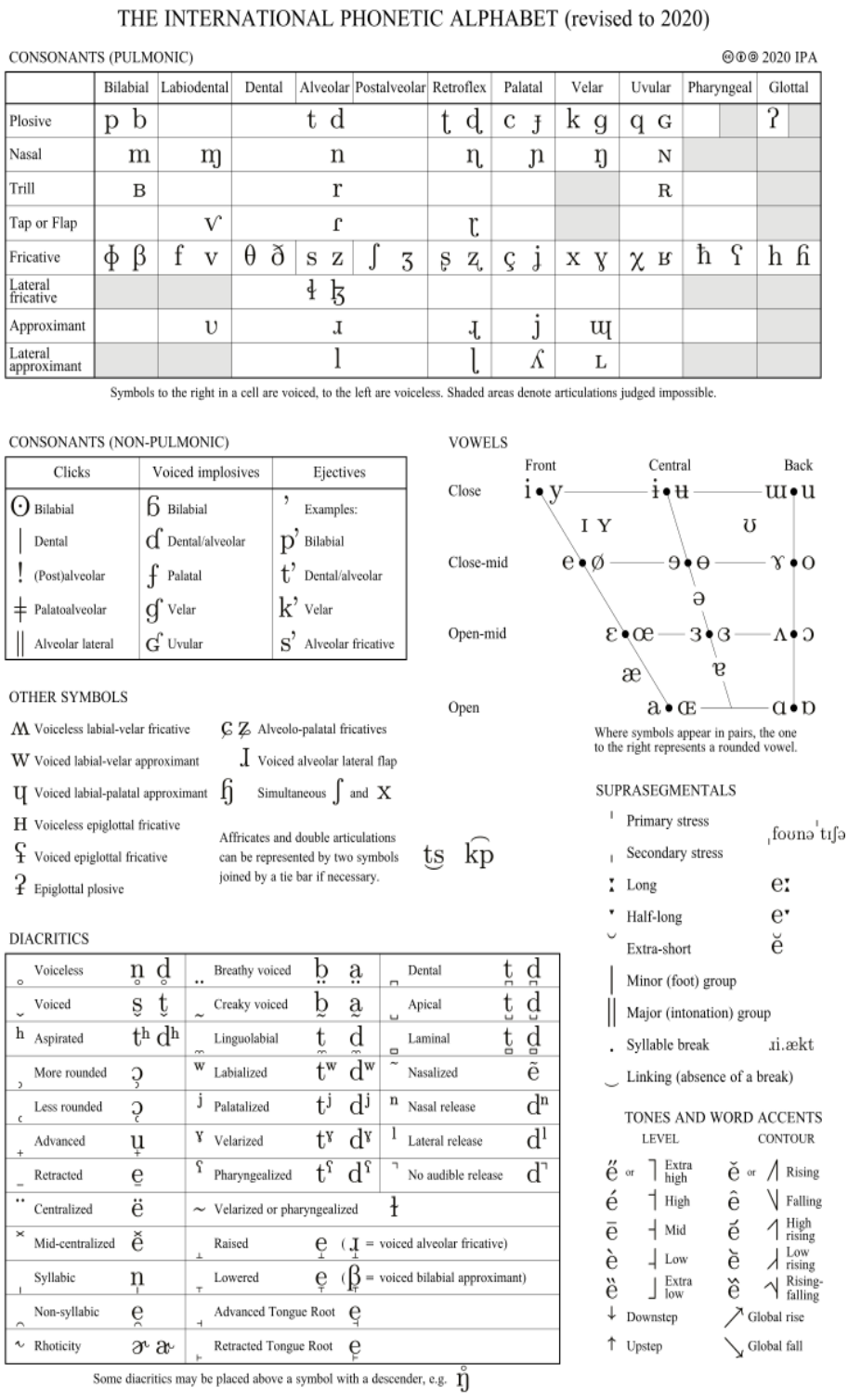


Figure 03: The International Phonetic Alphabet (revised to 2020)

2.2.2. Revisions of extIPA Chart and its Necessity

The extIPA symbol set was introduced some twenty-five years ago. Since that time, some minor changes have been introduced to the extIPA chart but no major rearrangement has been attempted. The 2010 Oslo meeting of ICPLA (International Clinical Phonetics and Linguistics Association) started a revision of the extIPA chart, and this process was recently completed.

A revised extIPA chart was approved at the 2016 ICPLA meeting. At the 1989 Kiel Convention of the IFA:' a sub-group was established to draw up recommendations for the transcription of disordered speech. The report produced at the Convention appeared in print in Duckworth, Allen, Hardcastle, and Ball (1990), being mainly a list of symbols, termed 'Extensions to the IPA', or 'ExtIPA' for short.

Examples of the use of the extIPA symbols are given in Ball (1991), Howard (1993) and Ball, Code, Rahilly and Hazlett (1994) among others, and Ball (1993) includes those at textbook level. Various changes and additions to the original set of symbols are reported in Bernhardt and Ball (1993). The changes meant, however, that there was a need for a listing of the current set of symbols, preferably in as concise a form as possible.

There was also a need for the symbol set to receive overt recognition from a relevant society, therefore the 1994 publication in JIPA marked the official adoption of the ExtIPA symbols by the International Clinical Phonetics and Linguistics Association (ICPLA). This article also includes a revised version (1997) of the ExtIPA for Disordered Speech. The revision involved the addition, the modification and removal of categories and symbols.

The places of articulation in extIPA are (other than those on the IPA chart);

i. Bilabial: using closing movement of both lips, e.g., [p] (e.g., pat in English), [b] (e.g., bat in English), [m] (e.g., mat in English), [w] (e.g., water in English)
ii. Labio-Dental: using lower lip and the upper teeth, e.g., [f] (e.g., fish in English) and [v] (e.g., vote in English)

iii. Labio-Alveolar: using the lips and the Alveolar Ridge, e.g., [p̪]

iv. Dento-Labial: involving the teeth and lips, e.g., [p̼]

v. Bidental: articulated with both the lower and upper teeth, e.g., [p̪̼]

vi. Linguolabial (or Apicolabial): consonants articulated by placing the tongue tip or blade against the upper lip, which is drawn downward to meet the tongue, e.g., [n̼] (e.g., n̼isi in Araki, IPA [n̼isi], meaning 'still')

vii. Inter-Dental: are produced by placing the tip of the tongue between the upper and lower front teeth, e.g., [t̪]

viii. Alveolar (Lower Alveolar): the blade of the tongue is used close to the Alveolar Ridge, e.g., [n̺]

ix. Retroflex: the tongue has a flat, concave, or even curled shape, and is articulated between the Alveolar Ridge and the hard palate., e.g., [ɳ] (e.g., 'ठंडा' in Hindi, IPA [ʈʰəɳɖaː], meaning 'cold')

x. Palatal: the front of the tongue is raised close to the palate, e.g., [j] (e.g., yes in English)

xi. Velar (Velo-Dorsal): the back of the tongue is used against the soft palate, e.g., [ŋ̺]

xii. Velo-Pharyngeal: the back of the tongue is used along with the Pharynx, e.g., [ŋ̟]

xiii. Upper-Pharyngeal: typically pronounced at the upper pharynx, e.g., [ɢ̞]

Given next are the manners of articulation in the extIPA;

i. Stop or Plosive: pulmonic consonant in which the vocal tract is blocked so that all airflow ceases, e.g., [p] (e.g., pat in English) and [b] (e.g., bat in English) (bilabial closure), [t] (e.g., time in English) and [d] (e.g., date in English) (alveolar closure), [k] (e.g., kite in English) and [g] (e.g., gate in English) (velar closure)

ii. Denasal: a quality of the voice caused by blocked nasal passages, e.g., [n̺]

iii. Nasal (also called Nasal Occlusive or Nasal Stops): an occlusive consonant produced with a lowered velum, allowing air to escape freely through the nose,

e.g., [m] (e.g., month in English) (bilabial closure), [n] (e.g., night in English) (alveolar closure), [ŋ] (e.g., sang in English) (velar closure)

iv. Fricative-Nasal: a consonant produced by forcing air through a narrow channel made by placing two articulators close together and using the nasal passage, e.g., [n̊̃]. Nasal fricatives vary in articulatory, aerodynamic, and acoustic-perceptual characteristics with two generally distinct types recognized

v. Median Fricative: a consonant produced by forcing air through a narrow channel in the middle of the oral cavity made by placing two articulators close together, e.g., [f̲]

vi. Lateral Fricative: sounds in which the channel through which the air flows is narrowed to the point that the flow of air becomes turbulent and noisy and here the tip of the tongue touches the back of the upper teeth, e.g., [ɬ̪]

vii. Median+Lateral Fricative: a consonant produced by forcing air through a narrow channel made by placing two articulators close together and using the nasal passage with a noisy turbulent airflow, the tip of the tongue touches the back of the upper teeth, e.g., [ɮ̪]

viii. Lateral Approximant: an articulation in which one articulator is close to another, but without the vocal tract being narrowed to such an extent that a turbulent airstream is produced; the tip of the tongue touches the back of the upper teeth, e.g., [l] (e.g., light in English)

ix. Percussive: resonant, hyper-resonant, stony dull or dull, e.g., [ʬ]

Given next is the extIPA for disordered speech (2015).

extIPA SYMBOLS FOR DISORDERED SPEECH

(Revised to 2015)

CONSONANTS (other than those on the IPA Chart)

	Bilabial	Labio-dental	Labio-alveolar	Dento-labial	Bidental	Linguo-labial	Inter-dental	Alveolar	Retroflex	Palatal	Velar	Velo-pharyngeal	Upper pharyngeal
Plosive		p̪ b̪	p͇ b͇	p̪͆ b̪͆		t̪ d̪	t̪͆ d̪͆						ʠ ɢ͆
Nasal			m̥͇ m͇	m̥͆ m̪͆		n̥̪ n̪	n̥̈ n̈						
Trill						r̪	r̪͆					ʗ ʛ	
Fricative, median			f͇ v͇	f̪͆ v̪͆	ɦ̪ ʜ̪	θ̪ ð̪	θ̪͆ ð̪͆	θ͇ ð͇				ɧ ɧ	
Fricative, lateral						ɬ̪ ɮ̪	ɬ̪͆ ɮ̪͆		ɬ ɮ	ʎ̝ ʎ̞	ʟ̝ ʟ̞		
Fricative, lat. + med.								ɬs ɮz					
Fricative, nasal	m̥̃ m̃	m̥̃ ñ̪						ñ̥ ñ	ɳ̊ ɳ̃	ɲ̊ ɲ̃	ŋ̊ ŋ̃		
Approxt., lateral						l̪̈	l̪̈͆						
Percussive	ʬ ʬ				⫏								

DIACRITICS

◌͇ labial spreading:	s͇	◌̃, ◌̽ denasal, partial denasal:	m̃ n̽	◌˒ main gesture offset right:	s˒
◌͈ strong articulation:	f͈	◌̃ fricative nasal escape:	ṽ	◌˓ main gesture offset left:	s˓
◌̗ weak articulation:	ɣ̗	◌̤ velopharyngeal friction:	s̤ ʒ̤	◌ʷ whistled articulation:	sʷ
\ reiteration:	p\p\p	↓ ingressive airflow:	p↓	◌◌ sliding articulation:	θs

CONNECTED SPEECH, UNCERTAINTY ETC.

(.) (..) (...)	short, medium, long pause
f, *fff*	loud(er) speech: [{ˌ laʊd ˌ}]
p, *ppp*	quiet(er) speech: [{ˌ kwaɪət ˌ}]
allegro	fast speech: [{*allegro* fast *allegro*}]
lento	slow speech: [{*lento* sloʊ *lento*}]
crescendo, *ralentando* etc. may also be used	
◯, Ⓒ, Ⓥ	indeterminate sound, consonant, vowel
Ⓕ, ⓟ etc.	indeterminate fricative, probably [p] etc.
( )	silent articulation, e.g. (ʃ), (m)
(( ))	extraneous noise, e.g. ((2 sylls))

VOICING

◌ˬ	pre-voicing:	ˬz	
◌ˬ	post-voicing:	zˬ	
◌̥	partial devoicing:	z̥ ʒ̥	
◌̬	initial partial devoicing:	z̬ ʒ̬	
◌̥	final partial devoicing:	z̥ ʒ̥	
◌̬	partial voicing:	s̬	
◌̬	initial partial voicing:	s̬	
◌̬	final partial voicing:	s̬	
◌⁼	unaspirated:	p⁼	
ʰ◌	pre-aspiration:	ʰp	

OTHER SOUNDS

ɻ̪	apical-r
r̈	bunched-r (molar-r)
s̻ z̻	laminal fricatives (incl. lowered tongue tip)
kˡ etc.	[k] with lateral fricated release etc.
tˡᵝ dˡᶻ	[t, d] with lateral and median release
tˠ̪ etc.	[t] with interdental aspiration etc.

t͡θ̪	linguolabial affricate etc.
ʞ ɒ̪ ɠ̪	velodorsal oral and nasal stops
¡	sublaminal lower alveolar percussive
!¡	alveolar click with sublaminal percussive release
ʘ͡r̪̃	buccal interdental trill (raspberry)
*	sound with no available symbol

Figure 04: extIPA Symbols for Disordered Speech (Revised to 2015)

2.2.3. Phonetic Transcription and Diacritics: Phonetic transcription (also known as phonetic script or phonetic notation) is the visual representation of the human speech sounds (or phones) by means of symbols or phonetic alphabet, such as the International Phonetic Alphabet. In all systems of transcription there is a distinction between broad/simplified transcription and narrow/detailed transcription. Broad transcription indicates only the most noticeable phonetic features of an utterance, whereas narrow transcription encodes more information about the phonetic characteristics of the allophones in the utterance. The difference between broad/simplified and narrow/detailed is a continuum, but the difference between phonemic and phonetic transcription is usually treated as a binary distinction. The broad/simplified transcription is mostly used.

2.2.4. Characteristics and Transcription of Typical and Atypical Speech: A transcription system for disordered speech needs to provide sufficient diversity of symbols and diacritics to account for the majority of observed phonetic variants. This section includes the existing studies in phonetic features, that including typical and atypical speech in adults, since the research focuses on adult speakers. This includes the basic principles of articulatory and acoustic features such as Linguistics and Suprasegmental features; i.e., consonant sounds, vowel sounds, clusters, places and manners of articulation, voicing, stress, intonation, duration or length of speech sounds, syllables, pitch patterns and related concepts to explain typical speech. It also includes the cross-linguistic studies on atypical speech, including the assessment procedures for adult speakers along with existing challenges.

This definitely shall benefit in Specific Language Impairments (SLI) and Speech Sound Disorders (SSD). Though, the participants of this research are adult speakers, it is imperative to look into the phonological development in children as the patients from SLI and SSD might suffer due to lacking the basic phonological features. Childhood speech and language difficulties often persist into adolescence (Conti-Ramsden & Durkin, 2007; Conti-Ramsden, Durkin, Simkin, & Knox, 2009) and adulthood, when they

are associated with social adaptation difficulties and increased risk of psychiatric disorder (Clegg, Hollis, Mawhood, & Rutter, 2005). High levels of speech, language and communication difficulties have been found among the young population (Bryan, 2004). There are clear benefits, therefore, in developing increasingly effective methods of diagnosis and treatment of such difficulties. To foster the idea, it is imperative to learn more about the processes that underlie typical and atypical speech and language development, and to develop parameters to identify communication disorders.

Atypical development is when development doesn't follow the standard features. It could include or arise due to learning and social disabilities and disorders. Atypical phonological processes are not seen in typically developing language learners. This may be a sign that a child or an adult has a phonological processing disorder. Some examples include initial consonant deletion, medial consonant deletion, glottal replacement, backing and stopping of glides. There’s a difference between speech and language disorders in general. It is based on the notion of speech versus language in the first place. Speech, is basically the sound of spoken language which includes the formation of a sound, the nature of the sound quality and the rhythm and flow of the sound whereas language is the words people use in a particular community to share ideas.

Communication, on the other had includes both verbal and nonverbal communication. A communication disorder disrupts an individual’s ability to exchange meaning with another when sending and/or receiving information. It can be congenital, meaning an individual is born with a disorder that impacts communication (e.g., cerebral palsy, deafness), or it can be acquired, meaning something happened after birth that affected communication (e.g., traumatic brain injury, meningitis) (Gillam & Marquardt, 2016). The World Health Organization (2011) uses the word ‘impairment’ to refer to those who have experienced a loss of function or an abnormality in structure. Hence, Specific Language Impairment (SLI) is also used as a popular term for communication disorders. This research,

particularly focuses on speech, hence relevant literature from speech, language, and verbal communication disorders have been taken under consideration for the study.

According to Lousie Cummings (2008), listed speech disorders are;

(a) Disorders of the Pre- and Perinatal Period, such as: Cleft Lip and Palate, Cerebral Palsy
(b) Disorders of Cognitive Development, such as: Learning Disability, Autistic Spectrum Disorder
(c) Disorders of Speech and Language Development, such as: Developmental Verbal Dyspraxia, Developmental Phonological Disorder, Specific Language Impairment
(d) Acquired Communication Disorders, such as, Acquired Dysarthria, Apraxia of Speech, Acquired Aphasia, Acquired Dysphagia
(e) Disorders of Fluency and Voice, such as: Stuttering, Cluttering, Voice Disorders

In a more recent edition (2014), he listed speech disorders as following;

(a) Developmental Communication Disorders; such as: Cleft Lip and Palate and other Craniofacial Anomalies, Developmental Dysarthria, Developmental Verbal Dyspraxia, Developmental Phonological Disorder, Specific Language Impairment, Intellectual Disability and Communication, Emotional Disturbance and Communication, Autism Spectrum Disorders and Communication
(b) Acquired Communication Disorders; such as: Speech Disorders Related to Head and Neck Cancer: Laryngectomy, Glossectomy, Acquired Dysarthria, Apraxia of Speech, Aphasia, Hemisphere Damage/Traumatic Brain Injury and Communication, Dementia and Communication, Psychiatric Disorders and Communication
(c) Voice, Fluency and Hearing Disorders; such as: Functional and Organic Voice Disorders, Stuttering and Cluttering

Along with Jack S. Damico, and Nicole Müller, Martin J. Ball listed the disorders (2010) are;

(a) Language Disorders, such as: Autism Spectrum Disorders, Delayed Language Development, Specific Language Impairment, Pragmatic Impairment, Learning Disabilities, Aphasia
(b) Speech Disorders, such as: Speech Sound Disorders, Dysarthria, Apraxia of Speech, Fluency and Fluency Disorders, Voice Disorders, Orofacial Anomalies, Speech Disorders Related to Head and Neck Cancer: Laryngectomy, Glossectomy, and Velopharyngeal and Maxillofacial Deficits
(c) Cognitive and Intellectual Disorders, such as: ADHD and Communication Disorders, Traumatic Brain Damage/Injury, Dementia and Communication

Later on, Martin J. Ball (2016) listed the disorders based on,

(a) Genetic Etiologies, such as: Cleft Lip and Palate, Genetic Syndromes such as Williams Syndrome (WS), Down Syndrome (DS), Fragile-X Syndrome (FXS), Noonan Syndrome, Cri-du-Chat Syndrome (CCS) and such
(b) Disorders with a Surgical Origin, such as: Laryngectomy, Glossectomy
(c) Neurogenic Speech Disorders, such as: Aphasia, Apraxia of Speech such as Acquired Apraxia of Speech, Progressive Apraxia of Speech, Dysarthria such as Flaccid, Spastic, Hypokinetic, Hyperkinetic, Ataxic
(d) Developmental Speech Sound Disorders, such as: Phonological Delay, Phonological Deviancy such as Inconsistency, Articulation Disorder, Motor Speech Disorders, Voice Disorders, Disorders of Fluency

Josheph R.Duffy (2013) listed various types of Dysarthia such as: Flaccid Dysarthrias, Spastic Dysarthria, Ataxic Dysarthria, Hypokinetic Dysarthria, Hyperkinetic Dysarthrias, Unilateral Upper Motor Neuron Dysarthria, Mixed Dysarthrias, along with Apraxia of Speech, Neurogenic Mutism, Acquired Psychogenic and Related Nonorganic Speech Disorders, Aphasia. In fact, each one these types could be extended to sub-types as patients display various symptoms.

The Bilinguistics Team, USA, has described; Communication Disorder as: any condition that affects an individual’s ability to communicate ranging from

difficulty producing a single sound for speech, to an inability to express wants and needs using either verbal or non-verbal communication, Speech Disorder as: difficulties with the actual production of sounds, and Language Disorder as: a difficulty understanding or putting words together to communicate ideas; and have listed a number of speech disorders along with features next.

- Articulation Disorders: difficulties producing sounds in syllables or saying words incorrectly to the point that listeners cannot understand what is being said can listed under this
- Fluency Disorders: problems such as stuttering, in which the flow of speech is interrupted by abnormal stoppages, repetitions (st-st-stuttering), or prolonging sounds and syllables (ssssstuttering)
- Resonance or Voice Disorders: problems with the pitch, volume, or quality of the voice that distract listeners from what's being said. These types of disorders may also cause pain or discomfort for a child when speaking
- Dysphagia: these include difficulties with drooling, eating, and swallowing
- Language disorders can be either receptive or expressive
- Receptive Disorders: difficulties understanding or processing language
- Expressive Disorders: difficulty putting words together, limited vocabulary, or inability to use language in a socially appropriate way

In their work, they have listed a number of speech, language, and communication disorders which are: Agenesis of the Corpus Callosum, Aphasia, Apraxia of Speech, Articulation and Phonological Disorders, Asperger Syndrome, Attention Deficit (and Hyperactivity) Disorder, Auditory Processing Disorder, Autism, Cerebral Palsy, Cleft Lip (and Palate), Cluttering, DiGeorge Syndrome, Down Syndrome, Epilepsy, Expressive Language Disorder, Intellectual Disability, Prematurity, Receptive Language Disorder, Selective Mutism, Specific Language Impairment, Stuttering/Disfluency.

To review, the listed disorders for speech, language, and communication could be as follows,

1. Speech Sound Disorders, such as, Cluttering, Stuttering, Dysphagia, Dysarthria, Spasmodic Dysphonia or Aphonia, Lisping, Speech Delay or Alalia

2. Disorders Related to Auditory Processing, such as, Central Auditory Processing Disorder (CAPD)
3. Specific Language Disorder (SLI), such as, Expressive Language Disorders, Receptive Language Disorders
4. Speech Disorders Related to Surgical Origin/Defect, such as, Laryngectomy, Glossectomy, and Velopharyngeal and Maxillofacial Deficits, Ankyloglossia, Cleft Palate
5. Disorders Related to Genetics; such as, Down Syndrome, DiGeorge Syndrome
6. Disorders Related to Neurological Conditions such as; Aphasia, Dementia, Asperger Syndrome (AS), Epilepsy, Attention Deficit/Hyperactivity Disorder (ADHD), Agenesis of the Corpus Callosum (ACC), Childhood Apraxia of Speech (CAS), Cerebral Palsy, Agnosia, Autism Spectrum Disorder
7. Disorders Related to Psychiatric Conditions, such as, Selective Mutism (SM)

The details are descried below with specific speech, language, and communication related features/characteristics.

1. Speech Sound Disorders refers to difficulty correctly pronouncing phonemes. The characteristics are: errors in speech sounds by omissions, distortions, substitutions, additions, or incorrect sequencing of speech sounds. Accent or dialect are not considered to be disorders. Such disorders are,

(a) Cluttering is a communication disorder resulting in decreased fluency and intelligibility that often coexists with stuttering. The characteristics are: monotone voice, indistinct, ‘mumbling’ speech involving sound distortions and omissions, errors in connected speech that are not present or less pronounced in single-word production or connected speech that is produced slowly, transpositions of sounds in words, phrases, or sentences, poor self-monitoring skills, fast speaking rate.

(b) Stuttering is disfluencies on units of sounds. The characteristics are: disfluencies on units smaller than the word level, such as sound prolongations and sound/syllable repetitions, effort/physiologic tension associated with

disfluent moments, a sense of loss of control, difficulty making fluent transitions from one sound or syllable to the next.

(c) Dysphagia is the medical term for swallowing difficulties. The characteristics are: frequent repetition or prolongation of any sound, or syllables, words; or by the rise of pauses that interrupt speech's rhythmic flow.

(d) Dysarthria is a speech disorder caused by muscle weakness. The characteristics are: often causes slurred or slow speech that can be difficult to understand, not be able to move tongue, lips, and jaw very well, changes in voice, may sound hoarse or breathy, uneven rhythm, higher- or lower-pitched than usual, often nasal.

(e) Spasmodic Dysphonia or Aphonia, or vocal fold paralysis. It causes involuntary spasms in the muscles of the voice box or larynx. This causes the voice to break and have a tight, strained or strangled sound. Voice quality can also be affected when psychological stressors lead to habitual, maladaptive Aphonia or Dysphonia. The resulting voice disorders are referred to as Psychogenic Voice Disorders or Psychogenic Conversion Aphonia/Dysphonia (Stemple et al., 2010). Perceptual signs and symptoms of Dysphonia include: rough vocal quality (raspy, audible aperiodicity in sound); breathy vocal quality (audible air escape in the sound signal or bursts of breathiness); strained vocal quality (increased effort; tense or harsh); strangled vocal quality (as if talking with breath held); abnormal pitch (too high, too low, pitch breaks, decreased pitch range); abnormal loudness/volume (too high, too low, decreased range, unsteady volume); abnormal resonance (hypernasal, hyponasal, cul-de-sac resonance); Aphonia (loss of voice); phonation breaks; Asthenia (weak voice); pulsed voice (fry register, audible creaks or pulses in sound); shrill voice (high, piercing sound, as if stifling a scream); and tremorous voice (shaky voice; rhythmic pitch and loudness undulations).

(f) Lisping is a speech disorder characterized by the inability to correctly pronounce the sounds of [s] or [z], known as the sibilant consonants. Usually [θ], [ð] sounds are substituted for the sibilants. The word ‘lisp,’ for example,

would be pronounced ‘lithp’ by someone with this speech disorder. Most people tend to believe that a lisp is a speech condition where a person’s [s] and [z] tend to be substituted in their speech, resulting in distorted conversation. The types include: Frontal Lisp, Palatal Lisp, Dental Lisp and Lateral Lisp.

(g) Speech Delay or Alalia refers to a condition where the child has difficulty using the lungs, vocal cords, mouth, tongue or teeth to produce sounds or speech. This condition causes the child to be slow in picking up words and also lack the ability to shape the mouth and tongue to produce normal speech. At the age of 12 months, there is cause for concern if the child is not able: using gestures such as waving good-bye and pointing at objects, practicing the use of several different consonant sounds, vocalizing or communicating needs. Between the ages of 15 and 18 months, children are at a higher risk for speech delay if they are displaying characteristics such as: not saying ‘momma’ and ‘dada’, not reciprocating when said ‘no’, ‘hello’, and ‘bye’, does not have a one-to-three-word vocabulary at 12 months and up to 15 words by 18 months, displaying difficulties imitating sounds and actions, shows preference to gestures over verbalization. Additional signs of speech delay after the age of 2 years and up to the age of 4 include: inability to spontaneously produce words and phrases, inability to follow simple directions and commands, cannot make two-word connections, lacks consonant sounds at the beginning or end of words, is difficult to understand by close family members, is unable to form simple 2-to-3-word sentences.

2. Disorders Related to Auditory Processing, such as, Central Auditory Processing Disorder (CAPD), refers to the way the central nervous system uses information. The characteristics are: developmental or acquired, difficulties understanding speech in noisy environments, trouble following directions, difficulty discriminating between similar-sounding speech sounds, struggle with spelling, reading, and comprehending verbal information.

3. Specific Language Impairment (SLI) is term that is often used for an impairment of either receptive (language comprehension) language impairment and/or expressive (language expression), not caused by any other

underlying condition. The characteristics are: incorrect or limited use of vocabulary, morphology (word structure) or syntax (sentence structure, short utterance/sentence length, grammatical errors aligned with age, reading disabilities, language abilities are lower than cognitive abilities. These can be presented as;

(a) Expressive Language Disorders are specific language disorder associated with difficulty speaking, writing, and/or using other symbol systems (i.e., sign language), may be developmental, appearing as the child is learning to talk, or acquired due to damage to the brain, able to understand language easier than they are able to express. The characteristics are: limited vocabulary or use of non-specific vocabulary, word finding difficulties, poor grammar, short or incomplete sentences, unable to clearly convey a concept.

(b) Receptive Language Disorders are impairments in the comprehension of a spoken, written, gestural and/or other symbol system. The characteristics are: understanding meaning of gestures, questions, the order of words in a sentence, plurals and verb tenses, following directions, identifying objects and pictures, limitations of age-appropriate vocabulary, difficulties taking turns.

4. Speech Disorders Related to Surgical Origin/Defect, such as,

(a) Laryngectomy, Glossectomy, and Velopharyngeal and Maxillofacial Deficits, even Ankyloglossia etc. might give rise to atypical speech. A Laryngectomy is a surgery to remove part or all of Larynx (voice box). Glossectomy is a term used to describe a variety of procedures resulting in the surgical extirpation of part, or all, of the tongue. The Velopharyngeal valve includes the soft palate as well as the pharynx and the side and back walls of the throat. Maxillofacial surgery involves an operation to correct a disease, injury or defect of face, jaw or mouth. Tongue-tie (Ankyloglossia) is a condition in which an unusually short, thick or tight band of tissue (Lingual Frenulum) tethers the bottom of the tongue's tip to the floor of the mouth. Ankyloglossia, also known as tongue-tie, is a short lingual frenum that interferes with normal tongue

movement. It is an uncommon congenital oral anomaly that can cause difficulty with speech articulation.

(b) Cleft Palate happens due to hole or space in the upper palate or roof of the mouth, occur on one side (unilateral) or both sided (bilateral). The characteristics are: difficulty with the resonance (sound) of vocal quality and/or velopharyngeal insufficiency or dysfunction (VPI or VPD).

5. Disorders Related to Genetics; such as,

(a) Down Syndrome is a congenital disorder, caused by the presence of an extra 21st chromosome, in which the affected person has mild to moderate intellectual disability, short stature, and a flattened facial profile. The characteristics are: have strengths in non-verbal communication skills such as gesture and sign, verbal or spoken language skills are usually delayed.

(b) DiGeorge Syndrome is a birth defect that is caused by an abnormality in chromosome 22 which affects the immune system. It is also known as: 22q11.2 deletion syndrome, Velocardiofacial Syndrome, and Strong Syndrome. The characteristics are: speech delayed, hypernasal speech, articulation and voice disorders, laryngeal anomalies, language impairment (e.g., slow vocabulary growth, difficulties formulating complex sentences), pragmatic and social skills difficulties, mostly nonverbal prior to age 2, receptive language abilities such as comprehension are generally stronger than expressive language abilities, articulation errors.

6. Disorders Related to Neurological Conditions such as;

(a) Aphasia is a language disorder caused by damage in a specific area of the brain that controls language expression and comprehension. As in, it is an acquired communication disorder that impairs a person's ability to use or understand language. The types include, (i) People with Broca's Aphasia have damage to the front portion of the language-dominant side of the brain. People with Broca's Aphasia, sometimes called an Expressive Aphasia, for example, may eliminate the words 'and' and 'the' from their language, and speak in short, but meaningful, sentences. They usually can

understand some speech of others. Because the damage is in the front part of the brain, is also important for motor movements, people with Broca's aphasia often have right-sided weakness or paralysis of the arm and leg. (ii) Those with Wernicke's Aphasia have damage to the side portion of the language-dominant part of the brain. Those with Wernicke's Aphasia, sometimes called a receptive aphasia, may speak in long confusing sentences, add unnecessary words, or create new words. They usually have difficulty understanding the speech of others. Global Aphasia is the result of damage to a large portion of the language-dominant side of the brain. People with Global Aphasia have difficulties with speaking or comprehending language. Other types include, Transcortical Aphasia, Conduction Aphasia, Mixed Aphasia, and Anomic. The characteristics, in general, may be: fluent and/or non-fluent speech, production and/or comprehension difficulties, cannot produce the sounds and/or physically hear words and see print but can't make sense of the words, slow and effortful speech, speak in short or incomplete sentences and omit small words (i.e. 'is', 'and', 'the'), difficulty naming common objects, difficulty in spelling and repeating or recite, interpreting figurative language literally, difficulty answering questions or following directions, speaks in short or incomplete sentences, speaks in sentences that don't make sense, substitutes one word for another or one sound for another, speaks unrecognizable words, has difficulty finding words and such. Aphasia may be labeled with one of these names: Logopenic Aphasia, Semantic Aphasia, Agrammatism (Benson, D. F., & Ardila, A., 1996, Hegde, M. N., 2022).

(b) Dementia is not a specific disease but is rather a general term for the impaired ability to remember, think, or make decisions that interferes with doing everyday activities. Alzheimer's Disease can cause the most common type of Dementia. The speech characteristics include: difficulty speaking, understanding and expressing thoughts, or reading and writing, repeating questions, using unusual words to refer to familiar objects, unable to recall the names of places, objects, recent events and such.

(c) Asperger Syndrome (AS) is a neurological condition that falls under the larger category of Autism Spectrum Disorders (ASD). ASD can co-exist with ADHD, tic disorders (such as Tourette syndrome), depression, anxiety disorders and OCD. The characteristics are: history of developmental delays, high level of vocabulary and formal speech patterns, lack of rhythm, odd inflection or monotone pitch, impaired ability to use or understand non-verbal behavior.

(d) Epilepsy is chronic neurological disorders characterized by seizures. The characteristics are: may co-occur with speech and language disorders, may be the cause of differences in language development, presence of epilepsy during childhood may impact brain development, affecting areas such as executive function, attention, and language displaying difficulties with language learning, as well as with reading and writing.

(e) Attention Deficit/Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder. The characteristics are: difficulty completing tasks and demonstrate disorganization, difficulty organizing pieces of information, difficulty organizing and sequencing story components.

(f) Agenesis of the Corpus Callosum (ACC) is a birth defect in which the corpus callosum is partially or completely absent. The characteristics are: developmental delays, cognitive and social processing problems, atypical motor and sensory processing, difficulties on multidimensional or multimodality tasks (including auditory integration tasks), impaired hand-eye coordination, lack of monitoring or self-evaluating (Brennan, 2006).

(g) Childhood Apraxia of Speech (CAS) is a speech sound disorder in which the precision and consistency of movements underlying speech are impaired in the absence of neuromuscular deficits (e.g., abnormal reflexes, abnormal tone), sometimes called Verbal Apraxia, Developmental Apraxia of Speech, Developmental Articulatory Dyspraxia, or Verbal Dyspraxia. The characteristics are: difficulty programming and planning speech movements, may use unusual intonation, pausing and stress patterns, use few words, use

more gestures or sound effects, affect vowels as well as consonants, difficulty imitating speech sounds.

(h) Cerebral Palsy is chronic movement or posture disorder affecting the brain's ability to control the muscle movement. The characteristics are: difficulty co-coordinating muscle movements needed for speech, difficulty creating cohesive sentences, difficulty communicating.

(i) Agnosia is the inability to process sensory information. Often there is a loss of ability to recognize objects, persons, sounds, shapes, or smells while the specific sense is not defective nor is there any significant memory loss. It is usually associated with brain injury or neurological illness. Speech Agnosia, or Auditory Verbal Agnosia, refers to 'an inability to comprehend spoken words despite intact hearing, speech production and reading ability'. The characteristics are: speech is fundamentally unrecognizable or untranslatable.

(j) Autism Spectrum Disorder is a developmental disability that is caused by neurological differences. The characteristics are: not speaking or very limited speech, loss of words the child was previously able to say, Poor vocabulary development, problems following directions or finding objects that are named, repeating what is said (echolalia), 'robotic' speech or speech that is high-pitched, problems answering questions, poor eye contact. A person with Autism may have challenges such as in understanding and using gestures (pointing or waving), understanding and using words, following directions, learning to read or write. Some children with autism read early but do not understand what they read (Hyperlexia); and they also have difficulties in having conversations.

7. Disorders Related to Psychiatric Conditions, such as,

(a) Selective Mutism (SM) is a psychiatric condition often caused by extreme anxiety of speaking in certain situations. The chrematistics are: anxiety related to an expressive language disorder or a language background, limited eye contact, limited non-verbal expressions.

In case of bilingual or multilingual patients, they could display various phonological features based on their L1, and often L2 or more. ‘Bilingualism is the result of the use of more than one code by an individual or a society’ (Bell, 1976, p. 135), which means a bilingual speaker, is able to use more than one code in the society. However, it depends on the social situations, the speaker’s psychological state, ability, choice and many more. All speakers adopt various styles to suit varying purposes (Bell, 1976, p. 118) and many studies have taken place in order to find if the bilingual possesses one or two different systems. According to Hockett (1958), a bilingual is the one who has perfect control over more than one language (p. 129). That means a bilingual will have control over the choice of lexical items. Bell (1976) suggests that a bilingual constitutes a range of linguistic and/or social skills. In order to communicate effectively the speaker needs to control not only linguistic choices but also social situations (p. 130).

All in all, the general features of atypical speech are: Lateralization/Lateral Articulation, Double Articulation, Backing to Velar , Pharyngeal Articulation, Glottal Articulation, Active Nasal Fricatives, Weak/Nasalized Consonants, Nasal Realizations of Fricatives, Nasal Realizations of Plosives, Absent Pressure Consonants, Palatalization/Palatal, Backing to Uvular, Gliding of Fricatives/Affricates, Substitution of Sounds, Consonant Harmony/ Assimilation, Missing Vowel Sounds, Consistent Omission of Initial Consonants, Persistent Substitution of Back Sounds, Deletion of Final Consonants, Unintelligible Speech, Deaffrication, Biphonemic Realization, Allophonic Variations, Fronting, Weak Syllable Deletion, Clusters Reduction, Liquid Deviation, Devoicing, Velarization/ Velopharyngeal Incompetence, Inconsistent /ɦ/.

2.3. Phonetics and Bangla Phonology

In order to understand the properties of a language, one needs to study the evolution of the language. This section includes Bangla as an Indo-European language, and a synopsis of the standard variety, which, has been described by many renowned Linguists. There is often a debate regarding the origin of the language and the number of pure vowels it demonstrates, i.e., a few sounds are considered either as the standard variety or a dialectical variations or individual

differences. This section also includes the cross-linguistic perspective on Bangla Phonetics and its integrating features.

2.3.1. Bangla as an Indo-European Language: Bangla, IPA /ˈbaːŋlaː/, is an Indo-Aryan language that is native to the Bengal region of South Asia. It is the official, national, and most widely spoken language of Bangladesh and the second most widely spoken of the 22 scheduled languages of India. With approximately 300 million native speakers and another 37 million as second language speakers, Bangla is the fifth most-spoken native language and the seventh most spoken language by total number of speakers in the world. It is also the fifth most spoken Indo-European language. The Indo-European languages are a language family native to the overwhelming majority of Europe, the Iranian plateau, and the northern Indian subcontinent. It is divided into several branches or sub-families, of which there are eight groups with languages still existing today: Albanian, Armenian, Balto-Slavic, Celtic, Germanic, Hellenic, Indo-Iranian, and Italic; and another nine subdivisions that are now extinct. There are about 445 living Indo-European languages, according to an estimate by Ethnologue, with over two-thirds of those belonging to the Indo-Iranian branch. All Indo-European languages are descended from a single prehistoric language, linguistically reconstructed as Proto-Indo-European, spoken sometime in the Neolithic to Early Bronze Age. Indo-European language family include ten major branches. These are;

i. Albanian, attested from the 13th century AD; Proto-Albanian evolved from an ancient Paleo-Balkan language, traditionally thought to be Illyrian, or otherwise a totally unattested Balkan Indo-European language that was closely related to Illyrian and Messapic
ii. Anatolian, extinct by Late Antiquity, spoken in Anatolia, attested in isolated terms in Luwian/Hittite mentioned in Semitic Old Assyrian texts from the 20th and 19th centuries BC, Hittite texts from about 1650 BC
iii. Armenian, attested from the early 5th century AD
iv. Balto-Slavic, believed by most Indo-Europeanists to form a phylogenetic unit, while a minority ascribes similarities to prolonged language-contact
    - Slavic (from Proto-Slavic), attested from the 9th century AD (possibly earlier), earliest texts in Old Church Slavonic; Slavic languages include Bulgarian, Russian, Polish, Czech, Slovak, Silesian, Kashubian,

Macedonian, Serbo-Croatian (Bosnian, Croatian, Montenegrin, Serbian), Sorbian, Slovenian, Ukrainian, Belarusian, and Rusyn

- Baltic, attested from the 14th century AD; although attested relatively recently, they retain many archaic features attributed to Proto-Indo-European (PIE); living examples are Lithuanian and Latvian

v. Celtic (from Proto-Celtic), attested since the 6th century BC; Lepontic inscriptions date as early as the 6th century BC; Celtiberian from the 2nd century BC; Primitive Irish Ogham inscriptions from the 4th or 5th century AD, earliest inscriptions in Old Welsh from the 7th century AD. Modern Celtic languages include Welsh, Cornish, Breton, Scottish Gaelic, Irish and Manx

vi. Germanic (from Proto-Germanic), earliest attestations in runic inscriptions from around the 2nd century AD, earliest coherent texts in Gothic, 4th century AD; Old English manuscript tradition from about the 8th century AD, includes English, Frisian, German, Dutch, Scots, Danish, Swedish, Norwegian, Afrikaans, Yiddish, Low German, Icelandic, Elfdalian, and Faroese

vii. Hellenic (from Proto-Greek, see also History of Greek); fragmentary records in Mycenaean Greek from between 1450 and 1350 BC have been found; Homeric texts date to the 8th century BC

viii. Indo-Iranian, attested circa 1400 BC, descended from Proto-Indo-Iranian (dated to the late 3rd millennium BC)

- Indo-Aryan, attested from around 1400 BC in Hittite texts from Anatolia, showing traces of Indo-Aryan words. Epigraphically from the 3rd century BC in the form of Prakrit (Edicts of Ashoka). The Rigveda is assumed to preserve intact records via oral tradition dating from about the mid-second millennium BC in the form of Vedic Sanskrit. Includes a wide range of modern languages from Northern India, Eastern Pakistan and Bangladesh, including Hindustani (Hindi, Urdu), Bengali, Odia, Assamese, Punjabi, Kashmiri, Gujarati, Marathi, Sindhi and Nepali, as well as Sinhala of Sri Lanka and Dhivehi of the Maldives and Minicoy
- Iranian or Iranic, attested from roughly 1000 BC in the form of Avestan. Epigraphically from 520 BC in the form of Old Persian

(Behistun inscription). Includes Persian, Pashto, Kurdish Balochi, Luri, and Ossetian

- Nuristani (includes Kamkata-vari, Vasi-vari, Askunu, Waigali, Tregami, and Zemiaki)

ix. Italic (from Proto-Italic), attested from the 7th century BC, includes the ancient Osco-Umbrian languages, Faliscan, as well as Latin and its descendants, the Romance languages, such as Italian, Venetian, Galician, Sardinian, Neapolitan, Sicilian, Spanish, Asturleonese, French, Romansh, Occitan, Portuguese, Romanian, and Catalan

x. Tocharian, with proposed links to the Afanasevo culture of Southern Siberia; extant in two dialects (Turfanian and Kuchean, or Tocharian A and B), attested from roughly the 6th to the 9th century AD; marginalized by the Old Turkic Uyghur Khaganate and probably extinct by the 10th century

In addition to the classical ten branches listed above, several extinct and little-known languages and language-groups have existed or are proposed to have existed.

i. Ancient Belgian: hypothetical language associated with the proposed Nordwestblock cultural area; speculated to be connected to Italic or Venetic, and to have certain phonological features in common with Lusitanian

ii. Cimmerian: possibly Iranic, Thracian, or Celtic

iii. Dacian: possibly very close to Thracian

iv. Elymian: poorly-attested language spoken by the Elymians, one of the three indigenous (i.e., pre-Greek and pre-Punic) tribes of Sicily; Indo-European affiliation widely accepted, possibly related to Italic or Anatolian

v. Illyrian: possibly related to Albanian, Messapian, or both

vi. Liburnian: evidence too scant and uncertain to determine anything with certainty

vii. Ligurian: possibly close to or part of Celtic

viii. Lusitanian: possibly related to (or part of) Celtic, Ligurian, or Italic

ix. Ancient Macedonian: proposed relationship to Greek

x. Messapian: not conclusively deciphered

xi. Paionian: extinct language once spoken north of Macedon

xii. Phrygian: language of the ancient Phrygians; very likely, but not certainly, a sister group to Hellenic

xiii. Sicel: an ancient language spoken by the Sicels (Greek Sikeloi, Latin Siculi), one of the three indigenous (i.e., pre-Greek and pre-Punic) tribes of Sicily; proposed relationship to Latin or proto-Illyrian (Pre-Indo-European) at an earlier stage

xiv. Sorothaptic: proposed, pre-Celtic, Iberian language

xv. Thracian: possibly including Dacian

xvi. Venetic: shares several similarities with Latin and the Italic languages, but also has some affinities with other Indo-European languages, especially Germanic and Celtic

2.3.2. A Synopsis of the Standard Variety: The study of Phonology has two explicit areas; Phonetics and Phonemics. The study of Phonetics discusses about the point of articulation, manner of articulation, vowel sounds, consonant sounds, semi-vowel sounds, semi-consonant sounds, pitch, tone, stress and so on. Phonetics have three branches; these are (a) motor-phonetics, articulatory phonetics, (b) acoustic phonetics, and (c) instrumental or auditory phonetics. Phonetics discusses how the actual sounds are pronounced, while phonemics represent how people interpret such sounds. Hence, Phonology includes the study of Phonetics as in the speech sounds and Phonemics as in the usage of the speech sounds. Given next is Bangla consonant chart.

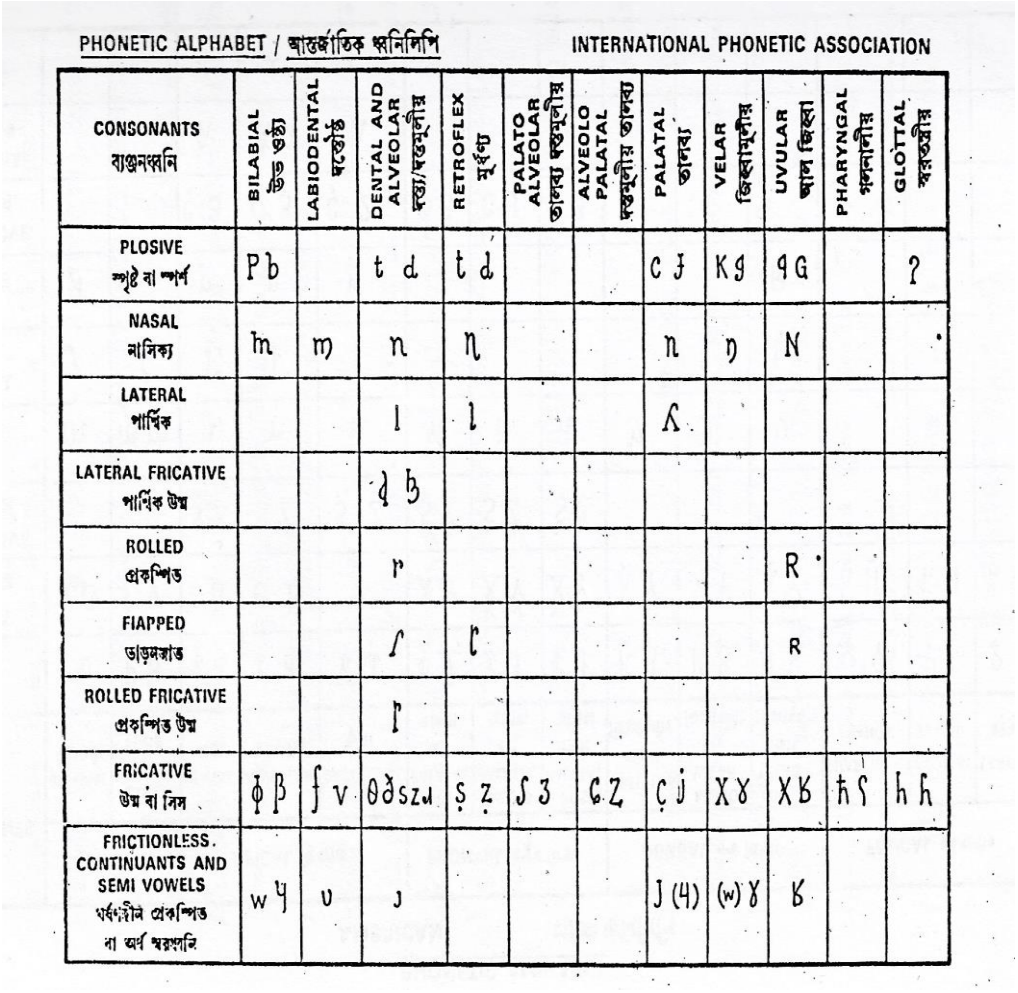
PLACES OF ARTICULATION FOR BENGALI CONSONANTS

।। বাংলা ব্যঞ্জনবর্ণের উচ্চারণ স্থান ।।

উচ্চারণের রীতি Manner of Articulation			কণ্ঠনালী Glottal	কণ্ঠ (কোমল তালু ও জিহ্বামূল) Velar	কঠিন তালুর উর্ধ্বভাগ ও জিহ্বামধ্য Alveopalatal	মূর্ধা বা তালুর শিরোভাগ ও উল্টানো জিহ্বাগ্র Retroflex	দন্তমূল ও জিহ্বাগ্রভাগ Alveolar	দন্ত ও জিহ্বাগ্রভাগ Dental	দন্ত ও ওষ্ঠ (অধর) Dentilabial	ওষ্ঠ্যয় Labial
স্পর্শবর্ণ (Stops)	অল্পপ্রাণ non-aspirate	অঘোষ		ক	চ	ট		ত		প
		ঘোষ		গ	জ	ড		দ		ব
	মহাপ্রাণ aspirate	অঘোষ		খ	ছ	ঠ		থ		ফ
		ঘোষ		ঘ	ঝ	ঢ		ধ		ভ
		নাসিক্য (ঘোষ)		ঙ	ঞ	ণ	ন			ম
কম্পনজাত (Trilled) (ঘোষ)							র			
পার্শ্বিক (Lateral) (ঘোষ)							ল			
তাড়নজাত Flapped	অল্পপ্রাণ					ড়				
	মহাপ্রাণ					ঢ়				
উষ্মধ্বনি Sibilants	অঘোষ		ঃ বিসর্গ						ফ	
	ঘোষ		হ						ভ	
	শিস্‌ধ্বনি (অঘোষ)				শ	[ষ]	স			
অর্ধস্বর (ঘোষ)					য়=y		জ =z ঘোষ			(ওয়)=w

Figure 05: Places of Articulation (Prof Rafiqul Islam, 2000)

From the above chart various places and manners of articulation for Bangla Consonant Sounds can be seen. There are Labial, Dentilabial, Dental, Alveolar, Retroflex, Alveopalatal, Velar and Glottal, in terms of places of articulation. As for manners of articulation, there are Stops (includes as pirated and nonaspirated), Nasal, Trilled, Lateral (Approximant), Flapped, Sibilants (Fricatives), Approximants. According to Prof Atindra Majumder (2020), the places of articulation are Bilabial, Labiodental, Dental, Alveolar, Retroflex, Palato-Alveolar, Alveolo-Palatal, Palatal, Velar, Uvular, Pharyngeal, Glottal. The manners of articulation are Plosive, Nasal, Lateral (Approximant), Lateral Fricative, Rolled, Flapped, Rolled Fricative, Fricative, Frictionless Continuants and Semi-Vowel. Given next are the Consonant and Vowel charts by Prof. Atindra Majumder (2020) where a variety of nasal sounds can be observed.



PHONETIC ALPHABET / আন্তর্জাতিক ধ্বনিলিপি — INTERNATIONAL PHONETIC ASSOCIATION

CONSONANTS ব্যঞ্জনধ্বনি	BILABIAL উভ ওষ্ঠ্য	LABIODENTAL দন্তৌষ্ঠ	DENTAL AND ALVEOLAR দন্ত্য/দন্তমূলীয়	RETROFLEX মূর্ধন্য	PALATO ALVEOLAR তালব্য দন্তমূলীয়	ALVEOLO PALATAL দন্তমূলীয় তালব্য	PALATAL তালব্য	VELAR জিহ্বামূলীয়	UVULAR আল জিহ্বা	PHARYNGAL গলনালীয়	GLOTTAL স্বরতন্ত্রীয়
PLOSIVE স্পৃষ্ট বা স্পর্শ	P b		t d	ʈ ɖ			c ɟ	K g	q G		ʔ
NASAL নাসিক্য	m̥	ɱ	n	ɳ			ɲ	ŋ	N		
LATERAL পার্শ্বিক			l	ɭ			ʎ				
LATERAL FRICATIVE পার্শ্বিক উষ্ম			ɮ ɬ								
ROLLED প্রকম্পিত			r						R		
FIAPPED তাড়নজাত			ɾ	ɽ					ʀ		
ROLLED FRICATIVE প্রকম্পিত উষ্ম			ɾ̝								
FRICATIVE উষ্ম বা নিস	ɸ β	f v	θ ð s z ɹ	ʂ ʐ	ʃ ʒ	ɕ ʑ	ç j	X ɣ	χ ʁ	ħ ʕ	h ɦ
FRICTIONLESS CONTINUANTS AND SEMI VOWELS ঘর্ষণহীন প্রকম্পিত বা অর্ধ স্বরধ্বনি	w ɥ	ʋ	ɹ				j (ɥ)	(w) ɣ	ʁ		

Figure 06: Phonetic Alphabet (Prof Atindra Majumder, 2020)

According to the International Phonetic Association, there are about 28 Bangla Consonant sounds where the places of articulation include, Bilabial, Labio-Dental,

Dental, Alveolar, Post-Alveolar, Velar, and Glottal. The manners of articulation include Plosive, Affricate, Nasal, Fricative, Approximant, and Lateral Approximant.

	Bilabial	Labio-dental	Dental	Alveolar	Post-alveolar	Velar	Glottal
Plosive	p b $b^{ɦ}$		t̪ d̪ $t̪^{h}$ $d̪^{ɦ}$		t d t^{h} $d^{ɦ}$	k g k^{h} $g^{ɦ}$	
Affricate					t̪ɕ d̪ʑ $t̪ɕ^{h}$ $d̪ʑ^{ɦ}$		
Nasal	m		n			ŋ	
Fricative		f		s	ʃ		h
Approximant				ɹ			
Lateral approximant				l			

p	pati	পাটি	‘grass mat’
b	bati	বাটি	‘bowl’
$b^{ɦ}$	$b^{ɦ}$ati	ভাটি	‘kiln’
t̪	t̪ak	তাক	‘shelf’
$t̪^{h}$	$t̪^{h}$ak	থাক	‘let it be’
d̪	d̪ag	দাগ	‘stain’
$d̪^{ɦ}$	$d̪^{ɦ}$akːa	ধাক্কা	‘shove’
t	tak	টাক	‘bald spot’
t^{h}	t^{h}akuɹ	ঠাকুর	‘lord’
d	dak	ডাক	‘call!’
$d^{ɦ}$	$d^{ɦ}$ak	ঢাক	‘cover!’
k	kaʃ	কাশ	‘wild sugarcane’
k^{h}	k^{h}aʃ	খাস	‘you eat’
g	gaʃ	গাস	‘you sing’
$g^{ɦ}$	$g^{ɦ}$aʃ	ঘাস	‘grass’
t̪ɕ	t̪ɕal	চাল	‘rice’
$t̪ɕ^{h}$	$t̪ɕ^{h}$al	ছাল	‘peel’
d̪ʑ	d̪ʑal	জাল	‘net’
$d̪ʑ^{ɦ}$	$d̪ʑ^{ɦ}$al	ঝাল	‘spicy’
f	faʃ	ফাঁস	‘noose’
s	saf	সাফ	‘clean’
ʃ	ʃaʃ	শ্বাস	‘breath’
h	haʃ	হাঁস	‘duck’
ɹ	ɹaʃ	হ্রাস	‘reduction’
l	laʃ	লাশ	‘corpse’
m	maʃ	মাস	‘month’
n	naʃ	নাশ	‘destruction’
m	amaɹ	আমার	‘my’
n	anaɹ	আনার	‘for bringing’
ŋ	daŋaɹ	ডাঙার	‘of dry land’

Journal of the International Phonetic Association (2010) 40/2
doi:10.1017/S0025100310000071
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Figure 07: Phonetic Alphabet (Journal of the IPA, 2010)

As for Bangla vowels, it is found that all Bangla vowels are produced with pulmonic-egressive air stream mechanism. As far as the state of glottis is concerned, all Bangla vowels are produced as voiced. According to the function of the velum Bangla vowels can be articulated as oral and/or nasalized. When the lung air passes through the oral or the oral and nasal cavities, there is no audible friction since there is sufficient passage between the active and passive articulators. Thus, all Bangla vowels are produced with open approximation. Besides these

commonalities among the vowels, each of them has certain unique properties. The unique properties of Bangla vowels are discussed next.

There is a controversy regarding the number of Bangla vowels. Chatterji (2002), Shaw (1996) and Islam (2002) say that there are seven pure vowels in Bangla which are [ই], [এ], [এ্যা], [আ], [অ], [ও] and [উ] (Diagram 01), represented as [ই] ([ɪ]), [এ] ([e]), [এ্যা] ([æ]), [আ] ([ɐ]), [অ] ([ɔ]), [ও] ([o]) and [উ] ([ʊ]). Hai (1985) and Huq (2002) mention that there are eight pure vowels in Bangla which are [ই], [এ], [এ্যা], [আ], [অ], [ও], [ও’], and [উ] (Diagram 02). These could be expressed as [ই] ([ɪ]), [এ] ([e]), [এ্যা] ([æ]), [আ] ([ɐ]), [অ] ([ɔ]), [ও] ([o]), [ও’] ([o’]) and [উ] ([ʊ]).

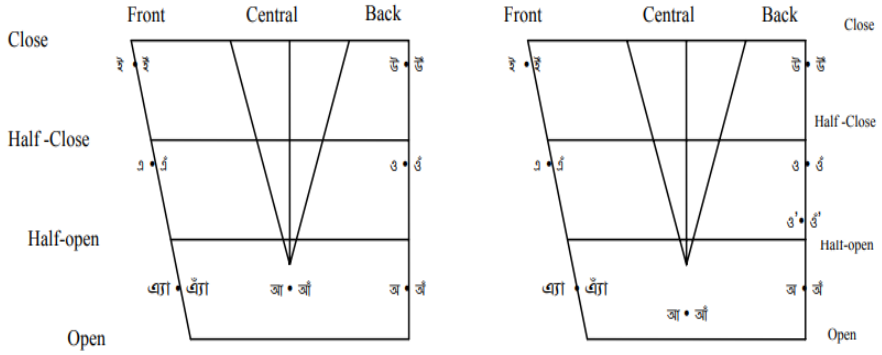


Diagram 01 Diagram 02

(Chatterji, 2002, Shaw, 1996 and Islam, 2002) (Hai, 1985 and Huq, 2002)

Figure 08: Vowel Chart Diagrams

As far as Diphthongs are concerned, with regard to their number Chatterji (ibid) and Shaw (pp. 330-31) say that there are twenty-five Diphthongs in Bangla which include [ইয়া], [ইও], [ইউ], [এই], [এআ], [এও], [এউ], [এ্যাএ], [এ্যাও], [আই], [আএ], [আও], [আউ], [অএ], [অআ], [অও], [ওই], [ওএ], [ওআ], [ওউ], [উই], [উএ], [উআ], [উও] and [ইএ]. These could be expressed as [ইয়া] ([ɪɐ]), [ইও] ([ɪo]), [ইউ] ([ɪʊ]), [এই] ([eɪ]), [এআ] ([eɐ]), [এও] ([eo]), [এউ] ([eʊ]), [এ্যাএ] ([æe]), [এ্যাও] ([æo]), [আই] ([ɐɪ]), [আএ] ([ɐe]), [আও] ([ɐo]), [আউ] ([ɐʊ]), [অএ] ([ɔe]), [অআ] ([ɔɐ]), [অও] ([ɔo]), [ওই] ([oɪ]), [ওএ] ([oe]), [ওআ] ([oɐ]), [ওউ] ([oʊ]), [উই] ([ʊɪ]), [উএ] ([ʊe]), [উআ] ([ʊɐ]), [উও] ([ʊo]) and [ইএ] ([ɪe]). Hai (pp. 27-29), however, says that the number of Diphthongs is thirty-one

of which nineteen are regular which are [ইই], [ইউ], [এই], [এও], [এউ], [এ্যাএ], [এ্যাও], [আই], [আও], [আউ], [আএ], [অও], [অএ], [ওও], [ওউ], [ওই], [ওএ], [উই] and [উউ], and twelve are irregular which include [ইআ], [ইএ], [ইও], [এআ], [এও], [এ্যাআ], [অআ], [ওআ], [ওএ], [উএ], [উআ], and [উও]. The regular ones could be represented as [ইই] ([ɪɪ]), [ইউ] ([ɪʊ]), [এই] ([eɪ]), [এও] ([eo]), [এউ] ([eʊ]), [এ্যাএ] ([æe]), [এ্যাও] ([æo]), [আই] ([ɐɪ]), [আও] ([ɐo]), [আউ] ([ɐʊ]), [আএ] ([ɐe]), [অও] ([ɔo]), [অএ] ([ɔe]), [ওও] ([oo]), [ওউ] ([oʊ]), [ওই] ([oɪ]), [ওএ] ([oe]), [উই] ([ʊɪ]) and [উউ] ([ʊʊ]). The twelve are irregular vowels could be included as [ইআ] ([ɪɐ]), [ইএ] ([ɪe]), [ইও] ([ɪo]), [এআ] ([eɐ]), [এও] ([eo]), [এ্যাআ] ([æɐ]), [অআ] ([ɔɐ]), [ওআ] ([oɐ]), [ওএ] ([oe]), [উএ] ([ʊe]), [উআ], ([ʊɐ]), and [উও], ([ʊo]).

It seems Prof. Hai (1967) has considered the long sounds as Dipthongs [i] and [u]. Including the two long sounds it becomes eight Pure Vowels. In literature, a pure vowel is a vowel which does not change in sound quality; as in there is no shift or glide from one sound to another. It can include the long vowels and short vowels. In that respect, there could be eight pure vowels. A vowel may be pronounced short or long in a word but the two modes of pronunciation will mean the same thing in Bangla. There will be no change of meaning for vowel length. (Hai 1967; p.16). As for Diphthongs, Prof. Hai (1967) has added [ইই] ([ɪɪ]), [ওও] ([oo]), [উউ] ([ʊʊ]), and [এ্যাআ] ([æɐ]). In addition to that, [ওএ] ([oe]), and [এও] ([eo]) has been considered to have both irregular and regular variety. Like most Magadhan languages (Magadhi: derived from the ancient Magadhi Prakrit), vowel length is not contrastive in Bangla; all else equal, there is no meaningful distinction between a ‘short vowel’ and a ‘long vowel’, unlike the situation in most Indo-Aryan languages. However, when morpheme boundaries come into play, vowel length can sometimes distinguish otherwise homophonous words. This is because open monosyllables (i.e., words that are made up of only one syllable, with that syllable ending in the main vowel and not a consonant) can have somewhat longer vowels than other syllable types. For example, the vowel in ‘ca’ ('tea') can be somewhat longer than the first vowel in ‘caṭa’ ('licking'), as ‘ca’ is a word with only one syllable, and no final consonant. The suffix ‘ṭa’ (snacks to be eaten with tea) can be

added to ‘ca’ to form ‘caṭa’ (tea and snacks to be eaten with tea), and the long vowel is preserved, creating a minimal pair ([ˈtʃɐt̪ɐ] vs. [ˈtʃɐˑt̪ɐː]).

In summary, all Bangla vowels are articulated with pulmonic egressive air-stream mechanism, voiced, articulated with the stricture of open approximation, described and classified as Front, Central and Back vowels, according to the position of the tongue. Active articulators for Bangla Front, Central and Back vowels are the front of the tongue, central part of the tongue and back of the tongue respectively. Passive articulators for Bangla Front, Central and Back vowels are the hard palate, central part of the palate and the soft palate respectively. Bangla vowels are described and classified as Close, Half/Near-Close, Half/Near-Open and Open vowels, according to the height of the tongue, and also as Rounded and Unrounded vowels according to the position of the lips. They are also described and classified as Pure vowels and Diphthongs according to the quality due to positions of the tongue. There is controversy regarding the number of vowels. There are seven/eight Pure vowels, and twenty-five/thirty-one Diphthongs. All pure vowels are oral, short and nasalized. Length of vowels does not necessarily contribute to the meaning of the words. In Bangla, there is also the use of consonant abbreviation, called ফলা, IPA /pʰɒlɐ/; i.e. sometimes consonant letters in Bangla shortens by changing the shape if it is connected with another consonant or a vowel. There are six of these abbreviations which are written below with examples.

i. য-ফলা (য)= সহ্য, কাঠিন্য; if there is অ-কারান্ত ([ɔ]- like or [ɒ]-like) or আ-কারান্ত ([ɐ]-like) in the previous letter, it becomes অ্যা-কারান্ত ([æ]- like)
ii. ব-ফলা (ব) = পক্ক, অশ্ব, বিশ্বাস, [b]-like feature
iii. ম-ফলা (ম)= বিস্ময়, মৃন্ময়ী, সম্মান, [m]-like feature
iv. র -ফলা (র) = প্রতি, প্রচুর, প্রমাণ, [ɾ]-like feature
v. ল-ফলা (ল) = আল্লামা, স্লোগান, অম্ল, [l]-like feature
vi. ন-ফলা (ন) =নন্দিনী, কান্না, বিভিন্ন, [n]-like feature

2.3.3. Cross-Linguistic Perspective on Bangla Phonetics and Integrating Features: Such features could be Schwa Deletion in Indian Languages, Nasalization, Vowel Doubling, Bangla Triphthongs, etc.

(i) Schwa Deletion in Indian Languages: Schwa deletion, or schwa syncope, is a phenomenon where schwas are obligatorily deleted in pronunciation even if the script suggests otherwise. The process is, the schwa [ə] sound at the end of the word is deleted. Bangla equivalent for Schwa is open-mid back rounded vowel or [ɔ]. Bangla deletes this vowel at the end when not ending in a consonant cluster but sometimes retains this vowel at the medial position. The consonant clusters at the end of a word usually follows a close-mid back rounded vowel or [o]. For example, the Sanskrit word पथ ([pɐt̪ʰɐ], way) corresponds to the Bangla word 'পথ' [pɔt̪ʰ]. But the Sanskrit word 'अन्त' ([ɐnt̪ɐ], end) retains the end vowel and becomes 'অন্ত' [ɔnt̪o] in Bangla, as it ends with a consonant cluster. However, Tatsama borrowings from Sanskrit generally retain the [ɔ] except in word-final positions and except in very informal speech. That vowel in medial position is not always retained. For instance, 'কলকাতা' is pronounced as [kolkɐt̪ɐ], and not [kolɔkɐt̪ɐ].

(ii) Nasalization: Another feature could be about Nasalization. In Bangla any vowel may be nasalized. Therefore, all the pure vowels in Bangla have their nasalized counterparts. There is, however, debate among the Bangla phoneticians on the status of nasal vowels in the language. Some argue that nasalization is a distinctive feature in Bangla, so nasals are separate vowels just like other pure vowels. (Bhattacharja, 2006, p. 131; Sen 2002, p. 183) Others argue that nasalization is not a distinctive feature in Bangla, so nasals should be counted as allophonic variation of the pure vowels (Khan, 2010; p. 222; Majumdar, 1997, p. 118). It seems, nasalization could, perhaps be considered as a suprasegmental feature which does not have an effect in the meaning.

(iii) Vowel Doubling: Vowel doubling is another point of discussion. In Bangla, vowel length carries less importance, as it is not a meaning-distinguishing factor in the language. However, Bangla seems to employ a combination of two vowels in some linguistic situations. In the first person present indefinite conjugation, verbs such as 'dewa'/ 'newa' (give/take) assume the shape of 'diyi'/'niyi'. They will

rather be pronounced as [dii] and [nii]. Same is the case with the verbs ‘dhowa’, IPA [ɖʱɒɐ] (meaning wash) and ‘showa’, IPA [ʃɒɐ] (meaning sleep); in the second person intimate imperative form, they will become ‘dhoo’ [ɖʱɐ] and ‘shoo’ [ʃɒ] respectively. Here the same vowel in sequence is found. It can be called ‘Vowel Doubling’, which is a unique feature of Bangla. (Chatterji, 1988, p. 35).

(iv) Bangla Triphthongs: According to Dr Bijoy Barman (2009), there are about 17 Bangla Triphthongs which are: [আইআ] ([ɐiɐ]), [এইআ] ([eiɐ]), [অইআ] ([ɔiɐ]), [উইআ] ([ʊiɐ]), [আএআ] ([ɐɪɐ]), [অএআ] ([ɔɪɐ]), [আইএ] ([ɐɪe]), [অয়এ] ([ɔɪe]), [অয়অ] ([ɔɪɔ]), [আইও] ([ɐɪo]), [আউআ] ([ɐʊɐ]), [এউআ] ([eʊɐ]), [অউআ] ([ɔʊɐ]), [অওআ] ([ɔoɐ]), [এওআ] ([eoɐ]), [এ্যাওআ] ([æoɐ]), [আওআ] ([ɐoɐ]). Triphthongs might be used more likely for informal speech. The phonological alternations of Bangla vary due to the dialectal differences between the speech of Bangla language speaking people living on the western (পশ্চিম, Poschim) side and eastern (পূর্ব, Purbo) side of Padma River. In the dialects prevalent in much of eastern and south-eastern Bangladesh (Barisal, Chittagong, Dhaka and Sylhet Divisions of Bangladesh), many of the stops and affricates heard in the West Bengal dialects are pronounced as fricatives. Western Palato-alveolar and alveolo-palatal affricates চ [tɕɔ~tʃɔ], ছ [ɕʰɔ~tʃʰɔ], জ [dʑɔ~dʒɔ] correspond to eastern চ [tsɔ], ছ [tsʰɔ~sɔ], জ [dzɔ~zɔ]. The aspirated velar stop খ [kʰ], the unvoiced aspirated labial stop ফ [pʰ] and the voiced aspirated labial stop ভ [bʱ] of Poshcim/western Bengali dialects correspond to খ় [x~ʜ], ফ় [f~ɸ] and ভ [β~v] in many dialects of Purbo/eastern Bengali. These pronunciations are more prevalent in the Sylheti of northeastern Bangladesh and south Assam, the language spoken by most of the Bengali community in the United Kingdom. Many Purbo/eastern Bengali dialects share phonological features with Assamese dialects, including the debuccalization of শ [ʃ~ɕ] to হ [ɦ] or খ় [x]. The influence of Tibeto-Burman languages on the phonology is mostly on the Bengali dialects spoken east of the Padma River and relatively less in West and South Bengal, as is seen by the lack of nasalized vowels in eastern Bengal, but nasalization is present in Indian Bengali dialects and an alveolar articulation for the otherwise postalveolar stops ট [ʈ], ঠ [ʈʰ], ড [ɖ], and ঢ [ɖʱ], resembling the equivalent phonemes in languages such as Thai and Lao. In the phonology of West and Southern Bengal, the distinction

between র [ɾ] and ড়/ঢ় [ɽ] is clear and distinct like neighbouring Indian languages. However, on the far eastern Bengali, Tibeto-Burman influence makes the distinction less clear, and it sometimes becomes similar to the phonology of the Assamese ৰ rô [ɹ]. Unlike most languages of the region, Purbo/eastern Bengali dialects tend not to distinguish aspirated voiced stops ঘ [gʱ], ঝ [dʑʱ], ঢ [ɖʱ], ধ [d̪ʱ], and ভ [bʱ] from their unaspirated equivalents, with some dialects treating them as allophones of each other and other dialects replacing the former with the latter completely. Some variants on the Bengali branch, particularly the Chittagonian, and Sylheti, have contrastive tone and so differences in pitch can distinguish words. There is also a distinction between ই and ঈ in many northern Bangladeshi dialects. ই represents the uncommon /ɪ/, but ঈ the standard /i/ used for both letters in most other dialects.

(v) Atypical Aphasic Speech Across Languages: Cross-linguistic studies have shown that atypical aphasic speech often involves simplification of word forms, although the specific patterns vary according to the phonological and morphological characteristics of each language. For example, an English-speaking individual with aphasia may produce ‘nana’ [ˈnænə] instead of ‘banana’ [bəˈnænə], demonstrating initial syllable deletion. Similarly, a Bangla speaker may produce ‘কম’ [kɔm] instead of ‘কলম’ [kɔlɔm] (in English it is pen), omitting the medial consonant. In Mandarin Chinese, the target word ‘苹果’ (píngguǒ, ‘apple’) [pʰǐŋ.kwɔ̀] may be reduced to ‘果’ (guǒ) [kwɔ̀], preserving only the second syllable. A Japanese speaker may simplify ‘りんご’ (ringo, in English it is apple) [ɾiŋgo] to ‘りご’ (rigo) [ɾigo] through deletion of the nasal consonant. Likewise, a Turkish speaker may produce ‘tap’ [tæp] instead of ‘kitap’ [kiˈtæp] (in English it is book), while an Arabic speaker may produce ‘تاب’ (tāb) [taːb] instead of ‘كتاب’ (kitāb) [kiˈtaːb], omitting the initial syllable. Comparable simplifications are also observed in Spanish, where ‘escuela’ [esˈkwela] (in English it is school) may be reduced to cuela’ [ˈkwela], and in Finnish, where ‘koulu’ [ˈkou̯lu] (in English it is school) may become ‘kou’ [kou̯]. These examples illustrate that although aphasic speech commonly involves omissions and phonological simplifications across languages, the specific manifestations are shaped by the phonetic and structural properties of each language.

2.3.4. Revisited Bangla Consonant and Vowel Sounds: The 'Consonant Sounds' chart next can be suggested, if the dialectic varieties and individual differences are omitted, i.e., the standard variety might include the following places of articulation: Bilabial, Dental, Alveolar, Palato-Alveolar/Post-Alveolar, Velar, Glottal, and the manners of articulation: Plosives, Fricatives, Nasals, and Approximants.

		Places of Articulation					
		Bilabial	Dental	Alveolar	Palato-Alveolar Or, Post-Alveolar	Velar	Glottal
Manners of Articulation	Plosives	[p], [pʰ], [b], [bʱ]	[t̪], [t̪ʱ], [d̪], [d̪ʱ]	[ʈ], [ʈʰ], [ɖ], [ɖʱ]	[c], [cʰ], [ɟ], [ɟʱ]	[k], [kʰ], [g], [gʱ]	
	Fricatives			[s]	[ʃ]		[ɦ]
	Nasals	[m]		[n]		[ŋ]	
	Approximants			[l]	[ɾ], [ɽ]		

Figure 09: Consonant Sounds (Original Work)

As for vowel sounds, the following can be suggested.

(i) Pure Vowels/Monothongs/Monophthongs: [ই] ([ɪ]), [এ] ([e]), [এ্যা] ([æ]), [আ] ([ɐ]), [অ] ([ɔ]), [ও] ([o]), [উ] ([ʊ]). These two Pure vowels are of debate: ঊ ([u]) and ঈ ([i])

(ii) Diphthongs: [ইয়া] ([ɪɐ]), [ইও] ([ɪo]), [ইউ] ([ɪʊ]), [এই] ([eɪ]), [এআ] ([eɐ]), [এও] ([eo]), [এউ] ([eʊ]), [এ্যাএ] ([æe]), [এ্যাও] ([æo]), [আই] ([ɐɪ]), [আএ] ([ɐe]), [আও] ([ɐo]), [আউ] ([ɐʊ]), [অএ] ([ɔe]), [অআ] ([ɔɐ]), [অও] ([ɔo]), [ওই] ([oɪ]), [ওএ] ([oe]), [ওআ] ([oɐ]), [ওউ] ([oʊ]), [উই] ([ʊɪ]), [উএ] ([ʊe]), [উআ] ([ʊɐ]), [উও] ([ʊo]) and [ইএ] ([ɪe])

(iii) Triphthongs: [আইআ] ([ɐiɐ]), [এইআ] ([eɪɐ]), [অইআ] ([ɔiɐ]), [উইআ] ([ʊiɐ]), [আএআ] ([ɐɪɐ]), [অএআ] ([ɔɪɐ]), [আইএ] ([ɐɪe]), [অয়এ] ([ɔɪe]), [অয়অ] ([ɔɪɔ]), [আইও] ([ɐɪo]), [আউআ] ([ɐʊɐ]), [এউআ] ([eʊɐ]), [অউআ] ([ɔʊɐ]), [অওআ] ([ɔoɐ]), [এওআ] ([eoɐ]), [এ্যাওআ] ([æoɐ]), and [আওআ] ([ɐoɐ])

As Bangla is a syllable-timed language 7 Pure Vowels can be suggested as ঈ ([i]), and ঊ ([u]) is only based on the length of the vowel sounds. As for Diphthongs, the number could be 25 following the above list. The sounds [ইই] ([ɪɪ]), [ওও] ([oo]), and [ঊঊ] ([ʊʊ]) are based on the length of the vowels, hence, are not considered in the above list. [এাআ] ([æɐ]) can perhaps be considered.

2.5. Other Parameters

The articulatory and acoustic features are the first parameters to identify the Bangla typical and atypical speech sounds. The IPA Chart (Revised on 2020), in this regard can be beneficial to study the typical speech whereas the extIPA can be used to identify the features of atypical speech patterns. The first pointer of measuring is to identify if the speech is pulmonic or non-pulmonic. For pulmonic consonant sounds, the places and manners of articulation could be identified next whereas for nonpulmonic consonant sounds, clicks, implosives and ejectives could be categorized. Going through the diacritic features along with other symbols, suprasegmental features, tones and accents are to be observed for identifying the linguistic and suprasegmental features. In case of vowel sounds, the types of vowels should be looked into. Since, Bangla language has various cross-linguistic interpretations, it is imperative to look into all the suggested features of consonants and vowels. Given next are the probable parameters.

Places of Articulation	**Manners of Articulation**
Primarily: Pulmonic or Non-Pulmonic If Non-Pulmonic, Clicks or Implosives or Ejectives If Pulmonic, Labial or Coronal or Dorsal or Laryngeal If Labial, Bilabial or Labio-Dental or Linguo-Labial or Labio-Alveolar or Labial-Velar or Labial-Palatal If Coronal, Dental or Alveolar or Palato-Alveolar/Post-Alveolar or Alveolo- Palatal or	Primarily: Stops/Plosives, Nasals, Fricatives, Approximants, Affricates, Percussive, Frictionless Continuants and Semi-Vowels, Additionals, Roll If Fricatives, Sibilants or Median or Lateral or Fricatives+Laterals+Medians or Fricatives+Nasals

Retroflex If Dental, Bidental or Dento-Labial or Interdental If Dorsal, Palatal or Velar or Uvular If Laryngeal, Pharyngeal/Epiglottal or Glottal ➢ If Pharyngeal, Velo-Pharyngeal or Upper-Pharyngeal	If Approximants, Central or Lateral If Additionals, Trill/Roll or Tap/Flap If Roll, Rolled or Rolled Fricative

Figure 10: Places and Manners Parameters (Original Work)

Additional Parameters (followed by the IPA Chart and extIPA for Disordered Speech) are next.

(a) Features of Phonation Modes	**(b) Features of Pitch Patterns**	**(a) Additional Features of Articulation**
Pre-Voicing	Primary Stress	Advanced Tongue Root
Post-Voicing	Secondary Stress	Retracted Tongue Root
Partial Devoicing	Long	Dental
Initial Partial	Half-Long	Apical
Devoicing	Extra-Short	Laminal
Final Partial	Minor (Intonation)	Nasalized
Devoicing	Group	Nasal Release
Partial Voicing	Major (Intonation)	Lateral Release
Initial Partial	Group	Double Articulations
Voicing	Syllable Break	. Simultaneous
Final Partial	Linking (Absence	. Non-Syllabic
Voicing	of a Break)	. Rhoticity
Unaspirated	. Extra High	. Labialized
. Aspirated	. High	. Palatalized
. Pre-Aspiration	. Mid	. Velarized
. Voiceless	. Low	. Pharyngealized
. Voiced	. Extra-Low	. Velarized or Pharyngealized
. Breathy Voice	. Down-step	. Raised
. Creaky Voice	. Up-step	. Main Gesture Offset Left
. No Audible Release	. Rising/Global Rise	. Main Gesture Offset Right

. Falsetto	. Falling/Global Fall	. Centralized
. Whisper	. High-Rising	. Mid-Centralized
. Whistled	. Low-Rising	. Syllabic
Articulation	. Rising-Falling	. Labial Spreading
. Sliding Articulation		. Strong Articulation
. Ingressive Airflow		. Weak Articulation
		. Reiteration
		. Denasal, Partial Denasal
		. Lowered
		. More Rounded
		. Less Rounded

Figure 11: Modes, Patterns and Articulation Parameters (Original Work)

Durational intervals in the linguistic input are also to be measured; i.e., if the sounds are the continuation of the same sound or not, as in, if there are any significant changes in the extension of the sounds or if phonetic characteristics of the sounds around it affect the sound, for instance whether the vowel is followed by a voiced or a voiceless consonant etc. In case of syllable-timed languages, i.e., in the languages whose syllables take approximately equal amounts of time to pronounce, stress and focus does not affect (vowel) duration (Irene Vogel & Angeliki Athanasopoulou). Also, if the sound change has any Linguistic categorical change. If the vowel length is distinguished phonemically, then there might be short and long vowels.

Chapter Three
Methodology for the Research

This chapter assesses the validity and reliability of the research by adopting systematic and specific methodology or techniques. It takes in fieldwork and electronic sources and provides linguistic analysis in relation to the literature review and received data to draw a conclusion. At first, it selects the logic of inquiry as a quantitative method with details provided anywhere needed. Then selects specific settings and participants, procedures for data collection and analysis considering the ethical matters as the participants were of atypical speech disorders. As the purpose of the research is to analyze the phonetic and phonological features of typical and atypical speech of Bangla language, the methodology section follows the research objectives and questions below as stated earlier.

3.1. Research Objectives

The main objectives of this research were to;

(a) revisit and catalogue the articulatory and acoustic features of Bangla typical speech,

(b) devise necessary articulatory and acoustic tools to collect Bangla typical and atypical speech,

(c) propose amendments to the existing extIPA for disordered speech in the context of Bangla atypical speech.

3.2. Research Questions

The initial comparisons of this research have been based on the features of Bangla typical and atypical speech. The queries below add to its practicality.

(a) Which articulatory and acoustic features are most significant in the production of Bangla atypical speech? Which phonological errors are more prominent?

(b) How are these features different from Bangla typical speech?

(c) What type of modifications are required to develop transcription models for Bangla atypical speech?

The study makes a comparative analysis of typical and atypical speech. Given next is the description of the participants, selected tools and instruments, statistical analysis procedures for this research.

3.3. Participants: This research utilizes adult typical and atypical participants who have standard Bangla as L1 as well as their mother tongue. There have not been any dialect variations within the participants. To further reduce possible discrepancies, the participants with typical speech were selected based on the ages of the atypical participants. The research comprises of a total of 110 participants with a ratio of 10 typical per atypical participant (10:1). Type versus Token ratio is, 2 : 840, i.e. types of patients versus number of occurrences. As for sample, it is 2 : 168. All atypical participants are diagnosed aphasic patients, primarily from Bangladesh Medical University (formerly BSMMU) and Metropolitan Medical Centre Ltd. The patients have suffered from Broca's Aphasia after cerebrovascular accident (CVA) with impressions of intracerebral haematoma in the cerebral hemisphere and are at the early stage of treatment and speech therapy, i.e., within 6 months to a year. All the data for this research are confidential to protect the patients' privacy, with the consent of the patients and/or their caregivers, and only aligns with the research. For each participant, a consent form has been used; a sample consent form has been added in the Appendix section.

3.4. Selected Tools and Instruments: In order to collect data, two Task-based Phonological Tests has been devised: (a) picture naming and (b) word naming. In each case, the patients were shown target stimuli and asked to say each target item within a 1-minute interval per flashcard. If the patient fails to give the correct response initially, a phonemic cue is provided which is the initial sound of the target word. All the words for the word naming test have been collected from Bangla Academy Concise Bangla Dictionary (বাংলা একাডেমী সংক্ষিপ্ত বাংলা অভিধান), therefore the words are standard text words. Also, a checklist has been devised to identify the articulatory and acoustic features of typical and atypical speech, along

with the types of phonological errors made by the patients. For this research, distortions, omissions, substitutions, and insertions has been listed. The tests have been administered in person. A pilot study has been administered to pre-test the tests and the checklist on a small number of people before it is used in earnest. For this research, word stimuli have been taken under consideration rather than non-word stimuli, this is because word stimuli are used to identify lexical phonologic output impairments (Hillis et al., 2001). Word naming, or word repetition tasks which require verbal production of familiar words, help to identify impairments of lexical phonologic output (Caramazza & Hillis, 1990). For analyzing the data gathered from typical and atypical speech, PRAAT has been used. It processed the recorded audio, generated waveforms and spectrograms which assisted to visualize vocal data in a more printable and quantifiable format. The software further computed precise and aggregated values of all the prosodic features such as intensity, pitch patterns, formants, pulses, frequency, syllable break, labeled words, and individual phonemes. All these instruments have been used for articulatory and acoustic feature analysis. Considering the number and type of the participants, the reference period of the study, and the nature of the investigation, the research design has been classified as cross-sectional/experimental study with stratified random sampling and it is semi-longitudinal.

For analysis, Glasgow Coma Scale (GCS) has also been used as a neurological assessment tool to determine the patients level of consciousness by scoring their verbal responses. It was also recommended at BMU. The V Scale (0-5) from Glasgow Coma Scale (1974) are V5 (Oriented: fluent speech, comprehension and production are intact), V4 (Confused Conversation: speech is connected but disoriented), V3 (Inappropriate Words: random or irrelevant words, affected comprehension), V2 (Incomprehensible Sounds: moans, no real words, severe speech/language breakdown), V1 (None/Coma: no verbal output).

Suggestive Typical versus Atypical Ratio Assessment Color-Flag Chart (original work) Green  is Normal Range (0–25 %), Yellow  is Elevated Atypical (26-50%), Orange  (51-75%) is Markedly Atypical, Red  is Highly Atypical (76-100%). For error types similar measures were taken identify the levels.

3.5. Statistical Analysis Procedure: For this research, PRAAT has been used to annotate and map the data. The data has been measured following categorical variables as the values can be easily separated into discrete categories. In each case the recorded data has been filtered with noise cancelation software. The sound waves were then run using PRAAT. The spectrograms provided a quantifiable status of the prosodic features along with the linguistic features. Given next is a pilot study flowchart and sample table. For both the tasks: Picture and Word Naming, the flowchart next gives a direction for data collection and analysis. The data collection has been divided into two parts: pre-activity and while-activity whereas the data analysis has the post- activity.

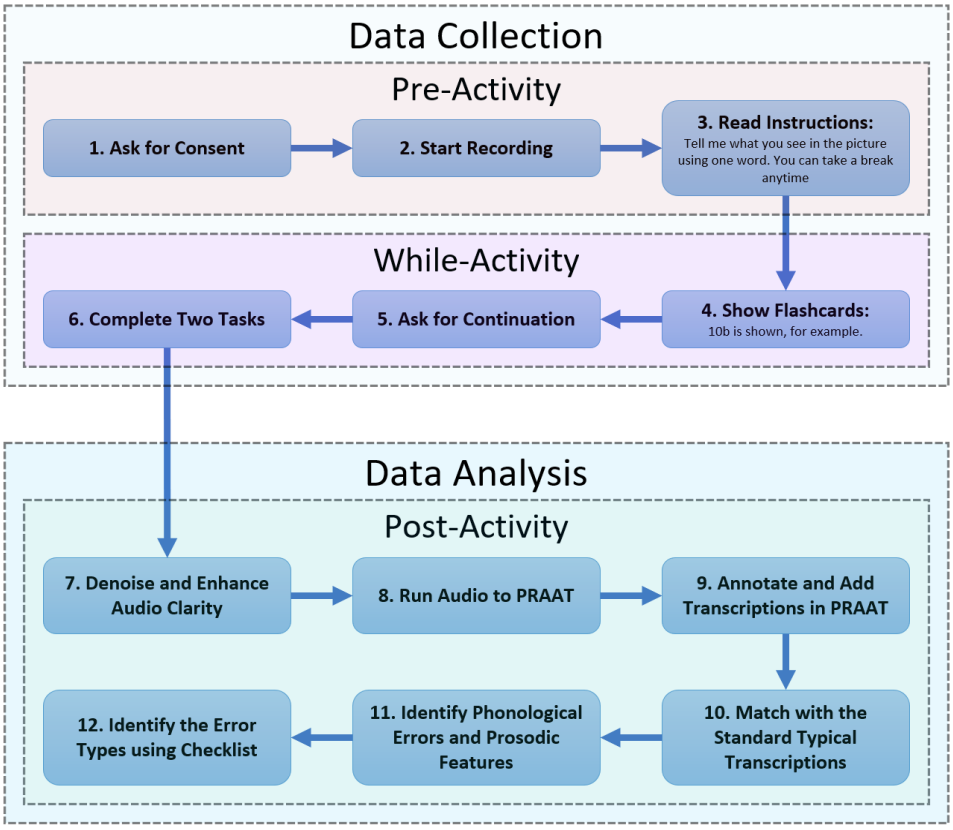
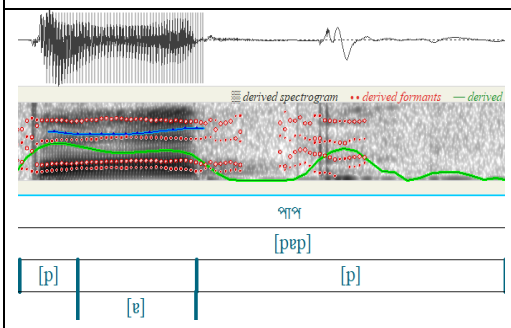
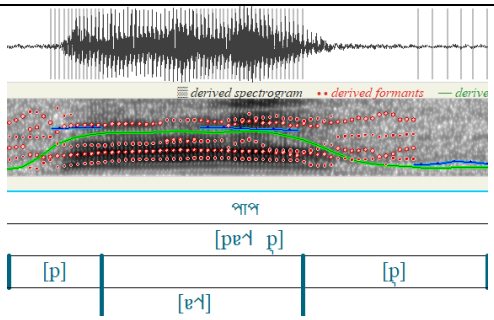


Figure 12: The Pilot Study Layout

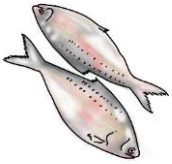
Given next is an Oscillogram of Word Naming Task, Item 1c: পাপ, /pɐp/ for typical and atypical speech using PRAAT.

Typical Speech	*Atypical Speech*
	
Figure 13 (a): Oscillogram of পাপ, [pɐp] It shows a PRAAT illustration of the word পাপ which is displayed in the Interval Tier 01: Bangla Text Word 'পাপ', and its transcription is in Interval Tier 02: IPA: [pɐp], Point Tier 01: Consonants [p], [p] and Point Tier 02: Vowel: [ɐ] 1c focuses on the sound, [p] which appears at the end of the word. It is a pulmonic egressive, bilabial, voiceless sound which is of 0.07 seconds, 80 dB, 258 Hz.	Figure 13 (b): Oscillogram of পাপ, [pɐˤp̰] Here, [p] appears at the end of the word. It's 0.04 seconds, 63 dB, 230 Hz. It has weak articulation. The atypical IPA is [pɐˤp̰]. Other features include: rising-falling onset addition with [ɐ]. Note: e[p] = atypical, distortion (weak articulation)

As for linguistic interpretation, in the word পাপ, [pɐˤp̰], [p̰] represents rising-falling onset addition, for segmental features it shows [+consonantal], [+labial], [+anterior]. Here, there is no secondary articulation, however it displays weak articulation. It's an end sound and the articulatory organs include upper and lower lips. The place of articulation is bilabial, manner is plosive, and it is a voiceless sound. It is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. There is weak Articulation (̰) as it shows lower intensity and blurred formants.

Appendix 01 (For Patients)

A. Task-based Phonological Test: Picture Naming Flashcards

 1b, 29b	 2a	 2c	 3c
 5c, 26a	 7b	 7c	 8c, 22b
 9a	 9c	 10b	 10c
 11a, 27b	 12a	 13a	 13c
 14a	 14c	 15b	 15c

 17c	 17d	 19a	 19c, 28b
 20c	 22c	 24d	 25c
 25d	 26b, 29a	 27c	 28c

Figure 14: Task-based Phonological Test: Picture Naming Flashcards

B. Task-based Phonological Test: Word Naming Flashcards

পুঁইশাক 1a	পাপ 1c	লাফানো 2b	ব্যায়াম 3a	সবুজ 3b	ভাল 4a
অভাব 4b	বিক্ষোভ 4c	তবুও 5a	দ্বিতীয় 5b	থামিয়ে 6a	কোথাও 6b
পথ 6c	দেয়না 7a	ধোঁয়া 8a	অর্ধেক 8b	আটক 9b	ঠিকানা 10a
আড্ডা 11b	রড 11c	বেঢপ 12b	টৈটৈ 12c	ঢুঁ 12d	আচার 13b

বছর	যেও	ঝাউবন	অঝোর	ঝাঁঝ	কুয়াশা
14b	15a	16a	16b	16c	17a
দোকান	খেয়া	কখন	আখ	আগামী	ঘেউঘেউ
17b	18a	18b	18c	19b	20a
আঘাত	সূফী	আস্থা	আফসোস	সেদিকেই	শ্বাস
20b	21a	21b	21c	22a	22c
হও	বহুত	বাহ	ম্যাও	মিউ	থামিয়া
23a	23b	23c	24a	24b	24c
নুয়ে	অনেক	লয়া	রয়ে	পাঁপড়	
25a	25b	27a	28a	29b	

Figure 15: Task-based Phonological Test: Word Naming Flashcards

Appendix 02 (For Data Analyses)

A. Task-based Phonological Test: Picture and Word Naming Transcriptions
(B= beginning, M=middle, E=ending, P=pure vowels, D=diphthongs)

Sl No.	Consonant Sounds		Text (Standard Bangla) (Interval Tier 01)	Transcriptions					
				IPA (Interval Tier 02)	List of Sounds				
					Consonant Sounds (Point Tier 01)			Vowels (Point Tier 02)	
					B	M	E	P	D
01	/p/	a	পুঁইশাক	[pu̯ĩʃɐk]	[p]	[ʃ]	[k]	[ɐ]	[u̯ĩ]
		b	পিঁপড়া	[pĩpɽɐ]	[p]	[p]	[ɽ]	[ĩ], [ɐ]	
		c	পাপ	[pɐp]	[p]		[p]	[ɐ]	

02	/pʰ/	a	ফুল	[pʰul]	[pʰ]		[l]	[u]	
		b	লাফানো	[lɐpʰɐno]	[l]	[pʰ]	[n]	[ɐ], [o]	
		c	বরফ	[bɔɾopʰ]	[b]	[ɾ]	[pʰ]	[ɔ], [o]	
03	/b/	a	ব্যায়াম	[bæ͡ɐm]	[b]		[m]		[æ͡ɐ]
		b	সবুজ	[ʃobuɟ]	[ʃ]	[b]	[ɟ]	[o], [u]	
		c	লেবু	[lebu]	[l]		[b]	[e], [u]	
04	/bʱ/	a	ভাল	[bʱɐlo]	[bʱ]		[l]	[ɐ], [o]	
		b	অভাব	[ɔbʱɐb]		[bʱ]	[b]	[ɔ], [ɐ]	
		c	বিক্ষোভ	[bɪkkʰobʱ]	[b]	[k], [kʰ]	[bʱ]	[ɪ], [o]	
05	/t̪/	a	তবুও	[t̪obuo͡]	[t̪]		[b]	[o]	[uo͡]
		b	দ্বিতীয়	[d̪it̪ɪo͡]	[d̪]	[t̪]		[i]	[ɪo͡]
		c	হাত	[ɦɐt̪]	[ɦ]		[t̪]	[ɐ]	
06	/t̪ʰ/	a	থামিয়ে	[t̪ʰɐmɪe͡]	[t̪ʰ]		[m]	[ɐ]	[ɪe͡]
		b	কোথাও	[kot̪ʰɐo͡]	[k]	[t̪ʰ]		[o]	[ɐo͡]
		c	পথ	[pɔt̪ʰ]	[p]		[t̪ʰ]	[ɔ]	
07	/d̪/	a	দেয়না	[d̪æ͡enɐ]	[d̪]		[n]	[ɐ]	[æ͡e]
		b	ইঁদুর	[ĩd̪uɾ]		[d̪]	[ɾ]	[ĩ], [u]	
		c	চাঁদ	[cɐ̃d̪]	[c]		[d̪]	[ɐ̃]	
08	/d̪ʱ/	a	ধোঁয়া	[d̪ʱõ͡ɐ]	[d̪ʱ]				[õ͡ɐ]
		b	অর্ধেক	[ɔɾd̪ʱek]	[ɾ]	[d̪ʱ]	[k]	[ɔ], [e]	

		c	ঔষধ	[o͡uʃɔɖ̪ʱ]		[ʃ]	[ɖ̪ʱ]	[ɔ]	[o͡u]
09	/ʈ/	a	টমেটো	[ʈɔmeʈo]	[ʈ]	[m]	[ʈ]	[ɔ], [e], [o]	
		b	আটক	[ɐʈok]		[ʈ]	[k]	[ɐ], [o]	
		c	খাট	[kʰɐʈ]	[kʰ]		[ʈ]	[ɐ]	
10	/ʈʰ/	a	ঠিকানা	[ʈʰikɐnɐ]	[ʈʰ]	[k]	[n]	[i], [ɐ]	
		b	কাঁঠাল	[kɐ̃ʈʰɐl]	[k]	[ʈʰ]	[l]	[ɐ̃]	
		c	কাঠ	[kɐʈʰ]	[k]		[ʈʰ]	[ɐ]	
11	/ɖ/	a	ডালিম	[ɖɐlim]	[ɖ]	[l]	[m]	[ɐ], [i]	
		b	আড্ডা	[ɐɖɖɐ]		[ɖ[	[ɖ]	[ɐ]	
		c	রড	[ɾɔɖ]	[ɾ]		[ɖ]	[ɔ]	
12	/ɖʱ/	a	ঢেঁড়স	[ɖʱæ̃ʈoʃ]	[ɖʱ]	[ʈ]	[ʃ]	[æ̃], [o]	
		b	বেঢপ	[beɖʱɔp]	[b]	[ɖʱ]	[p]	[e], [ɔ]	
		c	ঢৈঢৈ	[ɖʱo͡ɪɖʱo͡ɪ]	[ɖʱ]		[ɖʱ]		[o͡ɪ]
		d	ঢুঁ	[ɖʱu]	[ɖʱ]			[u]	
13	/c/ or /t̪ɕ/	a	চড়াই	[cɔʈ͡ɐɪ]	[c]		[ʈ]	[ɔ]	[ɐ͡ɪ]
		b	আচার	[ɐcɐɾ]		[c]	[ɾ]	[ɐ]	
		c	চামচ	[cɐmoc]	[c]	[m]	[c]	[ɐ], [o]	
14	/cʰ/ or /t̪ɕʰ/	a	ছাগল	[cʰɐgol]	[cʰ]	[g]	[l]	[ɐ], [o]	
		b	বছর	[bɔcʰoɾ]	[b]	[cʰ]	[ɾ]	[ɔ], [o]	
		c	মাছ	[mɐcʰ]	[m]		[cʰ]	[ɐ]	

15	/ɟ/ or /d̪ʑ/	a	যেও	[ɟe͡o]	[ɟ]				[e͡o]
		b	গাজর	[gɐɟoɾ]	[g]	[ɟ]	[ɾ]	[ɐ], [o]	
		c	জাহাজ	[ɟɐɦɐɟ]	[ɟ]	[ɦ]	[ɟ]	[ɐ]	
16	/ɟʱ/ or /dʑʱ/	a	ঝাউবন	[ɟʱe͡ubɔn]	[ɟʱ]	[b]	[n]	[ɔ]	[e͡u]
		b	অঝোর	[ɔɟʱoɾ]		[ɟʱ]	[ɾ]	[ɔ], [o]	
		c	ঝাঁঝ	[ɟʱɛ̃ɟʱ]	[ɟʱ]		[ɟʱ]	[ɛ̃]	
17	/k/	a	কুয়াশা	[ku͡ɐʃɐ]	[k]		[ʃ]	[ɐ]	[u͡ɐ]
		b	দোকান	[d̪okɐn]	[d̪]	[k]	[n]	[o], [ɐ]	
		c	নৌকা	[nou͡kɐ]	[n]		[k]	[ɐ]	[ou͡]
		d	নাক	[nɐk]	[n]		[k]	[ɐ]	
18	/kʰ/	a	খেয়া	[kʰe͡ɐ]	[kʰ]				[e͡ɐ]
		b	কখন	[kɔkʰon]	[k]	[kʰ]	[n]	[ɔ], [o]	
		c	আখ	[ɐkʰ]			[kʰ]	[ɐ]	
19	/g/	a	গয়না	[gɔ͡ɪnɐ]	[g]		[n]	[ɐ]	[ɔ͡ɪ]
		b	আগামী	[ɐgɐmi]		[g]	[m]	[ɐ], [i]	
		c	মোরগ	[moɾog]	[m]	[ɾ]	[g]	[o]	
20	/gʱ/	a	ঘেউঘেউ	[gʱe͡ugʱe͡u]	[gʱ]		[gʱ]		[e͡u]
		b	আঘাত	[ɐgʱɐt̪]		[gʱ]	[t̪]	[ɐ]	
		c	বাঘ	[bɐgʱ]	[b]		[gʱ]	[ɐ]	
21	/s/	a	সূফী	[supʰi]	[s]		[pʰ]	[u], [i]	
		b	আস্থা	[ɐst̪ʰɐ]		[s]	[t̪ʰ]	[ɐ]	
		c	আফসোস	[ɐpʰsos]	[pʰ]	[s]	[s]	[ɐ], [o]	

22	/ʃ/	a	সেদিকেই	[ʃeɖɪkeɪ͡]	[ʃ]	[ɖ]	[k]	[e], [ɪ]	[eɪ͡]
		b	ওষুধ	[oʃuɖʱ]		[ʃ]	[ɖ]/	[o], [u]	
		c	শ্বাস	[ʃɐʃ]	[ʃ]		[ʃ]	[ɐ]	
23	/ɦ/	a	হও	[ɦɔ͡o]	[ɦ]				[ɔ͡o]
		b	বহুত	[boɦuʈ]	[b]	[ɦ]	[ʈ]	[o], [u]	
		c	বাহ	[bɐɦ]	[b]		[ɦ]	[ɐ]	
24	/m/	a	ম্যাও	[mæ͡o]	[m]				[æ͡o]
		b	মিউ	[mɪ͡u]	[m]				[ɪ͡u]
		c	থামিয়া	[ʈʰɐmɪ͡ɐ]	[ʈʰ]	[m]		[ɐ]	[ɪ͡ɐ]
		d	কলম	[kɔlom]	[k]	[l]	[m]	[ɔ], [o]	
25	/n/	a	নুয়ে	[nue͡]	[n]				[ue͡]
		b	অনেক	[ɔnek]		[n]	[k]	[ɔ], [e]	
		c	আয়না	[ɐ͡enɐ]			[n]	[ɐ]	[ɐ͡e]
		d	পান	[pɐn]	[p]		[n]	[ɐ]	
26	/ŋ/		N/A	N/A	N/A	N/A	N/A	N/A	N/A
		a	আংটি	[ɐŋʈi]		[ŋ]	[ʈ]	[ɐ], [i]	
		b	ফড়িং	[pʰoɽɪŋ]	[pʰ]	[ɽ]	[ŋ]	[o], [ɪ]	
27	/l/	a	লয়া	[lɔ͡ɐ]	[l]				[ɔ͡ɐ]
		b	ডালিম	[ɖɐlɪm]	[ɖ]	[l]	[m]	[ɐ], [ɪ]	
		c	কল	[kɔl]	[k]		[l]	[ɔ]	
28	/ɾ/	a	রয়ে	[ɾo͡e]	[ɾ]				[o͡e]

		b	মোরগ	[moɾog]	[m]	[ɾ]	[g]	[o]	
		c	বানর	[bɐnoɾ]	[b]	[n]	[ɾ]	[ɐ], [o]	
29	/ɽ/		N/A	N/A	N/A	N/A	N/A	N/A	N/A
		a	ফড়িং	[pʰoɽɪŋ]	[pʰ]	[ɽ]	[ŋ]	[o], [ɪ]	
		b	পাঁপড়	[pɐ̃poɽ]	[p]	[p]	[ɽ]	[ɐ̃] [o]	
Notes:									

Figure 16: Task-based Phonological Test: Picture and Word Naming Transcriptions

B. Feature Detection Checklist (Sample)

Sl No.	Consonant Sounds		Text (Standard Bangla), IPA	Articulatory and Acoustic Features		
				Typical Features (Sample)	Atypical	
					Features (Sample)	Error Types
01	[p]	a	পুঁইশাক, [pu̯ĩ̯ʃɐk]	☐ Bilabial ☐ Labio-Dental ☐ Linguolabial ☐ Dental ☐ Alveolar ☐ Palato-Alveolar ☐ Retroflex ☐ Palatal ☐ Velar ☐ Uvular ☐ Pharyngeal	☐ Dental ☐ Labialized ☐ Palatalized ☐ Velarized/ Pharyngealized ☐ Apical ☐ Laminal ☐ Nasalized ☐ Gliding ☐ Rhoticity ☐ Rounded (More/Less)	☐ Distortion ☐ Substitution ☐ Omission ☐ Insertion/ Addition

				☐ Glottal ☐ Plosive ☐ Nasal ☐ Fricative ☐ Approximant ☐ Affricate ☐ Trill ☐ Egressive ☐ Front/Mid /Back ☐ Rounded/ Unrounded ☐ Clustered ☐ Voiced/ Voiceless Hz: …… dB: …… Sec: ……...	☐ Weak Syllable Deletion ☐ Clusters Reduction ☐ Linking ☐ Reiteration/ Double Articulation/ Pause ☐ Inconsistent /ɦ/ ☐ Whistled Articulation ☐ Ingressive Hz: …… dB: …… Sec: ……...	
Notes:						

Figure 17: Feature Detection Checklist (Sample)

Chapter Four
Analyses and Discussion

The present research is a quantitative one since the research focuses on the ratio or frequency of Bangla typical and atypical speech. It looks into the ratio analysis, sample patient reports, and linguistic interpretation of the received data sets.

4.1. Data Representation

As for ratio analyses, it starts with the Feature Detection Checklist for Task-based Phonological Tests (Picture and Word Naming). It measures the consonant sounds in Oscillogram (Sound Waves), as in Spectrogram presents the articulatory and acoustic features of both Bangla typical and atypical speech, along with error types.

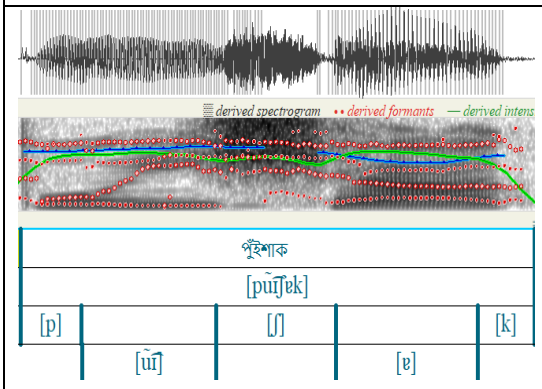
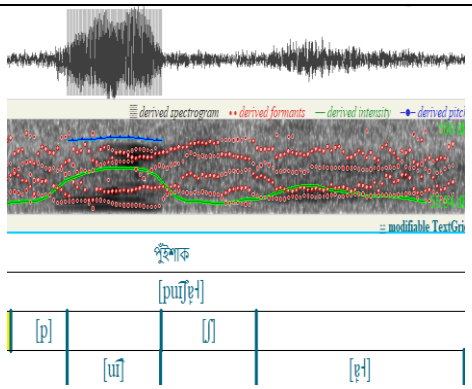
Patient Sl No. 03 (Recurrent)

General Information and Diagnosis	***Name:*** *Jannatul Ferdous*	***Age:*** *24*	***Sex:*** *Female*
History: *2012-2023*	In 2012, experienced headache, vomiting, double vision, diagnosed as a post fossa SOL and operated by posterior midline approach to remove the SOL and VP shunt followed by removal of the tumor in the right sub-occipital approach and was diagnosed as hemangioblastoma in the year of 2014. In 2023, she again got admitted with headaches, vomiting, and dimness of vision and diagnosed as recurrence of post fossa SOL and operated through right sub-occipital approach and removal of tumor took place. Histopathology came out to be Hemangioblastoma, WHO grade 1.		
Present Day:	Now, in 2025, for the last 6 months, her symptoms are,		

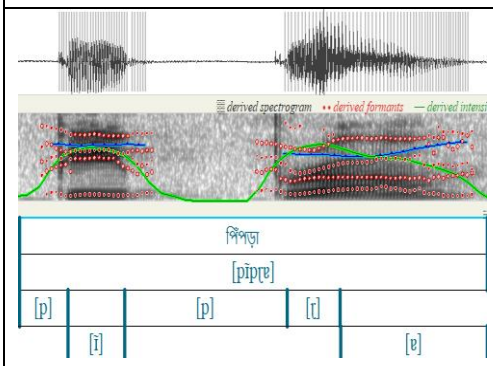
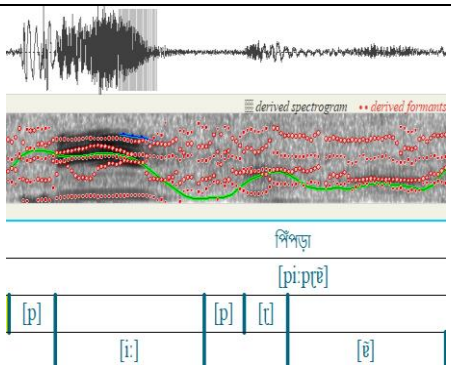
2025 *Recurring*	headaches aggravated during coughing and sneezing, gradual decrease of vision and tendency to fall towards left. ***On Nervous System Examination*** (received info) Higher Psychic Function Intact, GCS 15, Right handed Speech-Scanning, Gait-Ataxic, Lobe Sign: Absent No signs of meningeal irritation

Figure 18: General Information of Patient 03

Data Display 1 (a)

Typical Speech	*Atypical Speech*
	
Figure 19 (a): Oscillogram of পুঁইশাক, [pu͡ĩʃɐk] It shows a PRAAT illustration of the word পুঁইশাক which is displayed in the Interval Tier 01: Bangla Text Word ‘পুঁইশাক’, and its transcription is in Interval Tier 02: IPA: [pu͡ĩʃɐk], Point Tier 01: Consonants [p], [ʃ], [k] and Point Tier 02: Vowel: [ɐ] 1a focuses on the sound, [p] which appears at the beginning of the word. It is a pulmonic egressive, bilabial, voiceless sound of 0.07 seconds, 79 dB, 293 Hz.	Figure 19 (b): Oscillogram of পুঁইশাক, [pu͡ĩʃɐ̟ˈ] Here, [p] appears at the beginning of the word. It’s 0.16 seconds, 67 dB, 222 Hz. It is a typical [p] sound. The atypical IPA is [pu͡ĩʃɐ̟ˈ]. The other features include: retracted tongue root position with a low tone for [ɐ̟ˈ], as in, distortion. Also, omission of [k] sound. Note: b [p] = typical

Data Display 1 (b)

Typical Speech	*Atypical Speech*
	
Figure 20 (a): Oscillogram of পিঁপড়া, [pĩpɽʁ]	Figure 20 (b): Oscillogram of পিঁপড়া, [piːpɽʊ̃]
It shows a PRAAT illustration of the word পিঁপড়া which is displayed in the Interval Tier 01: Bangla Text Word 'পিঁপড়া', and its transcription is in Interval Tier 02: IPA: [pĩpɽʁ], Point Tier 01: Consonants [p], [p], [ɽ] and Point Tier 02: Vowel: [ĩ], [ʁ] 1b focuses on the sound, [p] which appears in the middle of the word. It is a pulmonic egressive, bilabial, voiceless sound which is of 0.2 seconds, 90 dB, 150 Hz.	Here, [p] appears in the middle of the word. It's 0.04 seconds, 63 dB, 230 Hz. It is a typical [p] sound. The atypical IPA is [piːpɽʊ̃]. The other features include: nasalization for [ʊ̃]. Note: m [p] = typical

Data Display 1 (c)

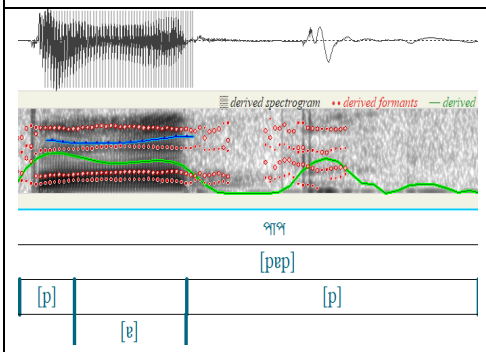
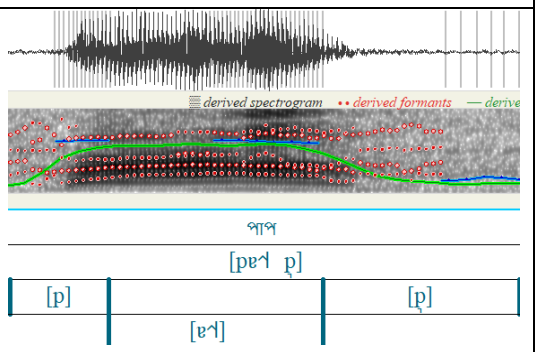
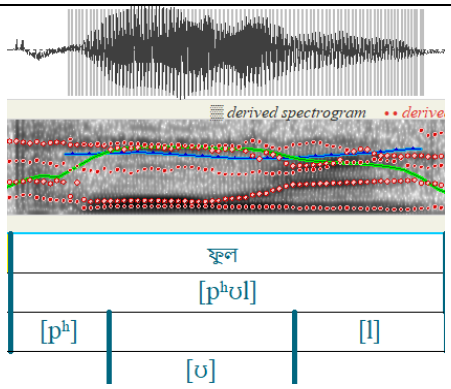
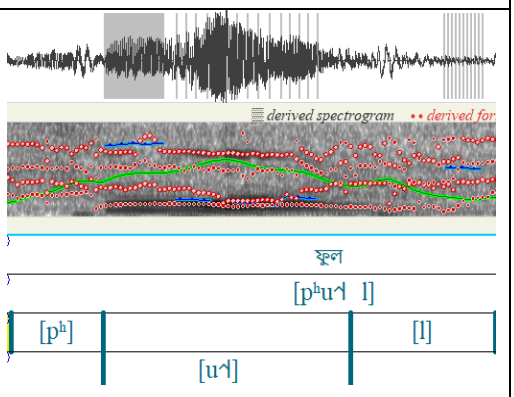
Typical Speech	*Atypical Speech*
	

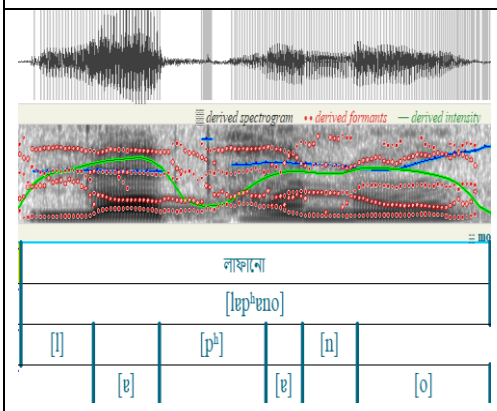
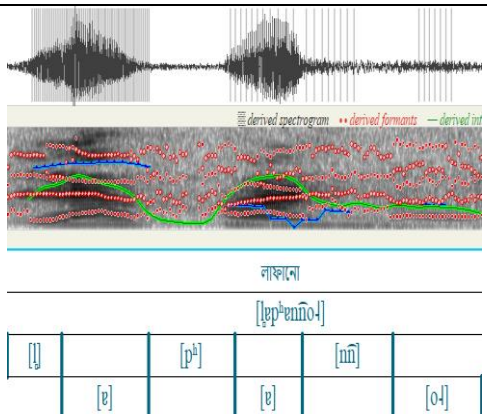
Figure 21 (a): Oscillogram of পাপ, [pɐp]	Figure 21 (b): Oscillogram of পাপ, [pɐˤp̚]
It shows a PRAAT illustration of the word পাপ which is displayed in the Interval Tier 01: Bangla Text Word 'পাপ', and its transcription is in Interval Tier 02: IPA: [pɐp], Point Tier 01: Consonants [p], [p] and Point Tier 02: Vowel: [ɐ] 1c focuses on the sound, [p] which appears at the end of the word. It is a pulmonic egressive, bilabial, voiceless sound which is of 0.07 seconds, 80 dB, 258 Hz.	Here, [p] appears at the end of the word. It's 0.04 seconds, 63 dB, 230 Hz. It has weak articulation. The atypical IPA is [pɐˤp̚]. Other features include: rising-falling of the [ɐˤ] sound. Note: e [p] = atypical, distortion (weak articulation)

Data Display 2 (a)

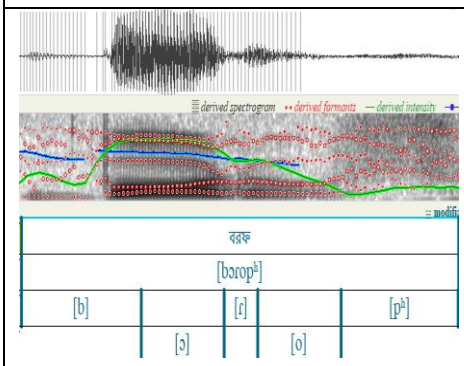
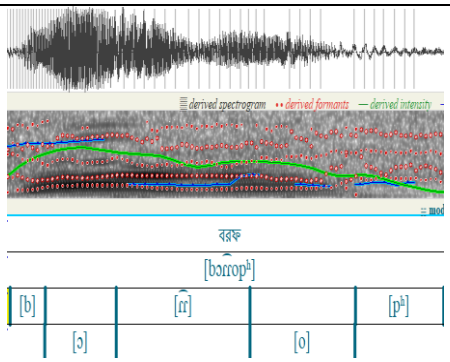
Typical Speech	*Atypical Speech*
	
Figure 22 (a): Oscillogram of ফুল, [pʰul] It shows a PRAAT illustration of the word ফুল which is displayed in the Interval Tier 01: Bangla Text Word 'ফুল', and its transcription is in Interval Tier 02: IPA: [pʰul], Point Tier 01: Consonants [pʰ], [l]	Figure 22 (b): Oscillogram of ফুল, [pʰuˤl] Here, [pʰ] appears at the beginning of the word. It's 0.19 seconds, 57 dB, 226 Hz. It shows typical [pʰ] sound. The atypical IPA is [pʰuˤl]. Other features include: rising-falling of the [uˤ] sound.

and Point Tier 02: Vowel: [u] 2a focuses on the sound, [pʰ] which appears at the beginning of the word. It is a pulmonic egressive, bilabial, voiceless sound which is of 0.09 seconds, 76 dB, 293 Hz.	Note: b [pʰ] = typical

Data Display 2 (b)

Typical Speech	*Atypical Speech*
	
Figure 23 (a): Oscillogram of লাফানো, [lɐpʰɐno]	Figure 23 (b): Oscillogram of লাফানো, [l̪ɐpʰɐn̪n̪o˩]
It shows a PRAAT illustration of the word লাফানো which is displayed in the Interval Tier 01: Bangla Text Word 'লাফানো', and its transcription is in Interval Tier 02: IPA: [lɐpʰɐno], Point Tier 01: Consonants [l], [pʰ], [n] and Point Tier 02: Vowel: [ɐ], [o] 2b focuses on the sound, [pʰ] which appears in the middle of the word. It is a pulmonic egressive, bilabial, voiceless sound which is of 0.16 seconds, 58 dB, 299 Hz.	Here, [pʰ] appears in the middle of the word. It's 0.2 seconds, 50 dB, 209 Hz. It is a typical [pʰ] sound. The atypical IPA is [l̪ɐpʰɐn̪n̪o˩]. Other features include: laminal for [l̪], double articulation of [n̪n̪], low tone for [o˩]. Note: m [pʰ] = typical

Data Display 2 (c)

Typical Speech	*Atypical Speech*
	
Figure 24 (a): Oscillogram of বরফ, [bɔɾopʰ]	Figure 24 (b): Oscillogram of বরফ, [bɔr͡ropʰ]
It shows a PRAAT illustration of the word বরফ which is displayed in the Interval Tier 01: Bangla Text Word 'বরফ', and its transcription is in Interval Tier 02: IPA: [bɔɾopʰ], Point Tier 01: Consonants [b], [ɾ], [pʰ] and Point Tier 02: Vowel: [ɔ], [o] 2c focuses on the sound, [pʰ] which appears at the end of the word. It is a pulmonic egressive, bilabial, voiceless sound which is of 0.16 seconds, 67 dB, 182 Hz.	Here, [pʰ] appears at the end of the word. It's 0.32 seconds, 50 dB, 160 Hz. It is a typical [pʰ] sound. The atypical IPA is [bɔr͡ropʰ]. Other features include: double articulation of [r͡r]. Note: e [pʰ] = typical

Data Display 3 (a)

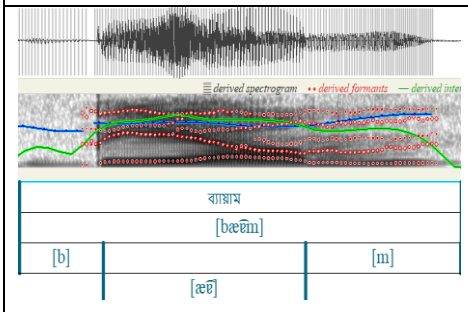
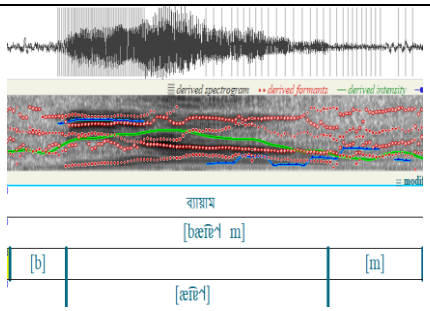
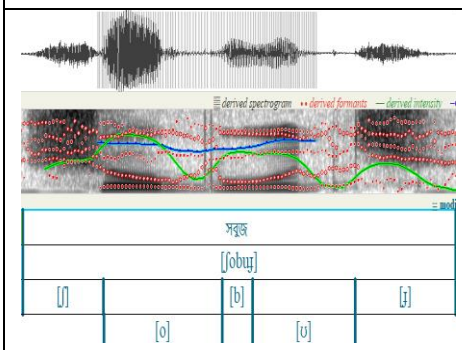
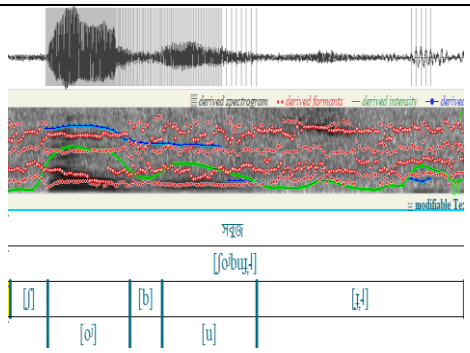
Typical Speech	*Atypical Speech*
	

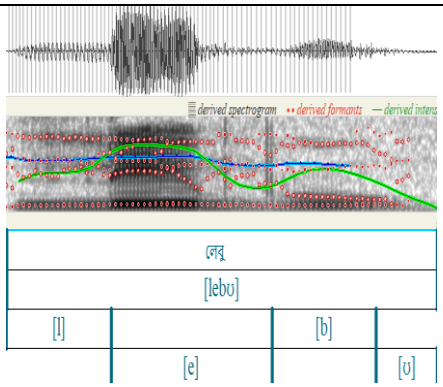
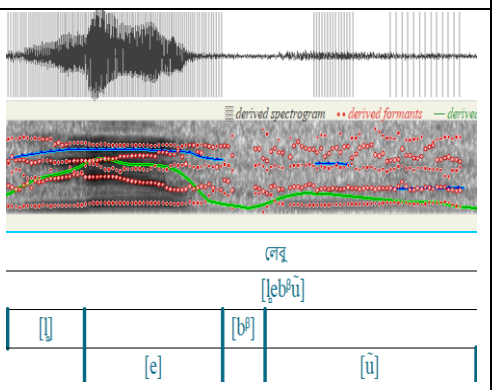
Figure 25 (a): Oscillogram of ব্যায়াম, [bæɐ̯m]	Figure 25 (b): Oscillogram of ব্যায়াম, [bæɪɐˠm]
It shows a PRAAT illustration of the word ব্যায়াম which is displayed in the Interval Tier 01: Bangla Text Word 'ব্যায়াম', and its transcription is in Interval Tier 02: IPA: [bæɐ̯m], Point Tier 01: Consonants [b], [m] and Point Tier 02: Vowel: [æɐ̯] 3a focuses on the sound, [b] which appears at the beginning of the word. It is a pulmonic egressive, bilabial, voiced sound which is of 0.12 seconds, 62 dB, 197 Hz.	Here, [b] appears at the beginning of the word. It's 0.23 seconds, 50 dB, 169 Hz. It is a typical [b] sound. The atypical IPA is [bæɪɐˠm]. Other features include: rising-falling of the [æɪɐˠ]. Note: b [b] = typical

Data Display 3 (b)

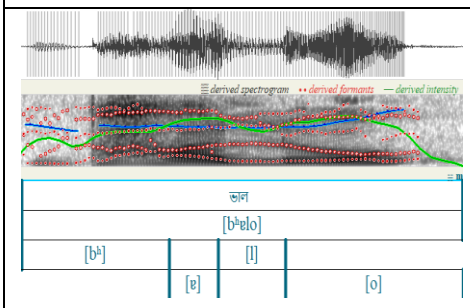
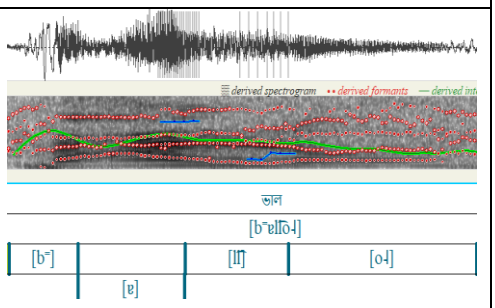
Typical Speech	*Atypical Speech*
	
Figure 26 (a): Oscillogram of সবুজ, [ʃobɯ̟]	Figure 26 (b): Oscillogram of সবুজ, [ʃoʲbɯ̟ˠ]
It shows a PRAAT illustration of the word সবুজ which is displayed in the Interval Tier 01: Bangla Text Word 'সবুজ', and its transcription is in Interval Tier	Here, [b] appears in the middle of the word. It's 0.11 seconds, 67 dB, 194 Hz. It is a typical [b] sound. The atypical IPA is [ʃoʲbɯ̟ˠ]. Other features include: retracted tongue root position and low tone of [ɯ̟ˠ],

02: IPA: [ʃobuɟ], Point Tier 01: Consonants [ʃ], [b], [ɟ] and Point Tier 02: Vowel: [o], [u] 3b focuses on the sound, [b] which appears in the middle of the word. It is a pulmonic egressive, bilabial, voiced sound which is of 0.05 seconds, 74 dB, 217 Hz.	palatalization of [oʲ]. Note: m [b] = typical

Data Display 3 (c)

Typical Speech	*Atypical Speech*
	
Figure 27 (a): Oscillogram of লেবু, [lebu] It shows a PRAAT illustration of the word লেবু which is displayed in the Interval Tier 01: Bangla Text Word 'লেবু', and its transcription is in Interval Tier 02: IPA: [lebu], Point Tier 01: Consonants [l], [b] and Point Tier 02: Vowel: [e], [u] 3c focuses on the sound, [b] which appears at the end of the word. It is a pulmonic egressive, bilabial, voiced sound which is of 0.11 seconds, 70 dB, 198 Hz.	Figure 27 (b): Oscillogram of লেবু, [l̪ebᵝ̃u] Here, [b] appears at the end of the word. It's 0.08 seconds, 50 dB, 183 Hz. It shows lip compression. The atypical IPA is [l̪ebᵝ̃u]. Other features include: laminal [l̪], nasalized [ũ]. Note: e [b] = atypical, distortion (lip compression)

Data Display 4 (a)

Typical Speech	*Atypical Speech*
	
Figure 28 (a): Oscillogram of ভাল, [bʱɐlo]	Figure 28 (b): Oscillogram of ভাল, [b̼ɐl͡lo↓]
It shows a PRAAT illustration of the word ভাল which is displayed in the Interval Tier 01: Bangla Text Word 'ভাল', and its transcription is in Interval Tier 02: IPA: [bʱɐlo]. Point Tier 01: Consonants [bʱ], [l] and Point Tier 02: Vowel: [ɐ], [o] 4a focuses on the sound, [bʱ] which appears at the beginning of the word. It is a pulmonic egressive, bilabial, voiced sound which is of 0.21 seconds, 70 dB, 239 Hz.	Here, [bʱ] appears at the beginning of the word. It's 0.21 seconds, 50 dB, 189 Hz. It is an unaspirated sound. The atypical IPA is [b̼ɐl͡lo↓]. Other features include: insertion and double articulation of [l͡l], low tone of [o↓]. Note: b [bʱ] = atypical, distortion (unaspirated), also could be noted as omission

Data Display 4 (b)

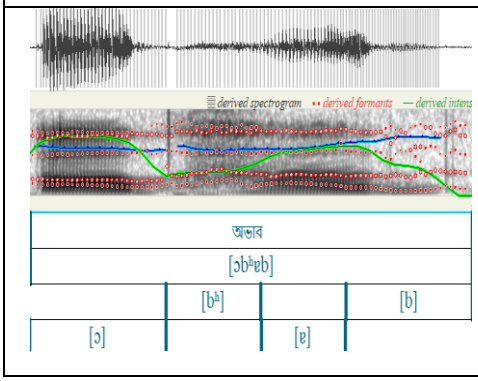
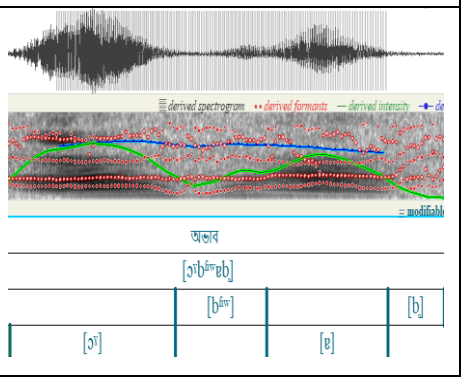
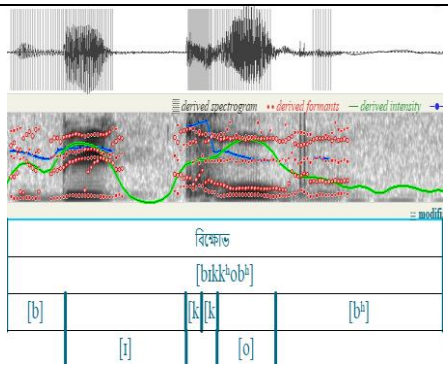
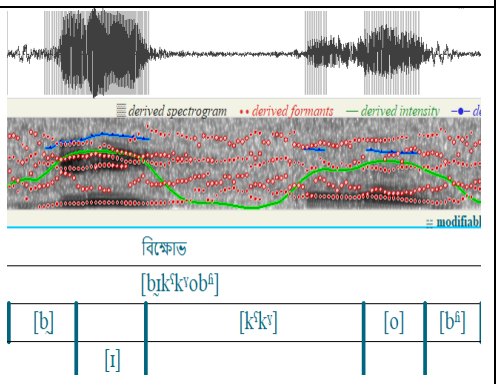
Typical Speech	*Atypical Speech*
	

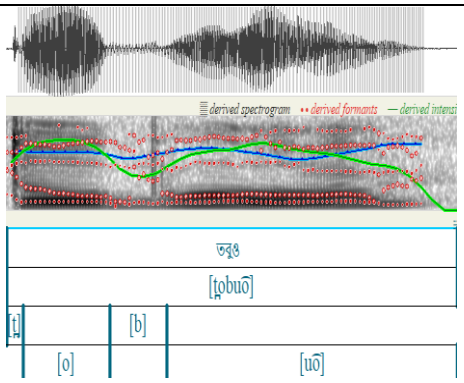
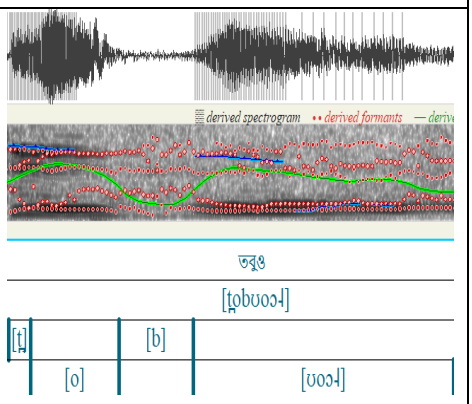
Figure 29 (a): Oscillogram of অভাব, [ɔbʱɐb]	Figure 29 (b): Oscillogram of অভাব, [ɔʸbʱʷɐb̰]
It shows a PRAAT illustration of the word অভাব which is displayed in the Interval Tier 01: Bangla Text Word 'অভাব', and its transcription is in Interval Tier 02: IPA: [ɔbʱɐb]. Point Tier 01: Consonants [bʱ], [b] and Point Tier 02: Vowel: [ɔ], [ɐ] 4b focuses on the sound, [bʱ] which appears in the middle of the word. It is a pulmonic egressive, bilabial, voiced sound which is of 0.12 seconds, 67 dB, 206 Hz.	Here, [bʱ] appears in the middle of the word. It's 0.3 seconds, 52 dB, 176 Hz. It is labialized. The atypical IPA is [ɔʸbʱʷɐb̰]. Other features include: velarized [ɔʸ], voiceless [b̰]. Note: m [bʱ] = atypical, distortion (labialized)

Data Display 4 (c)

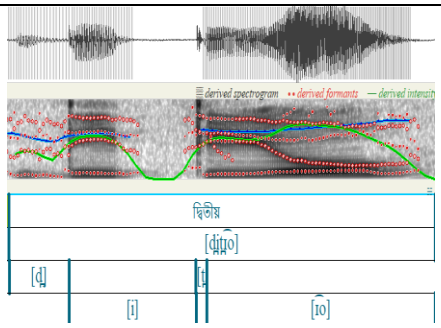
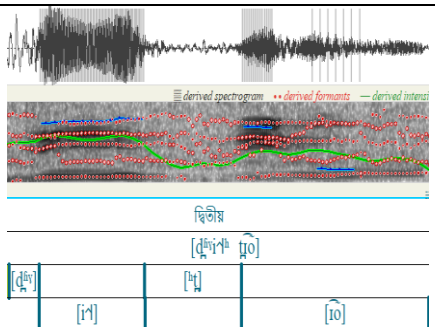
Typical Speech	*Atypical Speech*
	
Figure 30 (a): Oscillogram of বিক্ষোভ, [bɪkkʰobʱ]	Figure 30 (b): Oscillogram of বিক্ষোভ, [b̰ɪkˢkʸobʱ]
It shows a PRAAT illustration of the word বিক্ষোভ which is displayed in the Interval Tier 01: Bangla Text Word 'বিক্ষোভ', and its transcription is in Interval Tier 02: IPA: [bɪkkʰobʱ]. Point Tier 01:	Here, [bʱ] appears at the end of the word. It's 0.23 seconds, 50 dB, 164 Hz. It has breathy-voiced aspirated. The atypical IPA is [b̰ɪkˢkʸobʱ]. Other features include creaky-voiced [b̰], pharyngealized [kˢ],

Consonants [b], [k], [kʰ], [bʱ] and Point Tier 02: Vowel: [ɪ], [o] 4c focuses on the sound, [bʱ] which appears at the end of the word. It is a pulmonic egressive, bilabial, voiced sound which is of 0.34 seconds, 67 dB, 194 Hz.	velarized [kˠ]. Note: e [bʱ] = atypical, distortion (breathy-voiced aspirated), also could be noted as addition

Data Display 5 (a)

Typical Speech	*Atypical Speech*
	
Figure 31 (a): Oscillogram of তবুও, [t̪obuo͡]	Figure 31 (b): Oscillogram of তবুও, [t̪obʊɔɬ]
It shows a PRAAT illustration of the word তবুও which is displayed in the Interval Tier 01: Bangla Text Word 'তবুও', and its transcription is in Interval Tier 02: IPA: [t̪obuo͡] Point Tier 01: Consonants [t̪], [b] and Point Tier 02: Vowel: [o], [uo͡], 5a focuses on the sound, [t̪] which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.08 seconds, 80 dB, 278 Hz.	Here, [t̪] appears at the beginning of the word. It's 0.09 seconds, 60 dB, 384 Hz. It is a typical [t̪] sound. The atypical IPA is [t̪obʊɔɬ]. Other features include: substitution with short [ʊ], addition of low-toned [ɔɬ]. Note: b [t̪] = typical

Data Display 5 (b)

Typical Speech	*Atypical Speech*
	
Figure 32 (a): Oscillogram of দ্বিতীয়, [d̪ɪt̪ɪ͡o]	Figure 32 (b): Oscillogram of দ্বিতীয়, [d̪ʱʏiˀˠʰt̪ɪ͡õ]
It shows a PRAAT illustration of the word দ্বিতীয় which is displayed in the Interval Tier 01: Bangla Text Word 'দ্বিতীয়', and its transcription is in Interval Tier 02: IPA: [d̪ɪt̪ɪ͡o] Point Tier 01: Consonants [d̪], [t̪] and Point Tier 02: Vowel: [i], [ɪ͡o], 5b focuses on the sound, [t̪] which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.39 seconds, 79 dB, 274 Hz.	Here, [t̪] appears in the middle of the word. It's 0.22 seconds, 50 dB, 185 Hz. It has pre-aspiration. The atypical IPA is [d̪ʱʏiˀˠʰt̪ɪ͡õ]. Other features include: breathy-voice aspirated and velarized [d̪ʱʏ], rising-falling [iˀˠ], nasalized [õ]. Note: m [t̪] = atypical, distortion (pre-aspiration), also could be noted as addition

Data Display 5 (c)

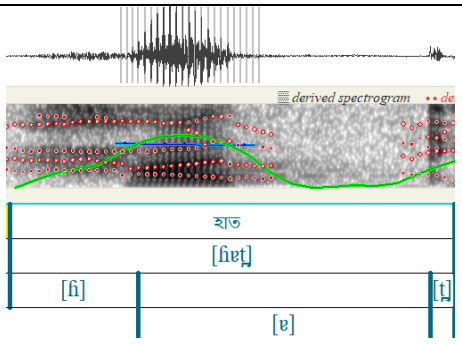
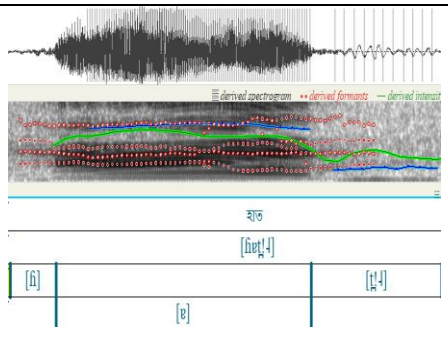
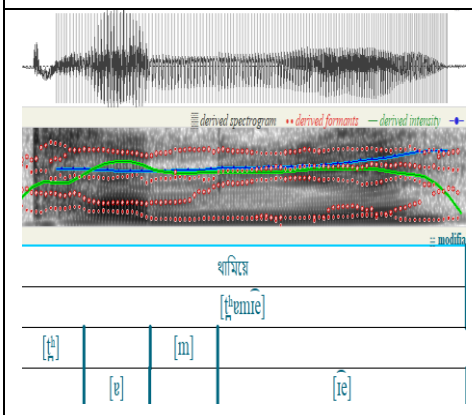
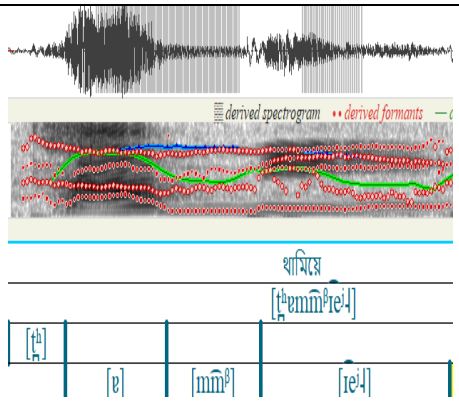
Typical Speech	*Atypical Speech*
	

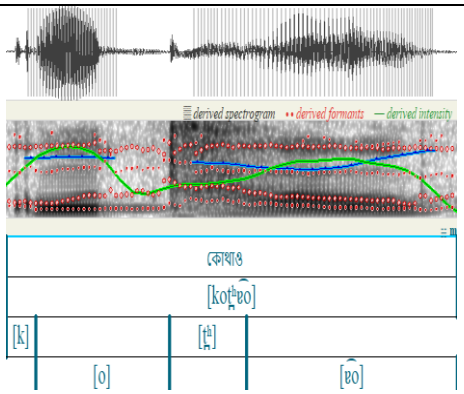
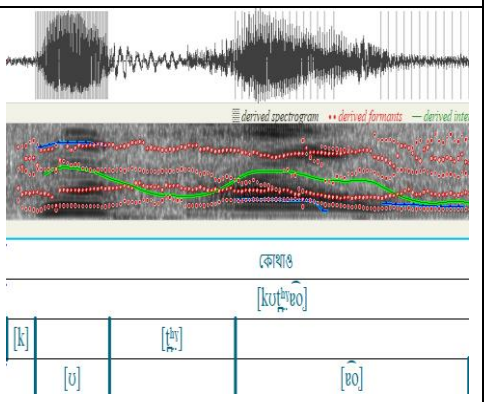
Figure 33 (a): Oscillogram of হাত, [ɦɐt̪]	Figure 33 (b): Oscillogram of হাত, [ɦɐt̪!ɬ]
It shows a PRAAT illustration of the word হাত which is displayed in the Interval Tier 01: Bangla Text Word ‘হাত’, and its transcription is in Interval Tier 02: IPA: [ɦɐt̪] Point Tier 01: Consonants [ɦ], [t̪] and Point Tier 02: Vowel: [ɐ], 5c focuses on the sound, [t̪] which appears at the end of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.39 seconds, 79 dB, 274 Hz.	Here, [t̪] appears at the end of the word. It’s 0.22 seconds, 50 dB, 285 Hz. It has post-alveolar click and low tone. The atypical IPA is [ɦɐt̪!ɬ]. Other features include: voiced-glottal fricative [ɦ]. Note: e [t̪] = atypical, distortion (post-alveolar click and low tone), also could be noted as addition

Data Display 6 (a)

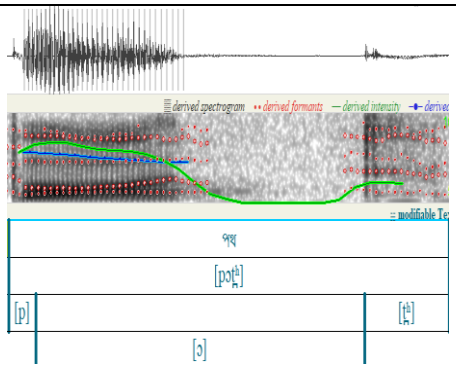
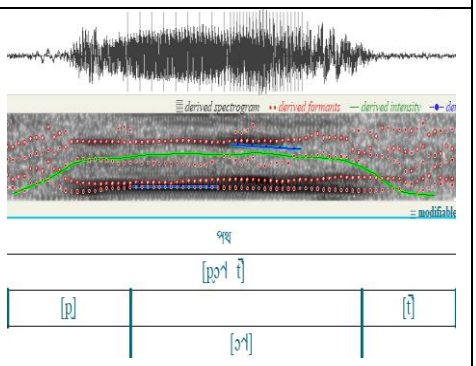
Typical Speech	*Atypical Speech*
	
Figure 34 (a): Oscillogram of থামিয়ে, [t̪ʰɐmɪe]	Figure 34 (b): Oscillogram of থামিয়ে, [t̪ʰɐmmᵝɪeʲɬ]
It shows a PRAAT illustration of the word থামিয়ে which is displayed in the Interval Tier 01: Bangla Text Word ‘থামিয়ে’, and its transcription is in Interval Tier 02:	Here, [t̪ʰ] appears at the beginning of the word. It’s 0.13 seconds, 55 dB, 185 Hz. It is a typical [t̪ʰ] sound. The atypical IPA is [t̪ʰɐmmᵝɪeʲɬ]. Other features include: addition, lip compression

IPA: [t̪ʰɐmɪe͡] Point Tier 01: Consonants [t̪ʰ], [m] and Point Tier 02: Vowel: [ɐ], [ɪe͡], 6a focuses on the sound, [t̪ʰ] which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.08 seconds, 71 dB, 246 Hz.	and double articulation of [mm͡ᵝ], palatalized low-toned [eʲ˩]. Note: b [t̪ʰ] = typical

Data Display 6 (b)

Typical Speech	*Atypical Speech*
	
Figure 35 (a): Oscillogram of কোথাও, [kot̪ʰɐo͡]	Figure 35 (b): Oscillogram of কোথাও, [kʊt̪ʰʲɐo͡]
It shows a PRAAT illustration of the word কোথাও which is displayed in the Interval Tier 01: Bangla Text Word 'কোথাও', and its transcription is in Interval Tier 02: IPA: [kot̪ʰɐo͡] Point Tier 01: Consonants [k], [t̪ʰ] and Point Tier 02: Vowel: [o], [ɐo͡], 6b focuses on the sound, [t̪ʰ] which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.09 seconds, 67 dB, 232 Hz.	Here, [t̪ʰ] appears in the middle of the word. It's 0.23 seconds, 60 dB, 184 Hz. It shows velarization. The atypical IPA is [kʊt̪ʰʲɐo͡]. Other features include: substitution with short [ʊ], less rounded [o̜]. Note: m [t̪ʰ] = atypical, distortion (velarization)

Data Display 6 (c)

Typical Speech	*Atypical Speech*
	
Figure 36 (a): Oscillogram of পথ, [pɔt̪ʰ]	Figure 36 (b): Oscillogram of পথ, [pɔ̯ˀt̚]
It shows a PRAAT illustration of the word পথ which is displayed in the Interval Tier 01: Bangla Text Word 'পথ', and its transcription is in Interval Tier 02: IPA: [pɔt̪ʰ] Point Tier 01: Consonants [p], [t̪ʰ] and Point Tier 02: Vowel: [ɔ], 6c focuses on the sound, [t̪ʰ] which appears at the end of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.08 seconds, 60 dB, 173 Hz.	Here, [t̪ʰ] appears at the end of the word. It's 0.48 seconds, 69 dB, 257 Hz. It shows no audible release with [t̚]. The atypical IPA is [pɔ̯ˀt̚]. Other features include: voiced [p̬], rising-falling of [ɔˀ]. Note: e [t̪ʰ] = atypical, omission (no audible release)

Data Display 7 (a)

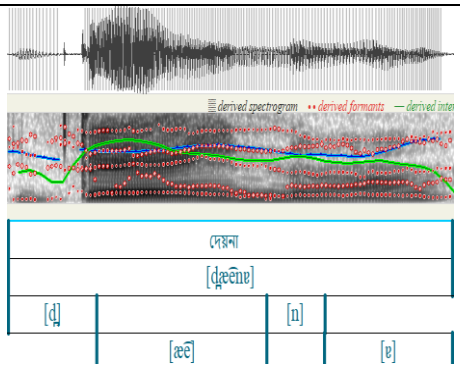
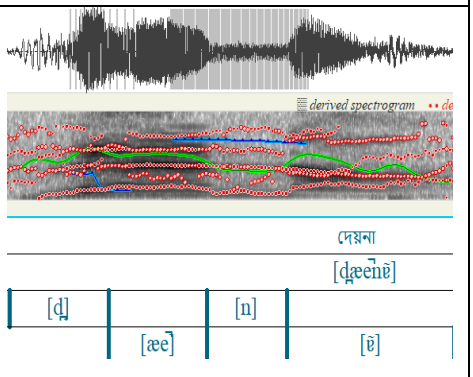
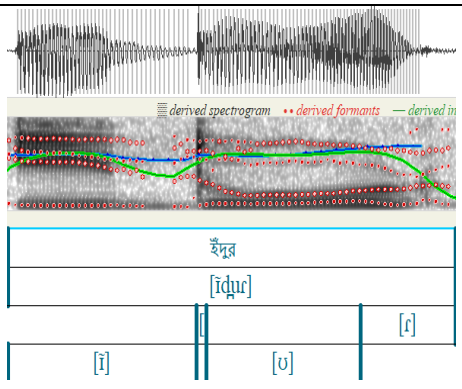
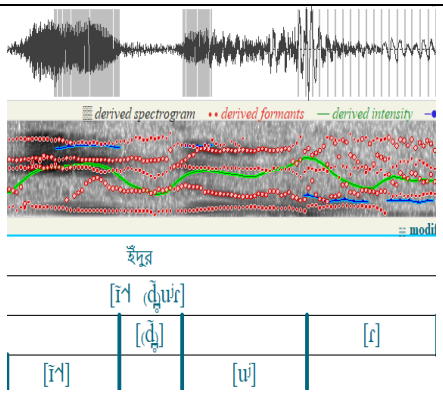
Typical Speech	*Atypical Speech*
	

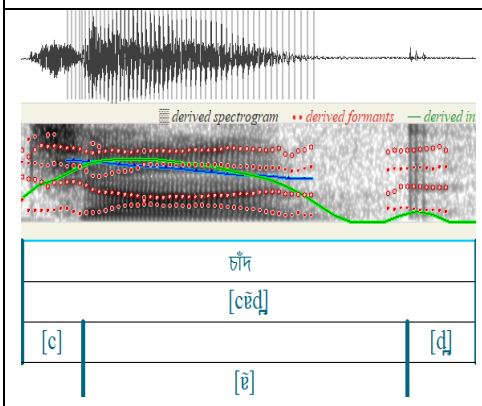
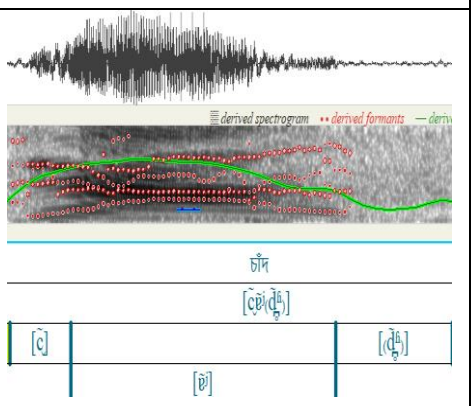
Figure 37 (a): Oscillogram of দেয়না, [d̪æ͡enɐ]	Figure 37 (b): Oscillogram of দেয়না, [d̪æ̃nɐ̃]
It shows a PRAAT illustration of the word দেয়না which is displayed in the Interval Tier 01: Bangla Text Word 'দেয়না', and its transcription is in Interval Tier 02: IPA: [d̪æ͡enɐ] Point Tier 01: Consonants [d̪], [n] and Point Tier 02: Vowel: [ɐ], [æ͡e], 7a focuses on the sound, [d̪] which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.13 seconds, 67 dB, 194 Hz.	Here, [d̪] appears at the beginning of the word. It's 0.13 seconds, 70 dB, 184 Hz. It shows a typical [d̪] sound. The atypical IPA is [d̪æ̃nɐ̃]. Other features include: no audible release of [æ̃], nasalized [ɐ̃]. Note: b [d̪] = typical

Data Display 7 (b)

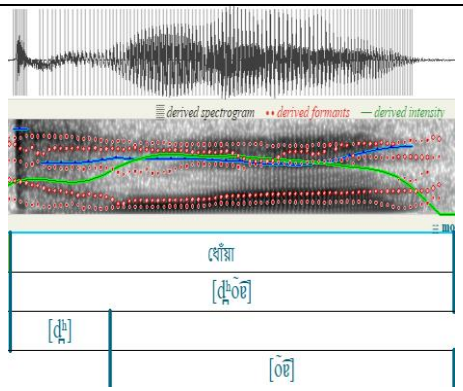
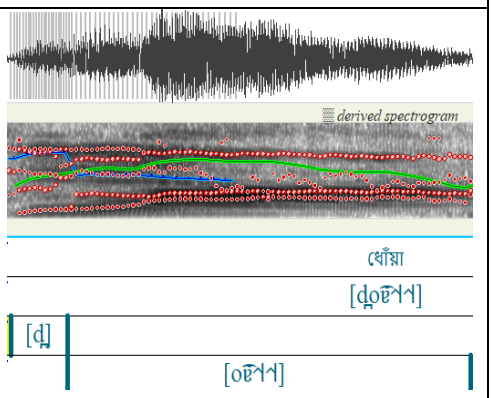
Typical Speech	*Atypical Speech*
	
Figure 38 (a): Oscillogram of ইঁদুর, [ĩd̪ur] It shows a PRAAT illustration of the word ইঁদুর which is displayed in the Interval Tier 01: Bangla Text Word 'ইঁদুর', and its transcription is in Interval Tier 02: IPA: [ĩd̪ur] Point Tier 01: Consonants [d̪], [r]	Figure 38 (b): Oscillogram of ইঁদুর, [ĩˀ(d̪̃)uʲr] Here, [d̪] appears in the middle of the word. It's 0.06 seconds, 59 dB, 182 Hz. It shows partial devoiced, nasalized [(d̪̃)]. The atypical IPA is [ĩˀ(d̪̃)uʲr]. Other features include: rising-falling [ĩˀ], palatalized [uʲ].

and Point Tier 02: Vowel: [ĩ], [u], 7b focuses on the sound, [d̪] which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.33 seconds, 79 dB, 258 Hz.	Note: m [d̪] = atypical, distortion (partial devoiced, nasalized [(d̪̥̃)])

Data Display 7 (c)

Typical Speech	*Atypical Speech*
	
Figure 39 (a): Oscillogram of চাঁদ, [cɐ̃d̪]	Figure 39 (b): Oscillogram of চাঁদ, [c̪̃ɐ̃ʲ(d̪̥̃ʱ)]
It shows a PRAAT illustration of the word চাঁদ which is displayed in the Interval Tier 01: Bangla Text Word 'চাঁদ', and its transcription is in Interval Tier 02: IPA: [cɐ̃d̪], Point Tier 01: Consonants [c], [d̪] and Point Tier 02: Vowel: [ɐ̃], 7c focuses on the sound, [d̪] which appears at the end of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.07 seconds, 50 dB, 167 Hz.	Here, [d̪] appears at the end of the word. It's 0.3 seconds, 64 dB, 152 Hz. It shows partial devoiced, nasalized [(d̪̥̃)] with breathy-voice aspirated. The atypical IPA is [c̪̃ɐ̃ʲ(d̪̥̃ʱ)]. Other features include: voiced [c̪̃], palatalized [ɐ̃ʲ]. Note: e [d̪] = atypical, distortion (partial devoiced, nasalized [(d̪̥̃)] with breathy-voice aspirated), also could be noted as addition due to aspiration

Data Display 8 (a)

Typical Speech	*Atypical Speech*
	
Figure 40 (a): Oscillogram of ধোঁয়া, [d̪ʱo̰͡ɐ̯]	Figure 40 (b): Oscillogram of ধোঁয়া, [d̪o͡ɐ̯ʷʌ]
It shows a PRAAT illustration of the word ধোঁয়া which is displayed in the Interval Tier 01: Bangla Text Word 'ধোঁয়া', and its transcription is in Interval Tier 02: IPA: [d̪ʱo̰͡ɐ̯], Point Tier 01: Consonants [d̪ʱ] and Point Tier 02: Vowel: [o̰͡ɐ̯], 8a focuses on the sound, [d̪ʱ] which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.11 seconds, 67 dB, 223 Hz.	Here, [d̪ʱ] appears at the beginning of the word. It's 0.23 seconds, 57 dB, 189 Hz. It shows substitution with a [d̪]. The atypical IPA is [d̪o͡ɐ̯ʷʌ]. Other features include: double rising-falling, nasalization with [o͡ɐ̯ʷʌ]. Note: b [d̪ʱ] = atypical, substitution (substitution with a [d̪])

Data Display 8 (b)

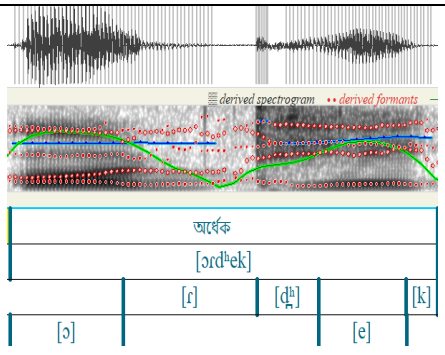
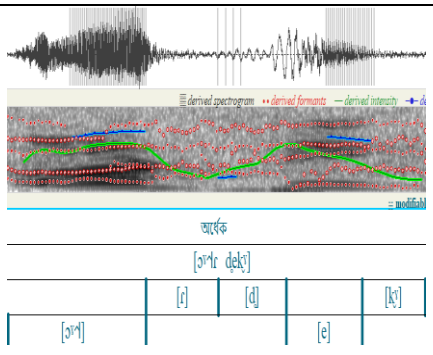
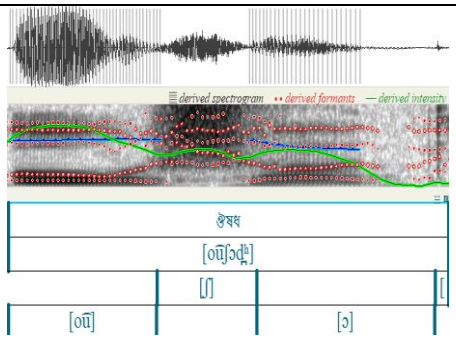
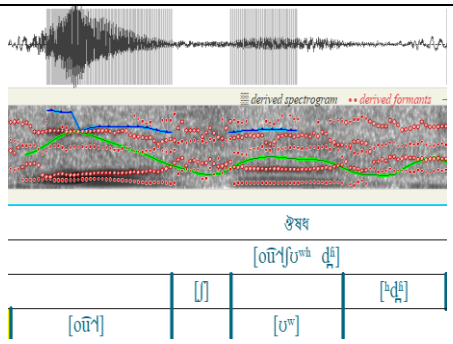
Typical Speech	*Atypical Speech*
	

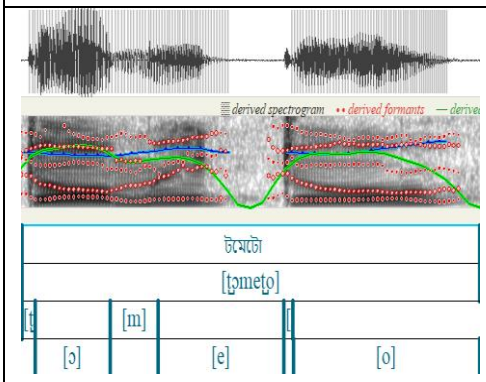
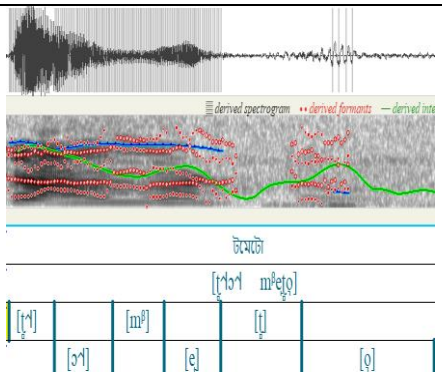
Figure 41 (a): Oscillogram of অর্ধেক, [ɔɾɖʱek]	Figure 41 (b): Oscillogram of অর্ধেক, [ɔʸˠɾɖe̞kʸ]
It shows a PRAAT illustration of the word অর্ধেক which is displayed in the Interval Tier 01: Bangla Text Word 'অর্ধেক', and its transcription is in Interval Tier 02: IPA: [ɔɾɖʱek], Point Tier 01: Consonants [ɾ], [ɖʱ], [k] and Point Tier 02: Vowel: [ɔ], [e], 8b focuses on the sound, [ɖʱ] which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.07 seconds, 66 dB, 232 Hz.	Here, [ɖʱ] appears in the middle of the word. It's 0.13 seconds, 65 dB, 161 Hz. It shows substitution with devoiced [ɖ̥]. The atypical IPA is [ɔʸˠɾɖe̞kʸ]. Other features include: velarized [ɔʸˠ] with rising-falling tone, velarized voiced [kʸ]. Note: m [ɖʱ] = atypical, substitution (substitution with devoiced [ɖ̥])

Data Display 8 (c)

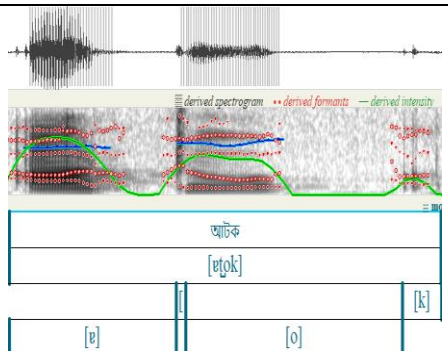
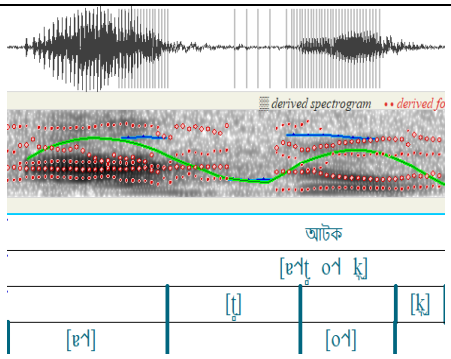
Typical Speech	*Atypical Speech*
	
Figure 42 (a): Oscillogram of ঔষধ, [o͡uʃɔɖʱ]	Figure 42 (b): Oscillogram of ঔষধ, [o͡uˠʃʊʷʰɖʱ]
It shows a PRAAT illustration of the word ঔষধ which is displayed in the Interval Tier 01: Bangla Text Word 'ঔষধ', and its transcription is in Interval Tier 02: IPA: [o͡uʃɔɖʱ], Point Tier 01: Consonants [ʃ], [ɖʱ] and Point Tier 02: Vowel: [ɔ], [o͡u],	Here, [ɖʱ] appears at the end of the word. It's 0.11 seconds, 53 dB, 174 Hz. It has a typical [ɖʱ] sound. The atypical IPA is [o͡uˠʃʊʷʰɖʱ]. Other features include: rising-falling tone of [o͡uˠ], insertion, labialization, of aspirated [ʊʷʰ].

8c focuses on the sound, [d̪ʱ] which appears at the end of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.64 seconds, 52 dB, 174 Hz.	Note: e [d̪ʱ] = typical

Data Display 9 (a)

Typical Speech	*Atypical Speech*
	
Figure 43 (a): Oscillogram of টমেটো, [ʈɔmeʈo]	Figure 43 (b): Oscillogram of টমেটো, [ʈ̚ˀɔˀmᵝe̞ʈ̚o̞]
It shows a PRAAT illustration of the word টমেটো which is displayed in the Interval Tier 01: Bangla Text Word 'টমেটো', and its transcription is in Interval Tier 02: IPA: [ʈɔmeʈo], Point Tier 01: Consonants [ʈ], [m], [ʈ] and Point Tier 02: Vowel: [ɔ], [e], [o], 9a focuses on the sound, [ʈ] which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.12 seconds, 71 dB, 266 Hz.	Here, [ʈ̚] appears at the beginning of the word. It's 0.11 seconds, 66 dB, 200 Hz. It shows laminal [ʈ̚ˀ] with rising-falling tone. The atypical IPA is [ʈ̚ˀɔˀmᵝe̞ʈ̚o̞]. Other features include: rising-falling [ɔˀ], [mᵝ] with compressed lips, retracted tongue-root position of [e̞], laminal [ʈ̚], and weak articulation of [o̞]. Note: b [ʈ̚] = atypical, distortion (laminal [ʈ̚ˀ] with rising-falling tone)

Data Display 9 (b)

Typical Speech	*Atypical Speech*
	
Figure 44 (a): Oscillogram of আটক, [ɐt̪ok]	Figure 44 (b): Oscillogram of আটক, [ɐˠt̪oˠk̟]
It shows a PRAAT illustration of the word আটক which is displayed in the Interval Tier 01: Bangla Text Word 'আটক', and its transcription is in Interval Tier 02: IPA: [ɐt̪ok]. Point Tier 01: Consonants [t̪], [k] and Point Tier 02: Vowel: [ɐ], [o], 9b focuses on the sound, [t̪] which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.38 seconds, 67 dB, 258 Hz.	Here, [t̪] appears in the middle of the word. It's 0.5 seconds, 60 dB, 178 Hz. It has laminal [t̪]. The atypical IPA is [ɐˠt̪oˠk̟]. Other features include: rising-falling [ɐˠ], and [oˠ], voiced [k̟] with weak articulation. Note: m [t̪] = atypical, distortion (laminal)

Data Display 9 (c)

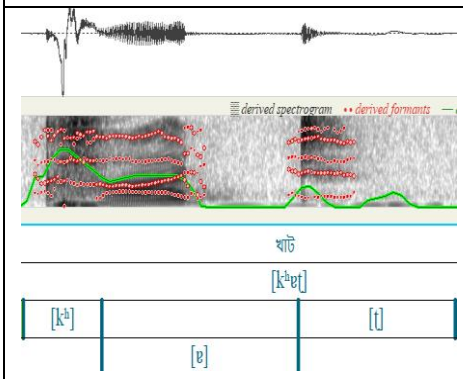
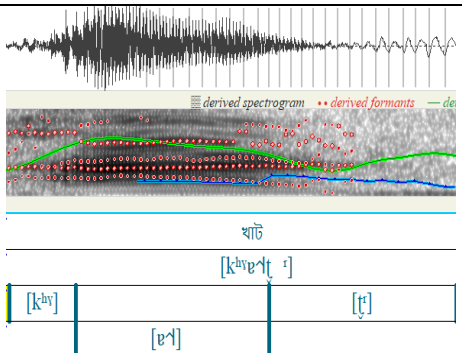
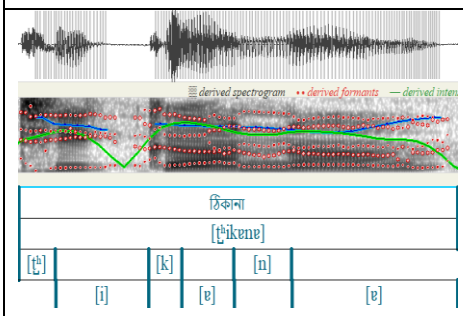
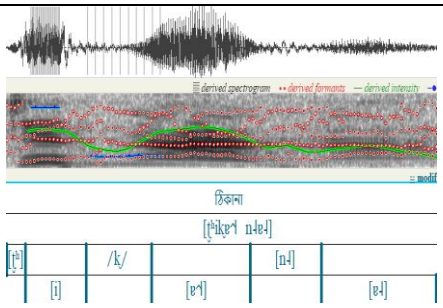
Typical Speech	*Atypical Speech*
	

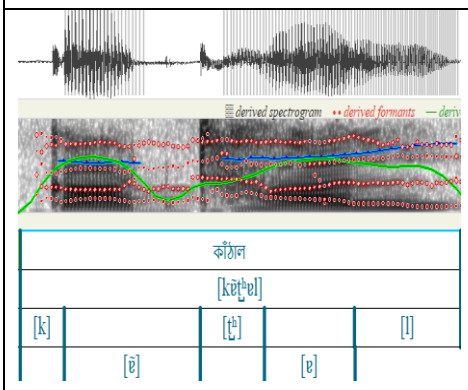
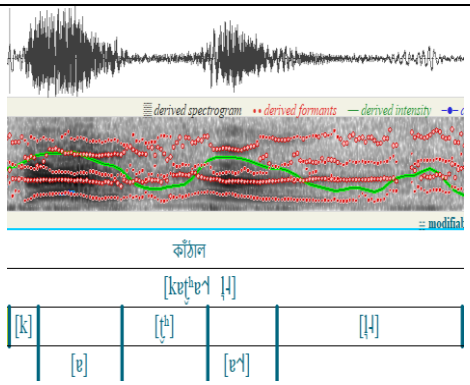
Figure 45 (a): Oscillogram of খাট, [kʰɐt̚]	Figure 45 (b): Oscillogram of খাট, [kʰʏɐ˥t̚ʳ]
It shows a PRAAT illustration of the word খাট which is displayed in the Interval Tier 01: Bangla Text Word 'খাট', and its transcription is in Interval Tier 02: IPA: [kʰɐt̚]. Point Tier 01: Consonants [kʰ], [t̚] and Point Tier 02: Vowel: [ɐ], 9c focuses on the sound, [t̚] which appears at the end of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.38 seconds, 67 dB, 258 Hz.	Here, [t̚] appears at the end of the word. It's 0.5 seconds, 60 dB, 178 Hz. It has a voiced rhotic release [t̚ʳ]. The atypical IPA is [kʰʏɐ˥t̚ʳ]. Other features include: velarized [kʰʏ], rising-falling tone of [ɐ˥]. Note: e [t̚] = atypical, distortion (voiced rhotic release)

Data Display 10 (a)

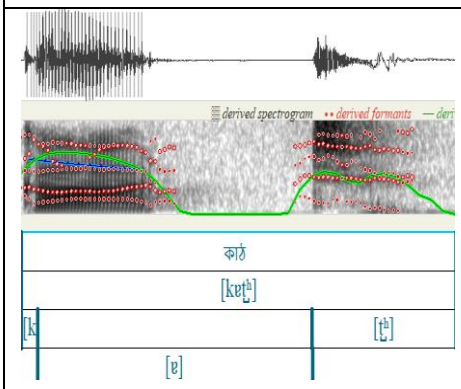
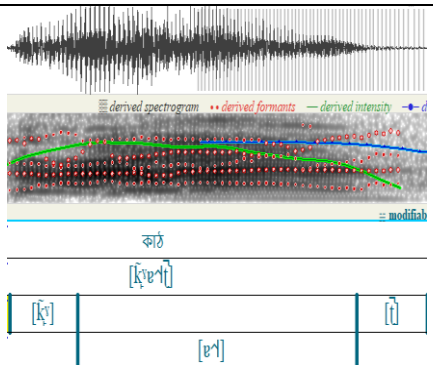
Typical Speech	*Atypical Speech*
	
Figure 46 (a): Oscillogram of ঠিকানা, [tʰikɐnɐ]	Figure 46 (b): Oscillogram of ঠিকানা, [tʰikɐ˥nɬɐɬ]
It shows a PRAAT illustration of the word ঠিকানা which is displayed in the Interval Tier 01: Bangla Text Word 'ঠিকানা', and its transcription is in Interval Tier 02: IPA: [tʰikɐnɐ], Point Tier 01: Consonants [tʰ], [k], [n] and Point	Here, [tʰ] appears at the beginning of the word. It's 0.17 seconds, 60 dB, 209 Hz. It has voiced [t̚ʰ]. The atypical IPA is [t̚ʰikɐ˥nɬɐɬ]. Other features include: voiced [k], rising-falling [ɐ˥], low toned [nɬ] and [ɐɬ]. Note: b [t̚ʰ] = atypical, distortion (voiced)

Tier 02: Vowel: [i], [ɐ], 10a focuses on the sound, [ʈʰ] which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.05 seconds, 71 dB, 356 Hz.	

Data Display 10 (b)

Typical Speech	*Atypical Speech*
	
Figure 47 (a): Oscillogram of কাঁঠাল, [kɐ̃ʈʰɐl]	Figure 47 (b): Oscillogram of কাঁঠাল, [kɐʈ̬ʰɐ˧˩˧]
It shows a PRAAT illustration of the word কাঁঠাল which displays the Interval Tier 01: Bangla Text Word 'কাঁঠাল', Interval Tier 02: Transcription, IPA: [kɐ̃ʈʰɐl], Point Tier 01: Consonants [k], [ʈʰ], [l], Point Tier 02: Vowels: [ɐ̃], [ɐ] 10b focuses on the sound, [ʈʰ] which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.09 seconds, 69 dB, 218 Hz.	Here, [ʈʰ] appears in the middle of the word. It's 0.15 seconds, 73 dB, 197 Hz. It has voiced [ʈ̬ʰ]. The atypical IPA is [kɐʈ̬ʰɐ˧˩˧]. Other features include: rising-falling [ɐ˧] weak articulation with low tone of [˩˧]. Note: m [ʈʰ] = atypical, distortion (voiced)

Data Display 10 (c)

Typical Speech	*Atypical Speech*
	
Figure 48 (a): Oscillogram of কাঠ, [kɐʈʰ]	Figure 48 (b): Oscillogram of কাঠ, [k̰ᵡɐˤt̚]
It shows a PRAAT illustration of the word কাঠ which is displayed in the Interval Tier 01: Bangla Text Word 'কাঠ', and its transcription is in Interval Tier 02: IPA: [kɐʈʰ]. Point Tier 01: Consonants [k], [ʈʰ] and Point Tier 02: Vowel: [ɐ], 10c focuses on the sound, [ʈʰ] which appears at the end of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.7 seconds, 67 dB, 190 Hz.	Here, [ʈʰ] appears at the end of the word. It's 0.17 seconds, 63 dB, 183 Hz. It has no audible release of [t̚]. The atypical IPA is [k̰ᵡɐˤt̚]. Other features include: rising-falling [ɐˤ] and velarized, nasalized [k̰ᵡ] with retracted tongue root position. Note: e [ʈʰ] = atypical, omission (no audible release)

Data Display 11 (a)

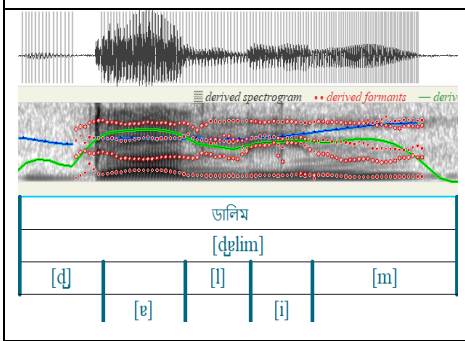
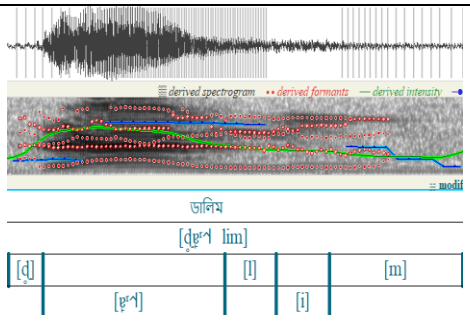
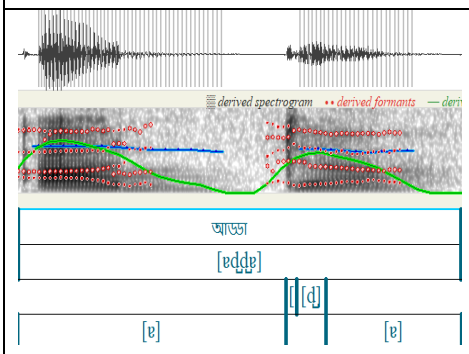
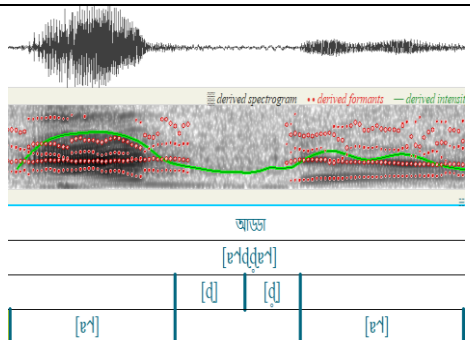
Typical Speech	*Atypical Speech*
	

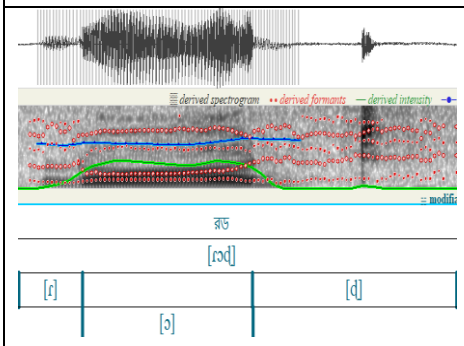
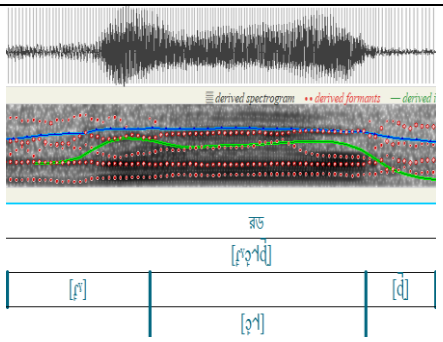
Figure 49 (a): Oscillogram of ডালিম, [ɖɐlim]	Figure 49 (b): Oscillogram of ডালিম, [ɖ̟ɐʳˠlim]
It shows a PRAAT illustration of the word ডালিম which is displayed in the Interval Tier 01: Bangla Text Word ‘ডালিম’, and its transcription is in Interval Tier 02: IPA: [ɖɐlim] Point Tier 01: Consonants [ɖ], [l], [m] and Point Tier 02: Vowel: [ɐ], [i], 11a focuses on the sound, [ɖ] which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.12 seconds, 67 dB, 191 Hz.	Here, [ɖ] appears at the beginning of the word. It’s 0.12 seconds, 66 dB, 228 Hz. It shows voicelessness. The atypical IPA is [ɖ̟ɐʳˠlim]. Other features include: velarized [ɐʳˠ] with rising-falling tone. Note: b [ɖ] = atypical, distortion (voiceless)

Data Display 11 (b)

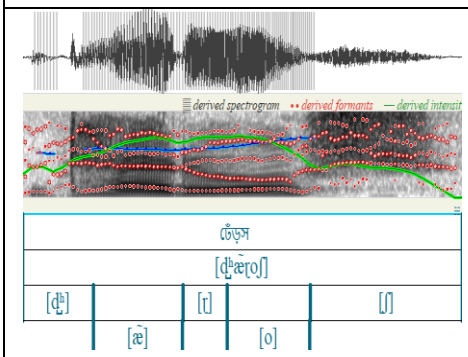
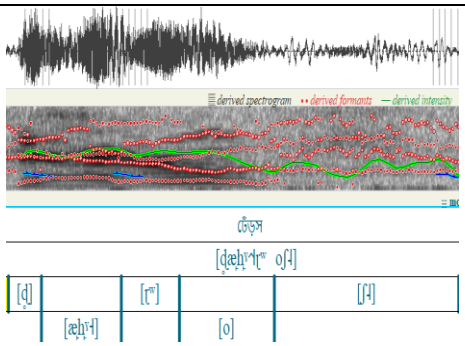
Typical Speech	*Atypical Speech*
	
Figure 50 (a): Oscillogram of আড্ডা, [ɐɖɖɐ]	Figure 50 (b): Oscillogram of আড্ডা, [ɐˠɖɖ̟ɐˠ]
It shows a PRAAT illustration of the word আড্ডা which is displayed in the Interval Tier 01: Bangla Text Word ‘আড্ডা’, and its transcription is in Interval Tier 02:	Here, [ɖ] appears in the middle of the word. It’s 0.65 seconds, 70 dB, 181 Hz. It has voiceless [ɖ̟] sound. The atypical IPA is [ɐˠɖɖ̟ɐˠ]. Other features include: rising-falling of the [ɐˠ] sound.

IPA: [ʁɖɖʁ], Point Tier 01: Consonants [ɖ], [ɖ], and Point Tier 02: Vowel: [ʁ], 11b focuses on the sound, [ɖ] which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.45 seconds, 73 dB, 207 Hz.	Note: m [ɖ] = atypical, distortion (voiceless)

Data Display 11 (c)

Typical Speech	*Atypical Speech*
	
Figure 51 (a): Oscillogram of রড, [ɾɔɖ]	Figure 51 (b): Oscillogram of রড, [ɾʸɔ̰ˀɖ̰]
It shows a PRAAT illustration of the word রড which is displayed in the Interval Tier 01: Bangla Text Word 'রড', and its transcription is in Interval Tier 02: IPA: [ɾɔɖ], Point Tier 01: Consonants [ɾ], [ɖ], and Point Tier 02: Vowel: [ɔ], 11c focuses on the sound, [ɖ] which appears at the end of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.45 seconds, 73 dB, 207 Hz.	Here, [ɖ] appears at the end of the word. It's 0.65 seconds, 70 dB, 181 Hz. It has no audible release. The atypical IPA is [ɾʸɔ̰ˀɖ̰]. Other features include: velarized retracted tongue root position of [ɾʸ], and retracted tongue root position of [ɔ̰ˀ] with rising-falling tone. Note: e [ɖ] = atypical, omission (no audible release)

Data Display 12 (a)

Typical Speech	*Atypical Speech*
	
Figure 52 (a): Oscillogram of ঢেঁড়স, [ɖʱæ̃ɽoʃ]	Figure 52 (b): Oscillogram of ঢেঁড়স, [ɖ̥ɐ̟ʱʸˤɻʷoʃʰˤ]
It shows a PRAAT illustration of the word ঢেঁড়স which is displayed in the Interval Tier 01: Bangla Text Word 'ঢেঁড়স', and its transcription is in Interval Tier 02: IPA: [ɖʱæ̃ɽoʃ]. Point Tier 01: Consonants [ɖʱ], [ɽ], [ʃ] and Point Tier 02: Vowel: [æ̃], [o], 12a focuses on the sound, [ɖʱ] which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.11 seconds, 60 dB, 202 Hz.	Here, [ɖʱ] appears at the beginning of the word. It's 0.23 seconds, 76 dB, 160 Hz. It has substitution with voiceless [ɖ̥]. The atypical IPA is [ɖ̥ɐ̟ʱʸˤɻʷoʃʰˤ]. Other features include: retracted tongue root position of [æ], retracted tongue root position of velarized [ʱʸˤ] with rising-falling tone, labialized [ɻʷ], and low tone of [ʃʰˤ]. Note: b [ɖʱ] = atypical, substitution (substitution with voiceless [ɖ̥])

Data Display 12 (b)

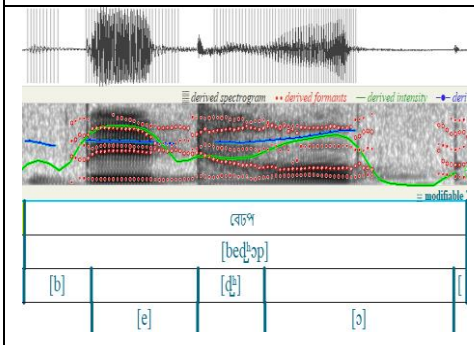
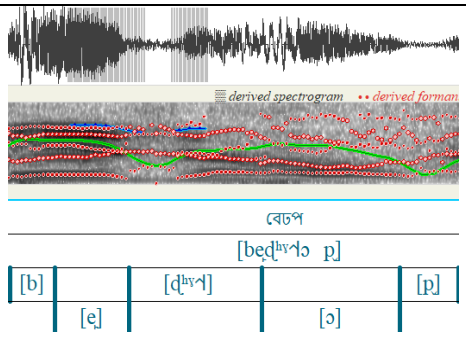
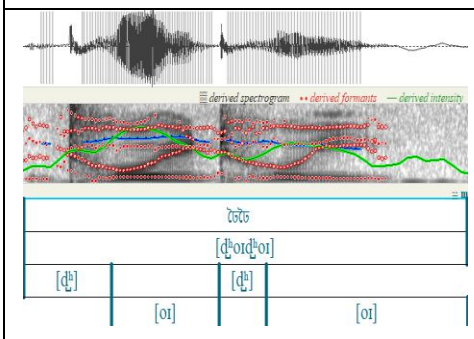
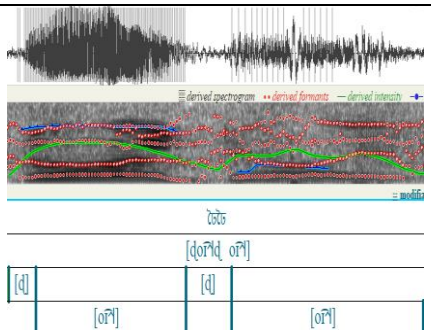
Typical Speech	*Atypical Speech*
	

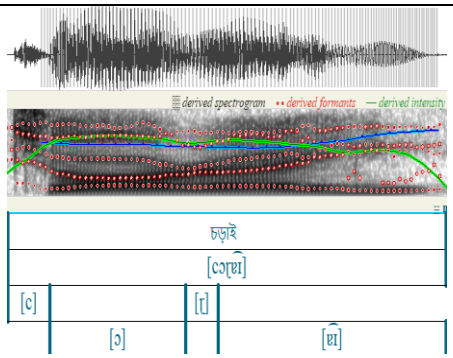
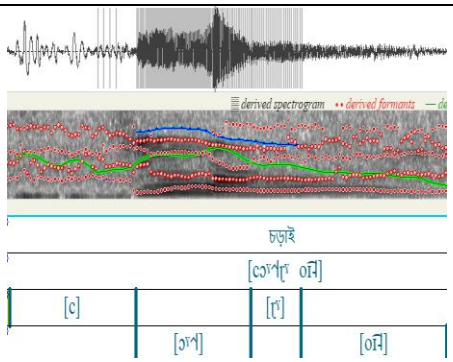
Figure 53 (a): Oscillogram of বেচপ, [bedʰɔp] It shows a PRAAT illustration of the word বেচপ which is displayed in the Interval Tier 01: Bangla Text Word 'বেচপ', and its transcription is in Interval Tier 02: IPA: [bedʰɔp], Point Tier 01: Consonants [b], [dʰ], [p] and Point Tier 02: Vowel: [e], [ɔ], 12b focuses on the sound, [dʰ] which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.09 seconds, 68 dB, 212 Hz.	Figure 53 (b): Oscillogram of বেচপ, [bẹdʰʏˤɔp̬] Here, [dʰ] appears in the middle of the word. It's 0.3 seconds, 64 dB, 166 Hz. It has velarized [dʰʏˤ] with rising-falling tone. The atypical IPA is [bẹdʰʏˤɔp̬]. Other features include: retracted tongue root position of [ẹ] and voiced [p̬]. Note: m [dʰ] = atypical, distortion (velarized [dʰʏˤ] with rising-falling tone)

Data Display 12 (c)

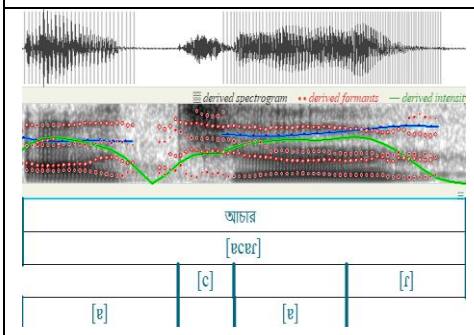
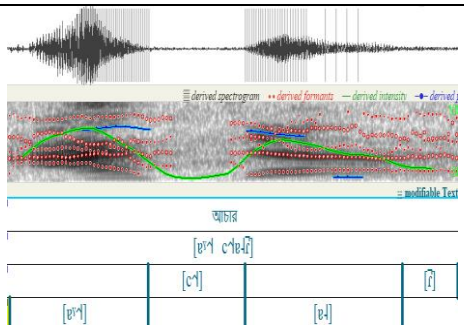
Typical Speech	*Atypical Speech*
	
Figure 54 (a): Oscillogram of চেচৈ, [dʰo͡ɪdʰo͡ɪ] It shows a PRAAT illustration of the word চেচৈ which is displayed in the Interval Tier 01: Bangla Text Word 'চেচৈ', and its transcription is in Interval Tier 02: IPA: [dʰo͡ɪdʰo͡ɪ], Point Tier 01: Consonants [dʰ], [dʰ]	Figure 54 (b): Oscillogram of চেচৈ, [do͡ɪˤdo͡ɪˤ] Here, [dʰ] appears near the end of the word. It's 0.3 seconds, 60 dB, 183 Hz. It has substitution with [d]. The atypical IPA is [do͡ɪˤdo͡ɪˤ]. Other features include: rising-falling of the [o͡ɪˤ] sound.

and Point Tier 02: Vowel: [ɔ͡ɪ], 12c focuses on the sound, [ɖʰ] which appears at the end of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.08 seconds, 66 dB, 199 Hz.	Note: e [ɖʰ] = atypical, substitution (substitution with [ɖ])

Data Display 13 (a)

Typical Speech	*Atypical Speech*
	
Figure 55 (a): Oscillogram of চড়াই, [cɔɽ͡ʁɪ]	Figure 55 (b): Oscillogram of চড়াই, [cɔˠʷɽˠ͡oɪ˩]
It shows a PRAAT illustration of the word চড়াই which is displayed in the Interval Tier 01: Bangla Text Word 'চড়াই', and its transcription is in Interval Tier 02: IPA: [cɔɽ͡ʁɪ], Point Tier 01: Consonants [c], [ɽ] and Point Tier 02: Vowel: [ɔ], [ʁɪ], 13a focuses on the sound, [c] or [t̪ɕ] which appears at the beginning of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiceless sound which is of 0.05 seconds, 73 dB, 271 Hz.	Here, [c] or [t̪ɕ] appears at the beginning of the word. It's 0.3 seconds, 63 dB, 211 Hz. It has a typical [c] or [t̪ɕ] sound. The atypical IPA is [cɔˠʷɽˠ͡oɪ˩]. Other features include: velarized [ɔˠʷ] with rising-falling, velarized [ɽˠ], substitution with [ɔ͡ɪ˩] with low tone. Note: b [c] = typical

Data Display 13 (b)

Typical Speech	*Atypical Speech*
	
Figure 56 (a): Oscillogram of আচার, [ɐcɐɾ]	Figure 56 (b): Oscillogram of আচার, [ɐˠˤcˤɐɻ̃]
It shows a PRAAT illustration of the word আচার which is displayed in the Interval Tier 01: Bangla Text Word 'আচার', and its transcription is in Interval Tier 02: IPA: [ɐcɐɾ], Point Tier 01: Consonants [c], [ɾ] and Point Tier 02: Vowel: [ɐ], 13b focuses on the sound, [c] or [t͡ɕ], appears in the middle of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiceless sound of 0.07 seconds, 60 dB, 270 Hz.	Here, [c] or [t͡ɕ] appears in the middle of the word. It's 0.21 seconds, 66 dB, 188 Hz. It rising-falling tone of [cˤ]. The atypical IPA is [ɐˠˤcˤɐɻ̃]. Other features include: velarized [ɐˠˤ] with rising-falling tone, no audible release with [ɻ̃], and low tone with [ɐɻ]. Note: m [c] = atypical, distortion (rising-falling tone of [cˤ])

Data Display 13 (c)

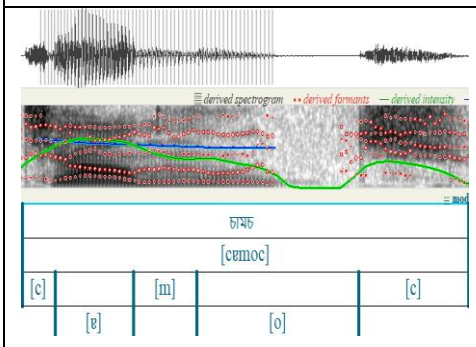
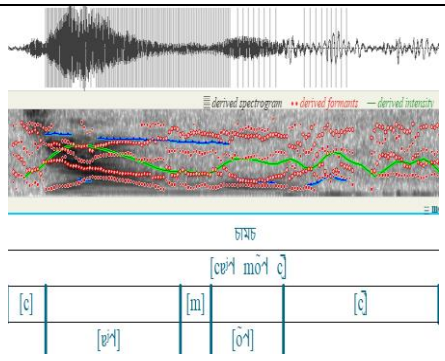
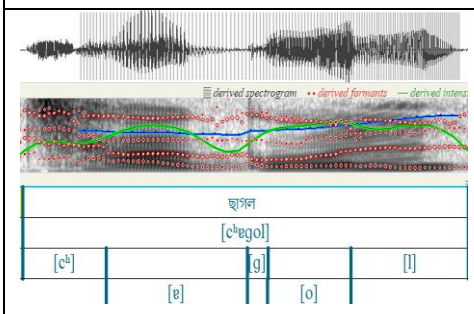
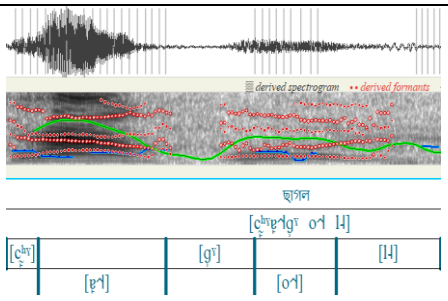
Typical Speech	*Atypical Speech*
	

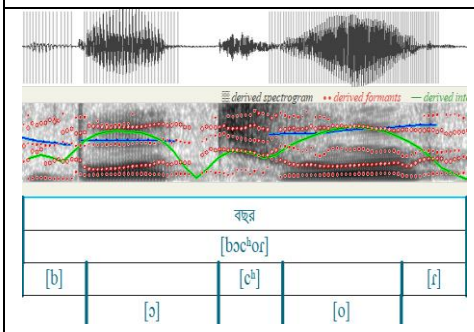
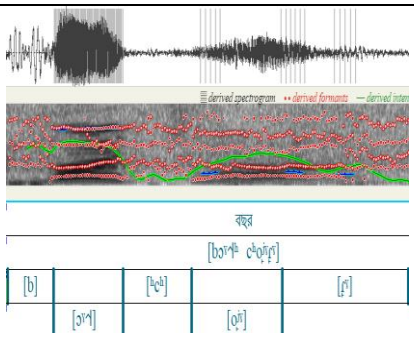
Figure 57 (a): Oscillogram of চামচ, [cɐmoc] It shows a PRAAT illustration of the word চামচ which is displayed in the Interval Tier 01: Bangla Text Word 'চামচ', and its transcription is in Interval Tier 02: IPA: [cɐmoc], Point Tier 01: Consonants [c], [m], [c] and Point Tier 02: Vowel: [ɐ], [o], 13c focuses on, [c] or [t̪ɕ] which appears at the end. It is pulmonic egressive, post-alveolar or palato-alveolar, voiceless, 0.04 seconds, 71 dB, 248 Hz.	Figure 57 (b): Oscillogram of চামচ, [cɐʲˤmõˤc̚] Here, [c] or [t̪ɕ] appears at the end of the word. It's 0.12 seconds, 60 dB, 224 Hz. It has no audible release of [c̚]. The atypical IPA is [cɐʲˤmõˤc̚]. Other features include: palatalized [ɐʲˤ] with rising-falling tone, nasalized [õˤ] with rising-falling tone. Note: e [c] = atypical, omission (no audible release)

Data Display 14 (a)

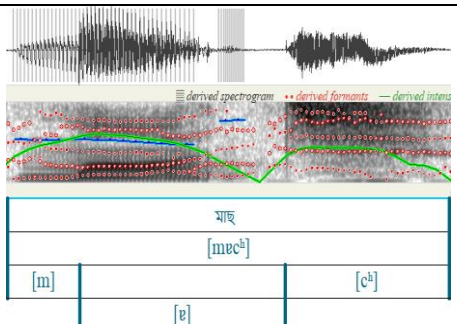
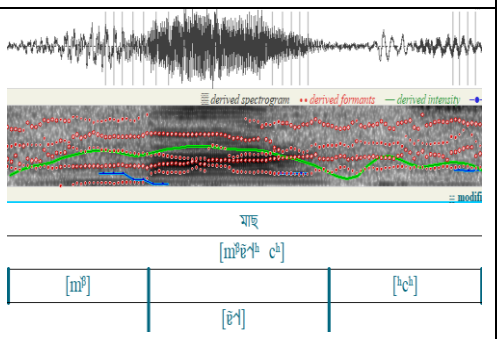
Typical Speech	*Atypical Speech*
	
Figure 58 (a): Oscillogram of ছাগল, [cʰɐgol] It shows a PRAAT illustration of the word ছাগল which is displayed in the Interval Tier 01: Bangla Text Word 'ছাগল', and its transcription is in Interval Tier 02: IPA: [cʰɐgol], Point Tier 01: Consonants [cʰ], [g], [l] and Point Tier 02: Vowel: [ɐ],	Figure 58 (b): Oscillogram of ছাগল, [ç̟ʰʸɐˤgˠoˤlɬ] Here, [cʰ] or [t̪ɕʰ] appears at the beginning of the word. It's 0.3 seconds, 67 dB, 188 Hz. It has retracted tongue root position of velarized [ç̟ʰʸ]. The atypical IPA is [ç̟ʰʸɐˤgˠoˤlɬ]. Other features include: retracted tongue root position of [ɐˤ] with rising-falling

[o] 14a focuses on the sound, [cʰ] or [t̪ɕʰ] which appears at the beginning of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiceless sound which is of 0.11 seconds, 70 dB, 237 Hz.	tone, velarized retraced tongue root position of [g̰ˠ], rising-falling of the [oˤ] sound, and low tone of [l̩̀]. Note: b [cʰ] = atypical, distortion (retracted tongue root position of velarized [ç̰ʰˠ])

Data Display 14 (b)

Typical Speech	*Atypical Speech*
	
Figure 59 (a): Oscillogram of বছর, [bɔcʰoɾ]	Figure 59 (b): Oscillogram of বছর, [bɔˠˤʰcʰo̤ʲˠɾ̤ˠ]
It shows a PRAAT illustration of the word বছর which is displayed in the Interval Tier 01: Bangla Text Word ‘বছর’, and its transcription is in Interval Tier 02: IPA: [bɔcʰoɾ], Point Tier 01: Consonants [b], [cʰ], [ɾ] and Point Tier 02: Vowel: [ɔ], [o], 14b focuses on the sound, [cʰ] or [t̪ɕʰ] which appears in the middle of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiceless sound which is of 0.09 seconds, 68 dB, 267 Hz.	Here, [cʰ] or [t̪ɕʰ] appears in the middle of the word. It’s 0.21 seconds, 60 dB, 190 Hz. It is a pre-aspiration with [ʰcʰ]. The atypical IPA is [bɔˠˤʰcʰo̤ʲˠɾ̤ˠ]. Other features include: velarized [ɔˠˤ] with rising-falling tone, retracted tongue root position of palatalized and velarized [o̤ʲˠ] and velarized [ɾ̤ˠ] with retracted tongue root position. Note: m [cʰ] = atypical, distortion (pre-aspiration), also could be noted as addition

Data Display 14 (c)

Typical Speech	*Atypical Speech*
	
Figure 60 (a): Oscillogram of মাছ, [mɐcʰ]	Figure 60 (b): Oscillogram of মাছ, [m̆ᵝɐ̃ʔʰcʰ]
It shows a PRAAT illustration of the word মাছ which is displayed in the Interval Tier 01: Bangla Text Word 'মাছ', and its transcription is in Interval Tier 02: IPA: [mɐcʰ]. Point Tier 01: Consonants [m], [cʰ] and Point Tier 02: Vowel: [ɐ], 14c focuses on the sound, [cʰ] or [t̪ɕʰ] which appears at the end of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiceless sound which is of 0.19 seconds, 71 dB, 183 Hz.	Here, [cʰ] or [t̪ɕʰ] appears at the end of the word. It's 0.53 seconds, 69 dB, 199 Hz. It has a typical [cʰ] or [t̪ɕʰ] sound. The atypical IPA is [m̆ᵝɐ̃ʔʰcʰ]. Other features include: rising [m̆ᵝ] with compressed lips, rising-falling of nasalized and aspirated [ɐ̃ʔʰ]. Note: e [cʰ] = typical

Data Display 15 (a)

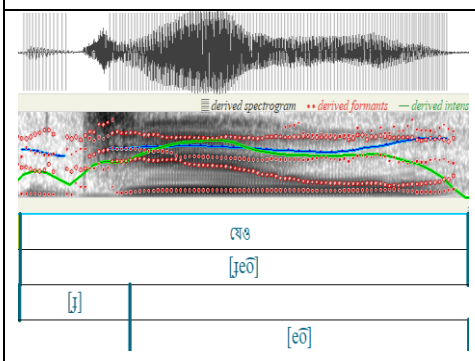
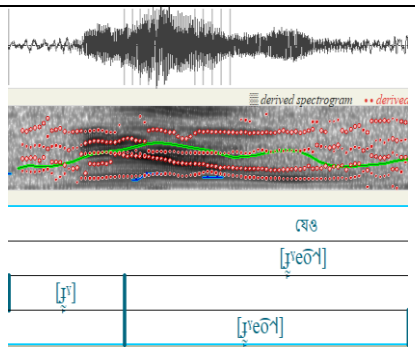
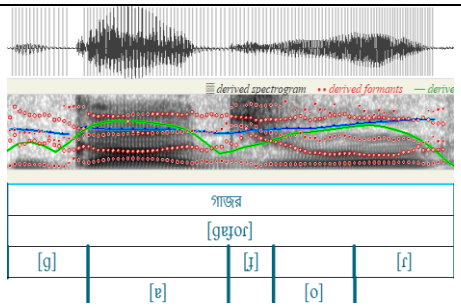
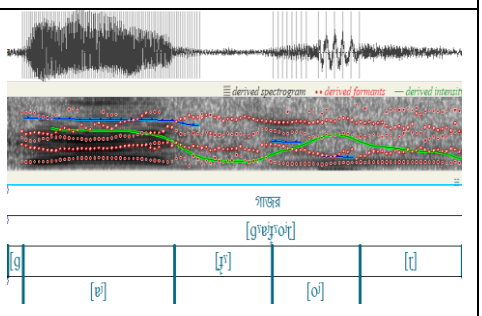
Typical Speech	*Atypical Speech*
	

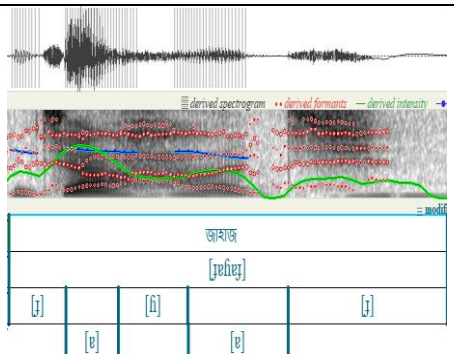
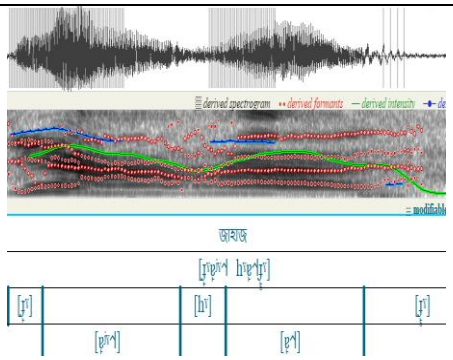
Figure 61 (a): Oscillogram of যেও, [ɟe͡o]	Figure 61 (b): Oscillogram of যেও, [ɟ̟ʸe͡oˠ]
It shows a PRAAT illustration of the word যেও which is displayed in the Interval Tier 01: Bangla Text Word 'যেও', and its transcription is in Interval Tier 02: IPA: [ɟe͡o]. Point Tier 01: Consonants [ɟ] and Point Tier 02: Vowel: [e͡o], 15a focuses on, [ɟ] or [d̠ʑ] which appears at the beginning of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiced sound which is of 0.15 seconds, 61 dB, 208 Hz.	Here, [ɟ] or [d̠ʑ] appears at the beginning of the word. It's 0.21 seconds, 61 dB, 191 Hz. It has velarized [ɟ̟ʸ] with retracted tongue root position. The atypical IPA is [ɟ̟ʸe͡oˠ]. Other features include: rising-falling of the [e͡oˠ] sound. Note: b [ɟ] = atypical, distortion (velarized [ɟ̟ʸ] with retracted tongue root position)

Data Display 15 (b)

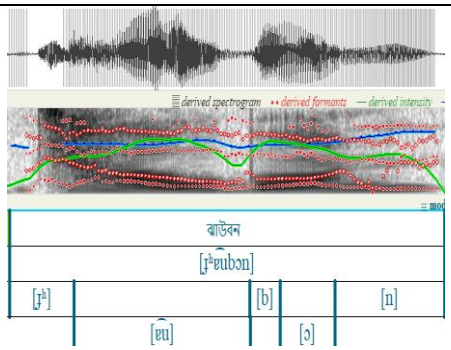
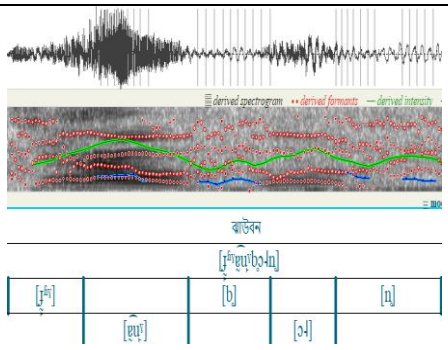
Typical Speech	*Atypical Speech*
	
Figure 62 (a): Oscillogram of গাজর, [gɐɟɔɾ] It shows a PRAAT illustration of the word গাজর which is displayed in the Interval Tier 01: Bangla Text Word 'গাজর', and its transcription is in Interval Tier 02: IPA: [gɐɟɔɾ]. Point Tier 01: Consonants [g], [ɟ],	Figure 62 (b): Oscillogram of গাজর, [gʲɐʲɟ̟ʸoˠɾ] Here, [ɟ] or [dʑ] appears in the middle of the word. It's 0.14 seconds, 56 dB, 184 Hz. It has velarized [ɟ̟ʸ] with retracted tongue root position. The atypical IPA is [gʲɐʲɟ̟ʸoˠɾ]. Other features include: velarized [gʲ], palatalized [ɐʲ] and

[ɾ] and Point Tier 02: Vowel: [ɐ], [o], 15b focuses on the sound, [ɟ] or [d̪ʑ] which appears in the middle of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiced sound which is of 0.06 seconds, 56 dB, 208 Hz.	[oʲ], substitution with [ɽ]. Note: m [ɟ] = atypical, distortion (velarized [ɟ̴ˠ] with retracted tongue root position)

Data Display 15 (c)

Typical Speech	*Atypical Speech*
	
Figure 63 (a): Oscillogram of জাহাজ, [ɟɐhɐɟ] It shows a PRAAT illustration of the word জাহাজ which is displayed in the Interval Tier 01: Bangla Text Word 'জাহাজ', and its transcription is in Interval Tier 02: IPA: [ɟɐhɐɟ]. Point Tier 01: Consonants [ɟ], [h], [ɟ] and Point Tier 02: Vowel: [ɐ], 15c focuses on the sound, [ɟ] or [d̪ʑ] which appears at the end of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiced sound which is of 0.09 seconds, 62 dB, 200 Hz.	Figure 63 (b): Oscillogram of জাহাজ, [ɟ̴ˠɐ̟ʲˠˤhˠɐ̟ˠˤɟ̴ˠ] Here, [ɟ] or [d̪ʑ] appears at the end. It's 0.13 seconds, 60 dB, 192 Hz, has retracted tongue root with voiceless velarization [ɟ̴ˠ]. The atypical IPA is [ɟ̴ˠɐ̟ʲˠˤhˠɐ̟ˠˤɟ̴ˠ]. Other features: velarized retracted tongue root with [ɟ̴ˠ], retracted tongue root of palatalized and velarized [ɐ̟ʲˠˤ] with rising-falling tone, velarized [hˠ], retracted tongue root of [ɐ̟ˠˤ] with rising-falling tone. Note: e [ɟ] = atypical, distortion (retracted tongue root with voiceless velarization [ɟ̴ˠ])

Data Display 16 (a)

Typical Speech	*Atypical Speech*
	
Figure 64 (a): Oscillogram of ঝাউবন, [ɻʱɐ͡ubɔn]	Figure 64 (b): Oscillogram of ঝাউবন, [ɻ̊ʱʏɐ̹͡u̹ʏb̥ɔɬn̥]
It shows a PRAAT illustration of the word ঝাউবন which is displayed in the Interval Tier 01: Bangla Text Word 'ঝাউবন', and its transcription is in Interval Tier 02: IPA: [ɻʱɐ͡ubɔn]. Point Tier 01: Consonants [ɻʱ], [b], [n] and Point Tier 02: Vowel: [ɔ], [ɐ͡u], 16a focuses on, [ɻʱ] or [dʑʱ] which appears at the beginning. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiced sound, of 0.11 seconds, 62 dB, 224 Hz.	Here, [ɻʱ] or [dʑʱ] appears at the beginning of the word. It's 0.34 seconds, 58 dB, 187 Hz. It has creaky voice and retracted tongue root position. It is also velarized. The atypical IPA is [ɻ̊ʱʏɐ̹͡u̹ʏb̥ɔɬn̥]. Other features include: velarized, creaky voiced, retracted tongue root position of [ɐ̹͡u̹ʏ], voiceless [b̥], low toned [ɔɬ], voiceless [n̥]. Note: b [ɻʱ] = atypical, distortion (retracted tongue root position, creaky voiced, velarized)

Data Display 16 (b)

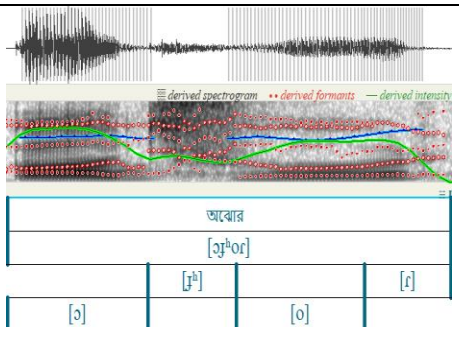
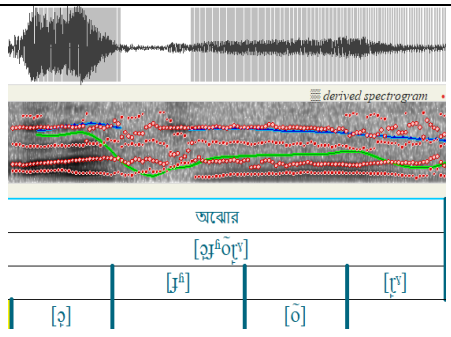
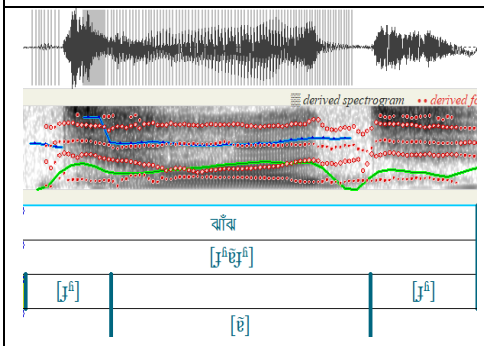
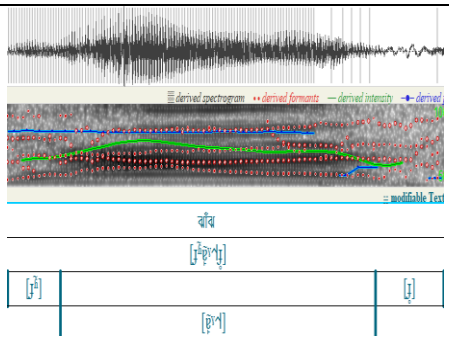
Typical Speech	*Atypical Speech*
	

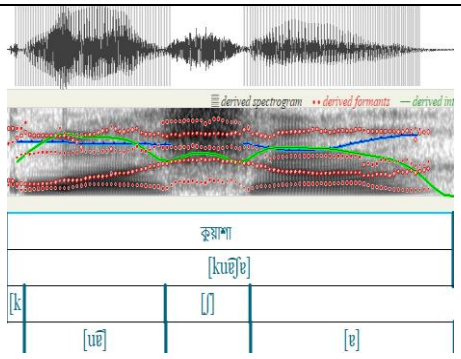
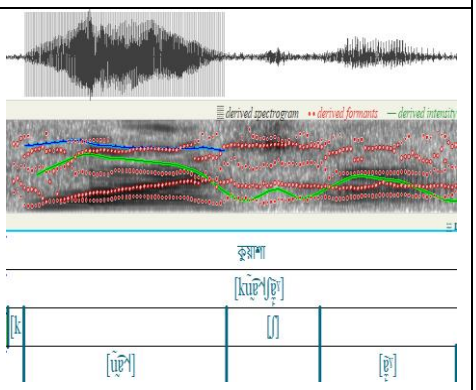
Figure 65 (a): Oscillogram of অঝোর, [ɔɟʱoɾ] It shows a PRAAT illustration of the word অঝোর which is displayed in the Interval Tier 01: Bangla Text Word ‘অঝোর’, and its transcription is in Interval Tier 02: IPA: [ɔɟʱoɾ]. Point Tier 01: Consonants [ɟʱ], [ɾ] and Point Tier 02: Vowel: [ɔ], [o], 16b focuses on the sound, [ɟʱ] or [d̪ʑʱ] which appears in the middle of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiced sound which is of 0.11 seconds, 64 dB, 224 Hz.	Figure 65 (b): Oscillogram of অঝোর, [ɔ̰ɟʱõr̰ʸ] Here, [ɟʱ] or [d̪ʑʱ] appears in the middle of the word. It’s 0.1 seconds, 53 dB, 167 Hz. It is a typical sound. The atypical IPA is [ɔ̰ɟʱõr̰ʸ]. Other features include: retracted tongue root position of [ɔ̰], nasalized [õ], substitution and velarized retracted tongue root position of [r̰ʸ]. Note: m [ɟʱ] = typical

Data Display 16 (c)

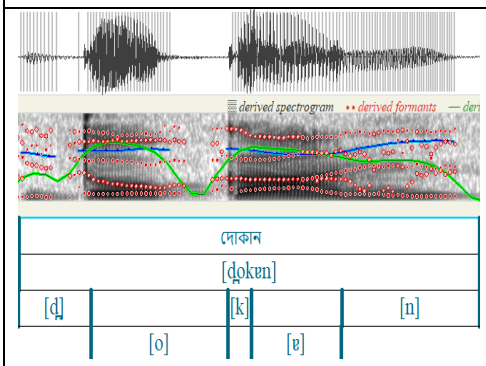
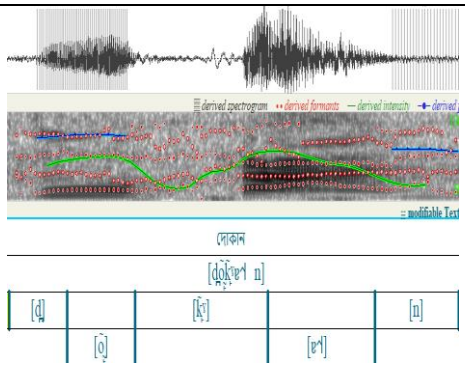
Typical Speech	*Atypical Speech*
	
Figure 66 (a): Oscillogram of ঝাঁঝ, [ɟʱɛ̃ɟʱ] It shows a PRAAT illustration of the word ঝাঁঝ which is displayed in the Interval Tier 01: Bangla Text Word ‘ঝাঁঝ’, and its transcription is in Interval Tier 02: IPA: [ɟʱɛ̃ɟʱ]. Point Tier 01: Consonants [ɟʱ] and	Figure 66 (b): Oscillogram ঝাঁঝ, [ɟʱ̃ɛ̰ʸˤɟ̚ʱ] Here, [ɟʱ] or [d̪ʑʱ] appears at the end of the word. It’s 0.11 seconds, 53 dB, 167 Hz. It is voiceless. The atypical IPA is [ɟʱ̃ɛ̰ʸˤɟ̚ʱ]. Other features include: nasalized [ɟʱ̃], retracted tongue root position for

Point Tier 02: Vowel: [ɐ̃], 16c focuses on the sound, [ɻʱ] or [d̪z̪ʱ] which appears at the end of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiced sound which is of 0.11 seconds, 64 dB, 224 Hz.	velarized and nasalized [ɐ̴̃ˠˤ] with rising-falling tone. Note: e [ɻʱ] = atypical, distortion (voiceless)

Data Display 17 (a)

Typical Speech	*Atypical Speech*
	
Figure 67 (a): Oscillogram of কুয়াশা, [kuɐ͡ʃɐ] It shows a PRAAT illustration of the word কুয়াশা which is displayed in the Interval Tier 01: Bangla Text Word 'কুয়াশা', and its transcription is in Interval Tier 02: IPA: [kuɐ͡ʃɐ]. Point Tier 01: Consonants [k], [ʃ] and Point Tier 02: Vowel: [ɐ], [uɐ͡], 17a focuses on the sound, [k] which appears at the beginning of the word. It is a pulmonic egressive, velar, voiceless sound which is of 0.08 seconds, 70 dB, 273 Hz.	Figure 67 (b): Oscillogram of কুয়াশা, [kʊ̃͡ɐˠʃɐ̴̃ˠ] Here, [k] appears at the beginning of the word. It's 0.09 seconds, 58 dB, 217 Hz. It is a typical [k] sound. The atypical IPA is [kʊ̃͡ɐˠʃɐ̴̃ˠ]. Other features include: creaky voice and nasalized [ʊ̃͡ɐˠ] with rising-falling tone. It also includes creaky voice, nasalization, velarization and retracted tongue root position for [ɐ̴̃ˠ]. Note: b [k] = typical

Data Display 17 (b)

Typical Speech	*Atypical Speech*
	
Figure 68 (a): Oscillogram of দোকান, [d̪okɐn]	Figure 68 (b): Oscillogram of দোকান, [d̪o̰k̰ˠɐˤn]
It shows a PRAAT illustration of the word দোকান which is displayed in the Interval Tier 01: Bangla Text Word 'দোকান', and its transcription is in Interval Tier 02: IPA: [d̪okɐn]. Point Tier 01: Consonants [d̪], [k], [n] and Point Tier 02: Vowel: [o], [ɐ], 17b focuses on the sound, [k] which appears in the middle of the word. It is a pulmonic egressive, velar, voiceless sound which is of 0.4 seconds, 77 dB, 255 Hz.	Here, [k] appears in the middle of the word. It's 0.11 seconds, 62 dB, 196 Hz. It has a typical [k] sound. The atypical IPA is [d̪o̰k̰ˠɐˤn]. Other features include: creaky voiced and nasalized [o̰] with retracted tongue root position. It also includes velarized and nasalized [k̰ˠ] with retracted tongue root position, and rising-falling of [ɐˤ]. Note: m [k] = typical

Data Display 17 (c)

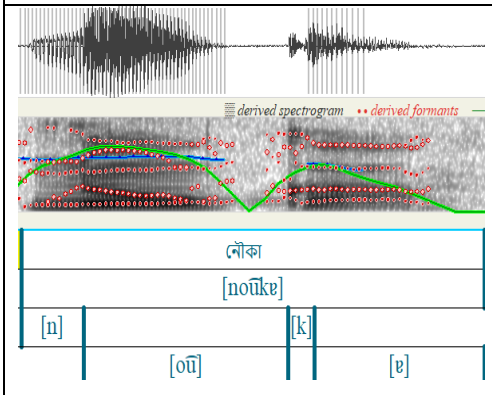
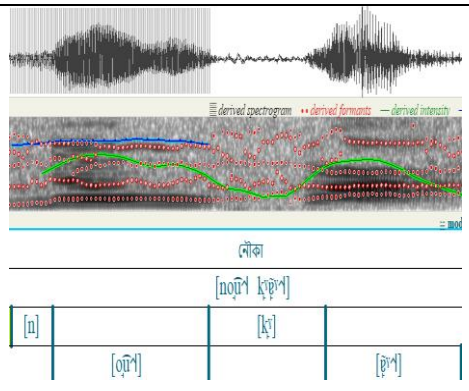
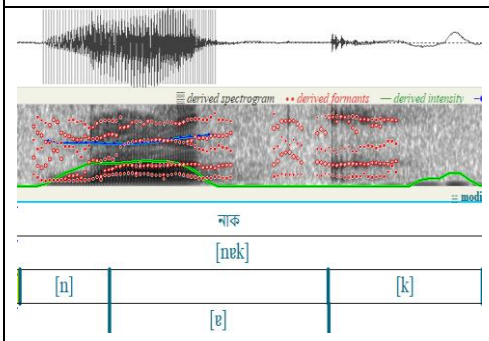
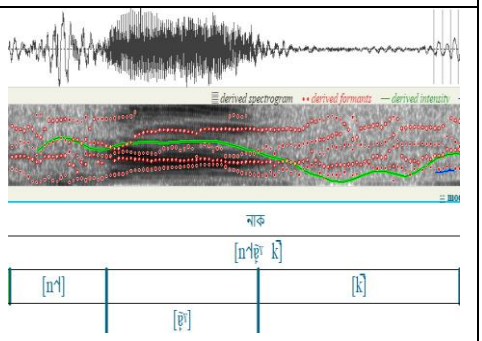
Typical Speech	*Atypical Speech*
	

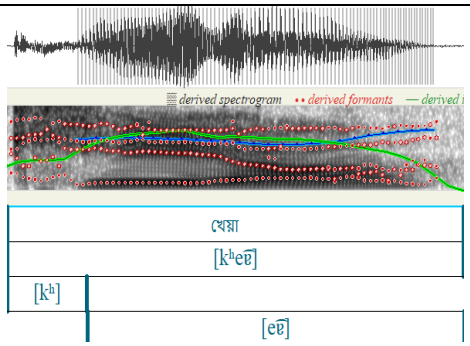
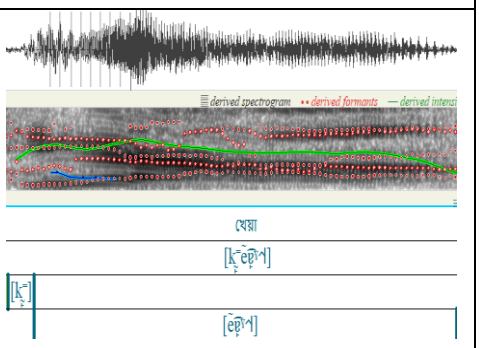
Figure 69 (a): Oscillogram of নৌকা, [no͡ukɐ]	Figure 69 (b): Oscillogram of নৌকা, [nọ͡uˠˀkˠɰ̃ˠˀ]
It shows a PRAAT illustration of the word নৌকা which is displayed in the Interval Tier 01: Bangla Text Word 'নৌকা', and its transcription is in Interval Tier 02: IPA: [no͡ukɐ]. Point Tier 01: Consonants [n], [k] and Point Tier 02: Vowel: [ɐ], [o͡u], 17c focuses on the sound, [k] which appears at the end of the word. It is a pulmonic egressive, velar, voiceless sound which is of 0.4 seconds, 77 dB, 255 Hz.	Here, [k] appears at the end of the word. It's 0.11 seconds, 62 dB, 196 Hz. It has retracted tongue root position and velarization. The atypical IPA is [nọ͡uˠˀkˠɰ̃ˠˀ]. Other features include: advanced tongue root position of [ọ͡uˠˀ] with rising-falling tone, velarized nasal retracted tongue root position of [ɰ̃ˠˀ] with rising-falling tone. Note: e [k] = typical, distortion (retracted tongue root position and velarization)

Data Display 17 (d)

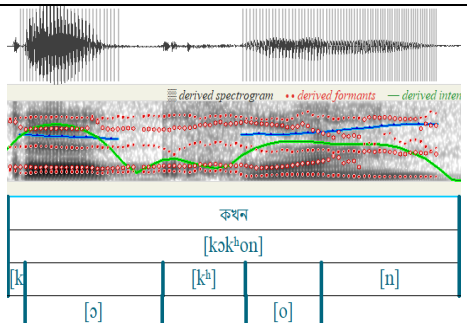
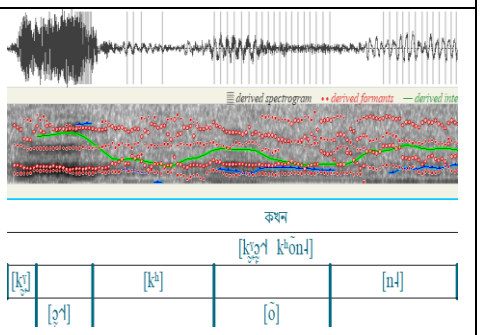
Typical Speech	*Atypical Speech*
	
Figure 70 (a): Oscillogram of নাক, [nɐk]	Figure 70 (b): Oscillogram of নাক, [nˠˀɰ̃ˠk̚]
It shows a PRAAT illustration of the word নাক which is displayed in the Interval Tier 01: Bangla Text Word 'নাক', and its transcription is in Interval Tier 02: IPA: [nɐk]. Point Tier 01: Consonants [n], [k]	Here, [k] appears at the end of the word. It's 0.11 seconds. It has no audible release. The atypical IPA is [nˠˀɰ̃ˠk̚]. Other features include: rising-falling of [nˠˀ], velarized nasal retracted tongue root position

and Point Tier 02: Vowel: [ɐ], 17d focuses on the sound, [k] which appears at the end of the word. It is a pulmonic egressive, velar, voiceless sound which is of 0.4 seconds, 77 dB, 255 Hz.	of [ɛ̯̃ʏ]. Note: e [k] = atypical, omission (no audible release)

Data Display 18 (a)

Typical Speech	*Atypical Speech*
	
Figure 71 (a): Oscillogram of খেয়া, [kʰe͡ɐ̯]	Figure 71 (b): Oscillogram of খেয়া, [k̟̃ɛ̯̃ʏˤ]
It shows a PRAAT illustration of the word খেয়া which is displayed in the Interval Tier 01: Bangla Text Word 'খেয়া', and its transcription is in Interval Tier 02: IPA: [kʰe͡ɐ̯]. Point Tier 01: Consonants [kʰ] and Point Tier 02: Vowel: [e͡ɐ̯], 18a focuses on the sound [kʰ], which appears at the beginning of the word. It is a pulmonic egressive, velar, voiceless sound which is of 0.08 seconds, 67 dB, 261 Hz.	Here, [kʰ] appears at the beginning of the word. It's 0.18 seconds, 63 dB, 199 Hz. It has unaspirated retracted tongue root position. The atypical IPA is [k̟̃ɛ̯̃ʏˤ]. Other features: nasalized velarized retracted tongue root position for [ɛ̯̃ʏˤ] with rising-falling tone. Note: b [kʰ] = atypical, distortion (unaspirated retracted tongue root position)

Data Display 18 (b)

Typical Speech	*Atypical Speech*
	
Figure 72 (a): Oscillogram of কখন, [kɔkʰon]	Figure 72 (b): Oscillogram of কখন, [k̟̈ʸ̞ɤ̞˥kʰõn˩]
It shows a PRAAT illustration of the word কখন which is displayed in the Interval Tier 01: Bangla Text Word 'কখন', and its transcription is in Interval Tier 02: IPA: [kɔkʰon]. Point Tier 01: Consonants [k], [kʰ], [n] and Point Tier 02: Vowel: [ɔ], [o], 18b focuses on the sound [kʰ], which appears in the middle of the word. It is a pulmonic egressive, velar, voiceless sound which is of 0.1 seconds, 59 dB, 251 Hz.	Here, [kʰ] appears in the middle of the word. It's 0.3 seconds, 60 dB, 194 Hz. It has a typical [kʰ] sound. The atypical IPA is [k̟̈ʸ̞ɤ̞˥kʰõn˩]. Other features include: velarized creaky-voiced [k̟̈ʸ̞], retracted tongue root position of [ɤ̞˥] with rising-falling tone, nasalized [õ], low toned [n˩]. Note: m [kʰ] = typical

Data Display 18 (c)

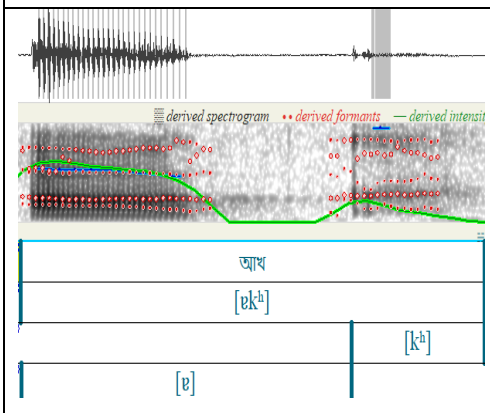
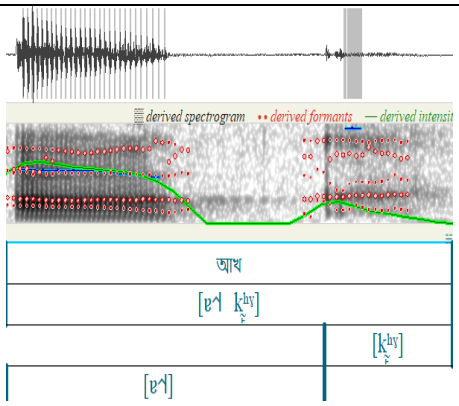
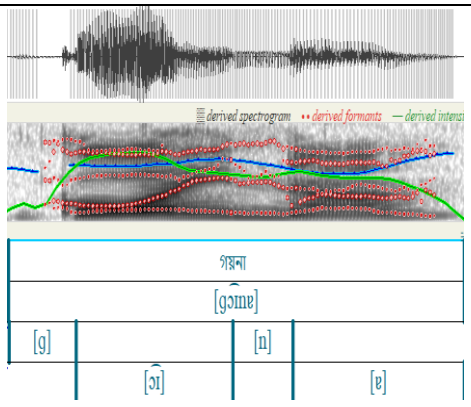
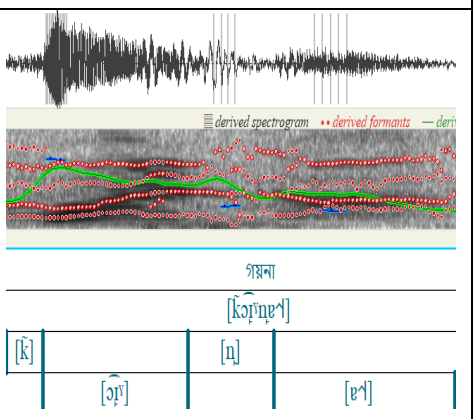
Typical Speech	*Atypical Speech*
	

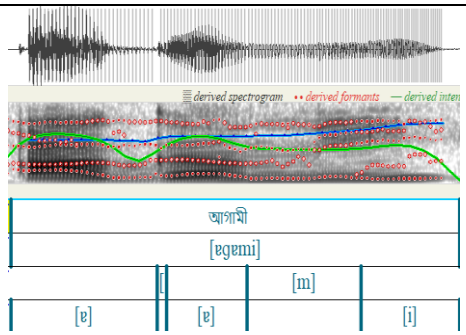
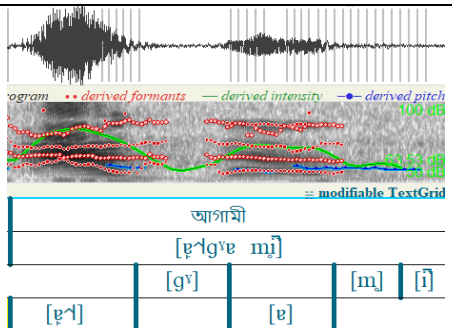
Figure 73 (a): Oscillogram of আখ, [ɐkʰ]	Figure 73 (b): Oscillogram of আখ, [ɐˤk̟ʰˠ]
It shows a PRAAT illustration of the word আখ which is displayed in the Interval Tier 01: Bangla Text Word 'আখ', and its transcription is in Interval Tier 02: IPA: [ɐkʰ]. Point Tier 01: Consonants [kʰ] and Point Tier 02: Vowel: [ɐ], 18c focuses on the sound [kʰ], which appears at the end of the word. It is a pulmonic egressive, velar, voiceless sound which is of 0.12 seconds, 56 dB, 178 Hz.	Here, [kʰ] appears at the end of the word. It's 0.3 seconds, 57 dB, 181 Hz. It has velarized retracted tongue root position of [k̟ʰˠ]. The atypical IPA is [ɐˤk̟ʰˠ]. Other features include: rising-falling of the [ɐˤ] sound. Note: e [kʰ] = atypical, distortion (velarized retracted tongue root position)

Data Display 19 (a)

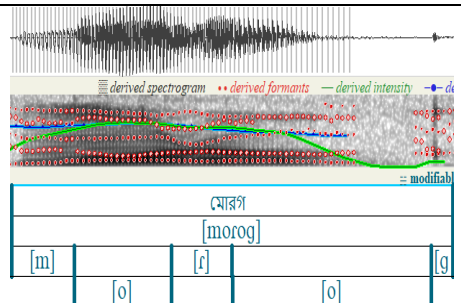
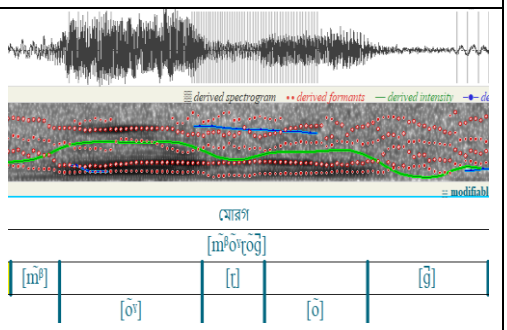
Typical Speech	*Atypical Speech*
	
Figure 74 (a): Oscillogram of গয়না, [gɔ͡ɪnɐ]	Figure 74 (b): Oscillogram of গয়না, [k̃ɔ͡ɪˠn̪ɐˤ]
It shows a PRAAT illustration of the word গয়না which is displayed in the Interval Tier 01: Bangla Text Word 'গয়না', and its transcription is in Interval Tier 02: IPA: [gɔ͡ɪnɐ].	Here, [g] appears at the beginning of the word. It's 0.05 seconds, 67 dB, 199 Hz. It has substitution with nasalization. The atypical IPA is [k̃ɔ͡ɪˠn̪ɐˤ]. Other features include: retracted tongue root

Point Tier 01: Consonants [g], [n] and Point Tier 02: Vowel: [ɐ], [ɔ͡ɪ], 19a focuses on the sound [g], which appears at the beginning of the word. It is a pulmonic egressive, velar, voiced sound which is of 0.09 seconds, 67 dB, 202 Hz.	position with velarization [ɔ͡ɪˠ], retracted tongue root position of [n̪] and rising-falling tone of the sound [ɐˤ]. Note: b [g] = atypical, substitution (substitution with nasalization)

Data Display 19 (b)

Typical Speech	*Atypical Speech*
	
Figure 75 (a): Oscillogram of আগামী, [ɐgɐmi] It shows a PRAAT illustration of the word আগামী which is displayed in the Interval Tier 01: Bangla Text Word 'আগামী', and its transcription is in Interval Tier 02: IPA: [ɐgɐmi]. Point Tier 01: Consonants [g], [m] and Point Tier 02: Vowel: [ɐ], [i], 19b focuses on the sound [g], which appears in the middle of the word. It is a pulmonic egressive, velar, voiced sound which is of 0.3 seconds, 72 dB, 239 Hz.	Figure 75 (b): Oscillogram of আগামী, [ɐˤgˠɐm̥ĩ] Here, [g] appears in the middle of the word. It's 0.07 seconds, 63 dB, 200 Hz. It has velarization. The atypical IPA is [ɐˤgˠɐm̥ĩ]. Other features include: retracted tongue root position of the sound [ɐˤ] with rising-falling, voiceless [m̥] and no audible release of [ĩ]. Note: m [g] = atypical, distortion (velarization)

Data Display 19 (c)

Typical Speech	*Atypical Speech*
	
Figure 76 (a): Oscillogram of মোরগ, [morɔg]	Figure 76 (b): Oscillogram of মোরগ, [m̃ᵝõʸɽõg̃]
It shows a PRAAT illustration of the word মোরগ which is displayed in the Interval Tier 01: Bangla Text Word 'মোরগ', and its transcription is in Interval Tier 02: IPA: [morɔg]. Point Tier 01: Consonants [m], [ɾ], [g] and Point Tier 02: Vowel: [o], 19c focuses on the sound [g], which appears at the end of the word. It is a pulmonic egressive, velar, voiced sound which is of 0.6 seconds, 52 dB, 150 Hz.	Here, [g] appears at the end of the word. It's 0.3 seconds. It has no audible release. The atypical IPA is [m̃ᵝõʸɽõg̃]. Other features include: nasalized and compressed lips for [m̃ᵝ], nasalized and velarized [õʸ], substitution with [ɽ], nasalized [õ]. Note: e [g] = atypical, omission (no audible release)

Data Display 20 (a)

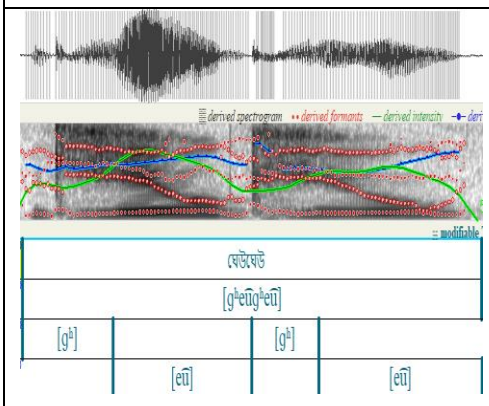
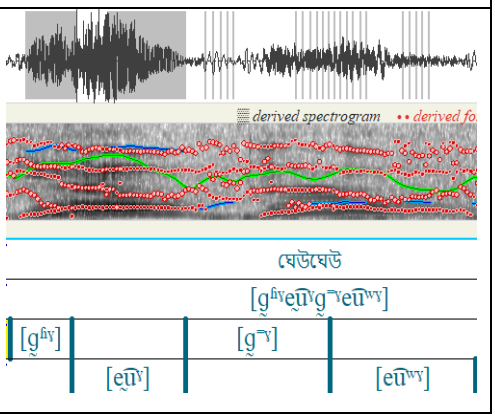
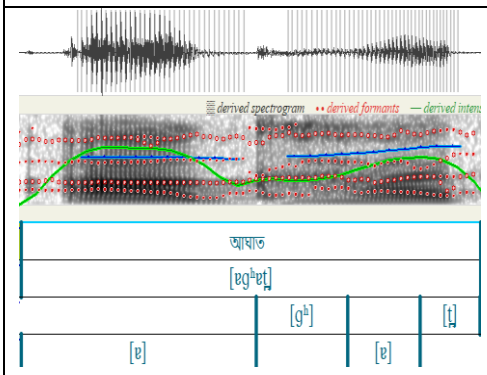
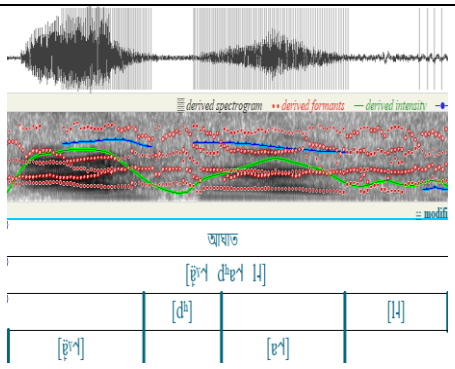
Typical Speech	*Atypical Speech*
	

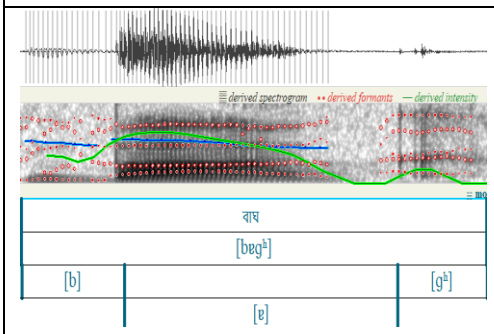
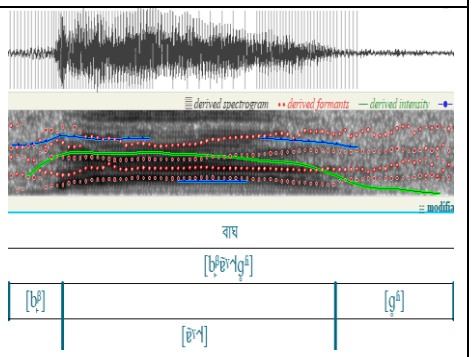
Figure 77 (a): Oscillogram of ঘেউঘেউ, [gʱe͡ugʱe͡u]	Figure 77 (b): Oscillogram of ঘেউঘেউ, [g̰ʱʏḛ͡uʏḡ̰ʏe͡uʷʏ]
It shows a PRAAT illustration of the word ঘেউঘেউ which is displayed in the Interval Tier 01: Bangla Text Word ‘ঘেউঘেউ’, and its transcription is in Interval Tier 02: IPA: [gʱe͡ugʱe͡u]. Point Tier 01: Consonants [gʱ], [gʱ] and Point Tier 02: Vowel: [e͡u], 20a focuses on the sound [gʱ], which appears at the beginning of the word. It is a pulmonic egressive, velar, voiced sound which is of 0.23 seconds, 67 dB, 212 Hz.	Here, [gʱ] appears at the beginning of the word. It’s 0.2 seconds, 56 dB, 189 Hz. It has creaky voiced velarized [g̰ʱʏ]. The atypical IPA is [g̰ʱʏḛ͡uʏḡ̰ʏe͡uʷʏ]. Other features include: creaky voiced velarized [ḛ͡uʏ], creaky voiced unaspirated velarized [ḡ̰ʏ], and labialized velarized [e͡uʷʏ]. Note: b [gʱ] = atypical, distortion (creaky voiced velarized)

Data Display 20 (b)

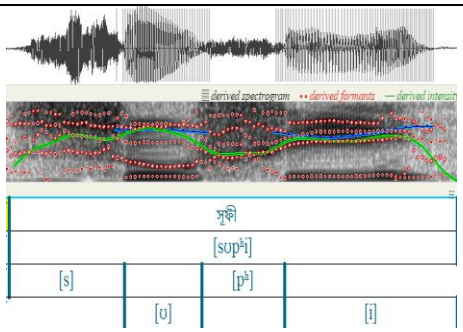
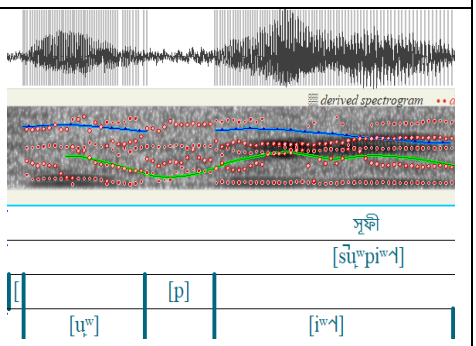
Typical Speech	*Atypical Speech*
	
Figure 78 (a): Oscillogram of আঘাত, [ɐgʱɐt̪]	Figure 78 (b): Oscillogram of আঘাত, [ɡ̰ʱʏdʱɐʏlʏ]
It shows a PRAAT illustration of the word আঘাত which is displayed in the Interval Tier 01: Bangla Text Word ‘আঘাত’, and its transcription is in Interval Tier 02: IPA: [ɐgʱɐt̪].	Here, [gʱ] appears in the middle of the word. It’s 0.2 seconds, 61 dB, 187 Hz. It has substitution and aspiration. The atypical IPA is [ɡ̰ʱʏdʱɐʏlʏ]. Other features include:

Point Tier 01: Consonants [gʱ], [t̪] and Point Tier 02: Vowel: [ɐ], 20b focuses on the sound [gʱ], which appears in the middle of the word. It is a pulmonic egressive, velar, voiced sound which is of 0.34 seconds, 63 dB, 223 Hz.	retracted tongue root position, velarization, rising-falling tone, and it is centralized with [ɐ̈ˠˤ], then there is rising-falling for [ɐˤ] and a low tone of [˩]. Note: m [gʱ] = atypical, substitution (substitution and aspiration)

Data Display 20 (c)

Typical Speech	*Atypical Speech*
	
Figure 79 (a): Oscillogram of বাঘ, [bɐgʱ]	Figure 79 (b): Oscillogram of বাঘ, [b̪ᵝɐ̃ˠˤg̊ʱ]
It shows a PRAAT illustration of the word বাঘ which is displayed in the Interval Tier 01: Bangla Text Word ‘বাঘ’, and its transcription is in Interval Tier 02: IPA: [bɐgʱ]. Point Tier 01: Consonants [b], [gʱ] and Point Tier 02: Vowel: [ɐ], 20c focuses on the sound [gʱ], which appears at the end of the word. It is a pulmonic egressive, velar, voiced sound which is of 0.09 seconds, 57 dB, 150 Hz.	Here, [gʱ] appears at the end of the word. It’s 0.3 seconds, 53 dB, 168 Hz. It has voicelessness. The atypical IPA is [b̪ᵝɐ̃ˠˤg̊ʱ]. Other features include: retracted tongue root position and compressed lips for [b̪ᵝ], nasalization, velarization and rising-falling for [ɐ̃ˠˤ]. Note: e [gʱ] = atypical, distortion (voicelessness)

Data Display 21 (a)

Typical Speech	*Atypical Speech*
	
Figure 80 (a): Oscillogram of সূফী, [supʰi]	Figure 80 (b): Oscillogram of সূফী, [s̄u̟ʷpiʷʕ]
It shows a PRAAT illustration of the word সূফী which is displayed in the Interval Tier 01: Bangla Text Word 'সূফী', and its transcription is in Interval Tier 02: IPA: [supʰi]. Point Tier 01: Consonants [s], [pʰ] and Point Tier 02: Vowel: [u], [i], 21a focuses on the sound [s], which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.22 seconds, 70 dB, 303 Hz.	Here, [s] appears at the beginning of the word. It's 0.3 seconds. It has no audible release. The atypical IPA is [s̄u̟ʷpiʷʕ]. Other features include: labialized retracted tongue root position of [u̟ʷ], and labialized rings-falling for [iʷʕ]. Note: b [s] = atypical, omission (no audible release)

Data Display 21 (b)

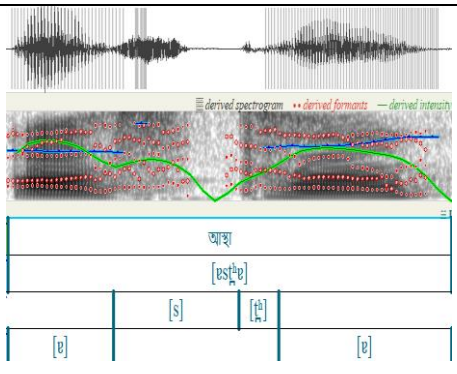
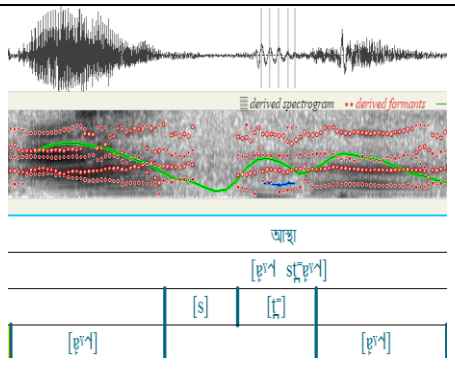
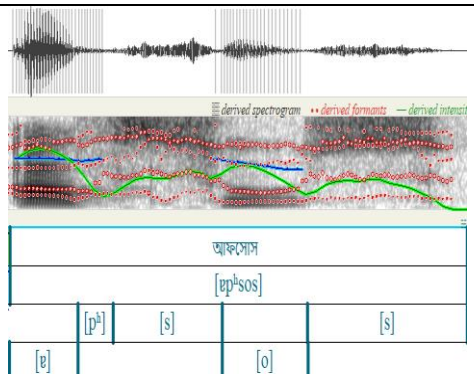
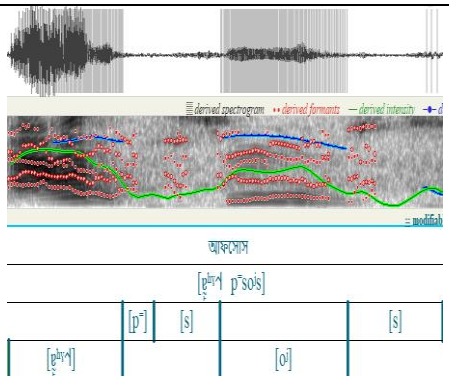
Typical Speech	*Atypical Speech*
	

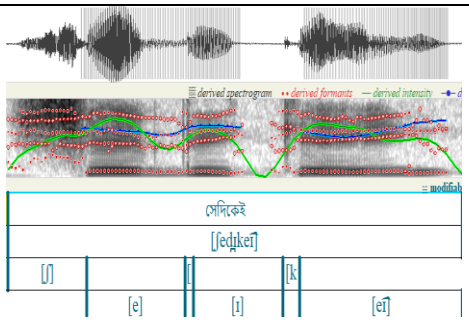
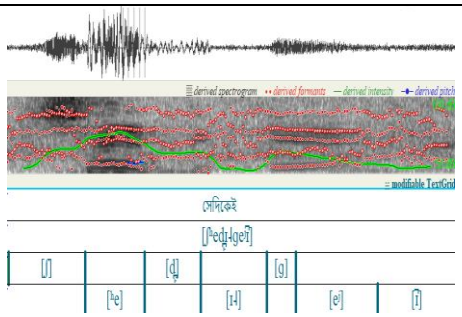
Figure 81 (a): Oscillogram of আস্থা, [ɐsʈʰɐ]	Figure 81 (b): Oscillogram of আস্থা, [ɐ̟ˠˤsʈ̟̿ɐ̟ˠˤ]
It shows a PRAAT illustration of the word আস্থা which is displayed in the Interval Tier 01: Bangla Text Word 'আস্থা', and its transcription is in Interval Tier 02: IPA: [ɐsʈʰɐ]. Point Tier 01: Consonants [s], [ʈʰ] and Point Tier 02: Vowel: [ɐ], 21b focuses on the sound [s], which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.16 seconds, 76 dB, 220 Hz.	Here, [s] appears in the middle of the word. It's 0.4 seconds, 60 dB, 183 Hz. It a typical [s] sound. The atypical IPA is [ɐ̟ˠˤsʈ̟̿ɐ̟ˠˤ]. Other features include: velarized retracted tongue root position with rising-falling for [ɐ̟ˠˤ], unaspirated [ʈ̟̿], velarized rising-falling for [ɐ̟ˠˤ]. Note: m [s] = typical

Data Display 21 (c)

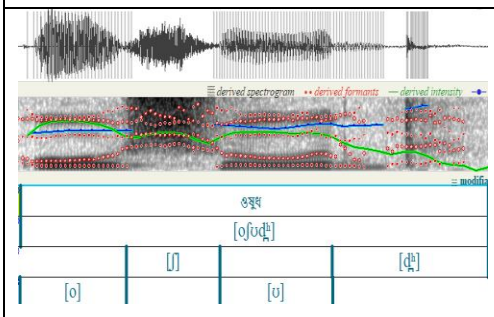
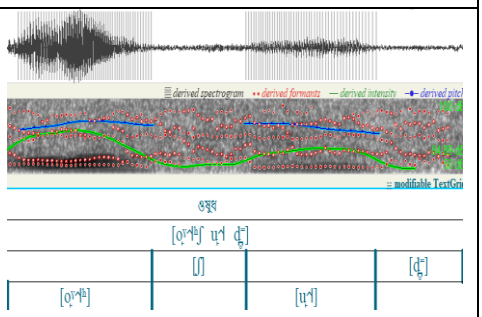
Typical Speech	*Atypical Speech*
	
Figure 82 (a): Oscillogram of আফসোস, [ɐpʰsos]	Figure 82 (b): Oscillogram of আফসোস, [ɐ̟ʰˠˤp̟̿soʲs]
It shows a PRAAT illustration of the word আফসোস which is displayed in the Interval Tier 01: Bangla Text Word 'আফসোস', and its transcription is in Interval Tier 02: IPA: [ɐpʰsos]. Point Tier 01: Consonants [pʰ], [s],	Here, [s] appears at the end of the word. It's 0.2 seconds, 50 dB, 201 Hz. It has a typical [s] sound. The atypical IPA is [ɐ̟ʰˠˤp̟̿soʲs]. Other features include: retracted tongue position, creaky voice,

[s] and Point Tier 02: Vowel: [ɐ], [o], 21c focuses on the sound [s], which appears at the end of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.16 seconds, 67 dB, 224 Hz.	velarization, aspiration, rising-falling for [ʂ̬ʰˠˤ], unaspirated [pˉ], palatalized [oʲ]. Note: e [s] = typical

Data Display 22 (a)

Typical Speech	*Atypical Speech*
	
Figure 83 (a): Oscillogram of সেদিকেই, [ʃeɖɪkeɪ̯]	Figure 83 (b): Oscillogram of সেদিকেই, [ʃʰeɖ̠ɪ˩geʲɪ̚]
It shows a PRAAT illustration of the word সেদিকেই which is displayed in the Interval Tier 01: Bangla Text Word 'সেদিকেই', and its transcription is in Interval Tier 02: IPA: [ʃeɖɪkeɪ̯]. Point Tier 01: Consonants [ʃ], [ɖ], [k] and Point Tier 02: Vowel: [e], [ɪ], [eɪ̯], 22a focuses on the sound [ʃ], which appears at the beginning of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiceless sound which is of 0.13 seconds, 76 dB, 281 Hz.	Here, [ʃ] appears at the beginning of the word. It's 0.3 seconds, 58 dB, 208 Hz. It has distortion with aspiration. The atypical IPA is [ʃʰeɖ̠ɪ˩geʲɪ̚]. Other features include: retracted tongue root position for [ɖ̠], low tone for [ɪ˩], substitution with [g], palatalization for [eʲ], and no audible release for [ɪ̚]. Note: b [ʃ] = atypical, distortion (aspiration), also could be noted as addition

Data Display 22 (b)

Typical Speech	*Atypical Speech*
	
Figure 84 (a): Oscillogram of ওষুধ, [oʃuɖ̪ʱ]	Figure 84 (b): Oscillogram of ওষুধ, [o̤ʷˠʰʃṳˠɖ̪̈]
It shows a PRAAT illustration of the word ওষুধ which is displayed in the Interval Tier 01: Bangla Text Word 'ওষুধ', and its transcription is in Interval Tier 02: IPA: [oʃuɖ̪ʱ]. Point Tier 01: Consonants [ʃ], [ɖ̪ʱ] and Point Tier 02: Vowel: [o], [u] 22b focuses on the sound [ʃ], which appears in the middle of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiceless sound which is of 0.12 seconds, 72 dB, 283 Hz.	Here, [ʃ] appears in the middle of the word. It's 0.3 seconds, 60 dB, 183 Hz. It has a typical [ʃ] sound. The atypical IPA is [o̤ʷˠʰʃṳˠɖ̪̈]. Other features include: velarized retracted tongue root position with aspiration of [o̤ʷˠʰ] with rising-falling tone, rising-falling retracted tongue root position of [ṳˠ], unaspirated voiceless [ɖ̪̈]. Note: m [ʃ] = typical

Data Display 22 (c)

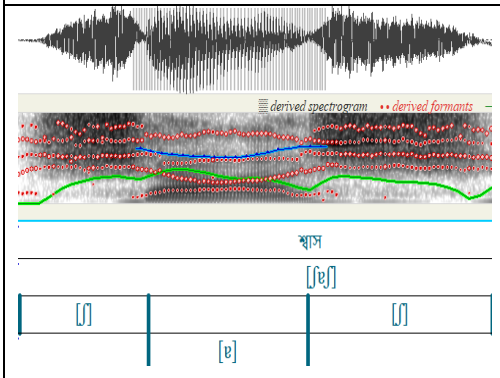
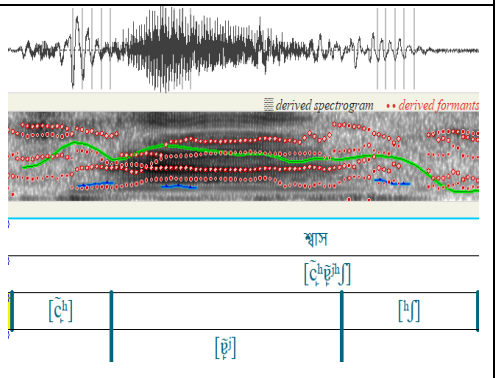
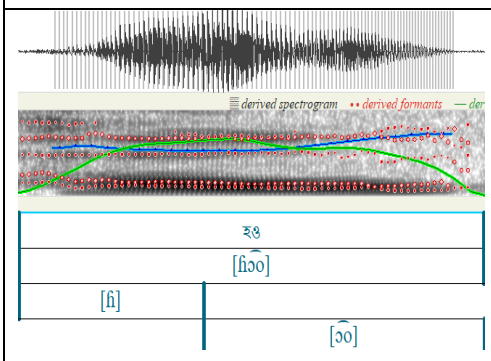
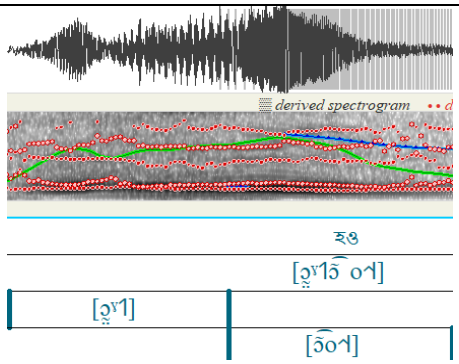
Typical Speech	*Atypical Speech*
	

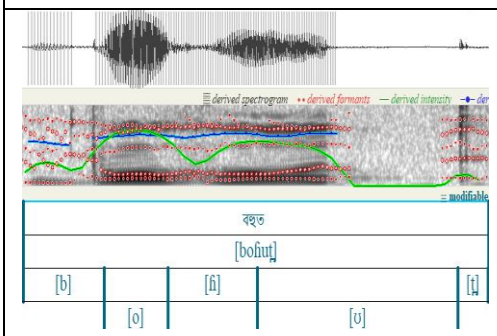
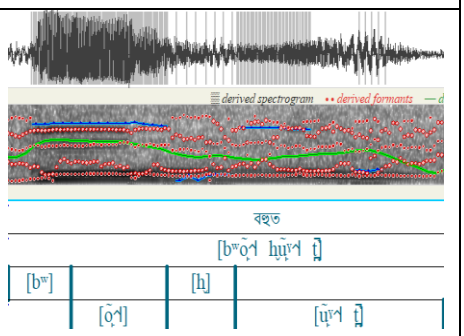
Figure 85 (a): Oscillogram of শ্বাস, [ʃɐʃ] It shows a PRAAT illustration of the word শ্বাস which is displayed in the Interval Tier 01: Bangla Text Word ‘শ্বাস’, and its transcription is in Interval Tier 02: IPA: [ʃɐʃ]. Point Tier 01: Consonants [ʃ], [ʃ] and Point Tier 02: Vowel: [ɐ] 22c focuses on [ʃ], which appears at the end of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiceless sound which is of 0.12 seconds, 72 dB, 283 Hz	Figure 85 (b): Oscillogram of শ্বাস, [ʃ̃ʰɐ̃ʲʰʃ] Here, [ʃ] appears at the end of the word. It’s 0.3 seconds, 60 dB, 183 Hz. It pre-aspiration. The atypical IPA is [ʃ̃ʰɐ̃ʲʰʃ]. Other features include: nasalized aspirated retracted tongue root position with [ʃ̃ʰ], nasalized retracted tongue root position with palatalization of [ɐ̃ʲ]. Note: e [ʃ] = atypical, distortion (pre-aspiration), also could be noted as addition

Data Display 23 (a)

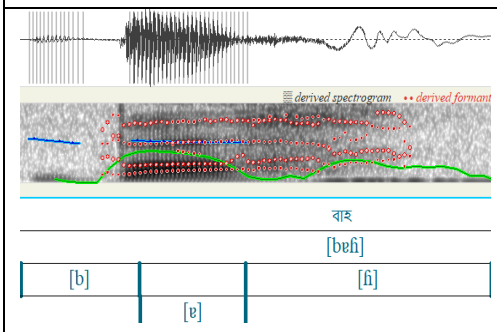
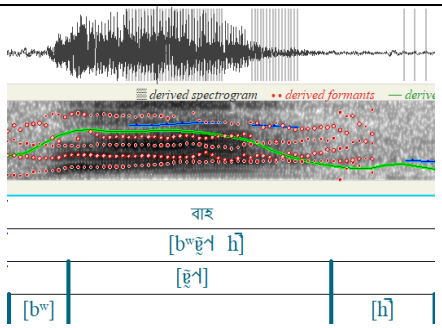
Typical Speech	*Atypical Speech*
	
Figure 86 (a): Oscillogram of হও, [ɦɔ͡o] It shows a PRAAT illustration of the word হও which is displayed in the Interval Tier 01: Bangla Text Word ‘হও’, and its transcription is in Interval Tier 02: IPA: [ɦɔ͡o]. Point Tier 01: Consonants [ɦ] and Point	Figure 86 (b): Oscillogram of হও, [ɞˠʔɔ͡o˥] Here, [ɦ] appears at the beginning of the word. It’s 0.2 seconds, 56 dB, 255 Hz. It shows substitution with velarized breathy and creaky voiced [ɞˠ] with a rising tone. The atypical IPA is [ɞˠʔɔ͡o˥]. Other features include: nasalized [ɔ͡o˥]

Tier 02: Vowel: [ɔo͡], 23a focuses on the sound [ɦ], which appears at the beginning of the word. It is a pulmonic egressive, glottal, voiceless sound which is of 0.17 seconds, 78 dB, 224 Hz.	with rising-falling tone. Note: b [ɦ] = atypical, substitution (velarized breathy and creaky voiced [ɐ̰ˠ˥] with a rising tone)

Data Display 23 (b)

Typical Speech	*Atypical Speech*
	
Figure 87 (a): Oscillogram of বহুত, [boɦut̪] It shows a PRAAT illustration of the word বহুত which is displayed in the Interval Tier 01: Bangla Text Word 'বহুত', and its transcription is in Interval Tier 02: IPA: [boɦut̪]. Point Tier 01: Consonants [b], [ɦ], [t̪] and Point Tier 02: Vowel: [o], [u], 23b focuses on the sound [ɦ], which appears in the middle of the word. It is a pulmonic egressive, glottal, voiceless sound which is of 0.13 seconds, 64 dB, 265 Hz.	Figure 87 (b): Oscillogram of বহুত, [bʷõˌˠ˥hũˠˠt̪] Here, [ɦ] appears in the middle of the word. It's 0.09 seconds, 65 dB, 183 Hz. It is seemingly voiced. The atypical IPA is [bʷõˌˠ˥hũˠˠt̪]. Other features include: labialized [bʷ], nasalized retracted tongue root position with rising-falling tone for [õˌˠ˥], velarized nasalized retracted tongue root position with rising-falling tone for [ũˠˠ], no audible release for [t̪]. Note: m [ɦ] = atypical, distortion (voiced)

Data Display 23 (c)

Typical Speech	*Atypical Speech*
	
Figure 88 (a): Oscillogram of বাহ, [bɐɦ]	Figure 88 (b): Oscillogram of বাহ, [bʷɐ̃ˤh̃]
It shows a PRAAT illustration of the word বাহ which is displayed in the Interval Tier 01: Bangla Text Word ‘বাহ’, and its transcription is in Interval Tier 02: IPA: [bɐɦ]. Point Tier 01: Consonants [b], [ɦ] and Point Tier 02: Vowel: [ɐ], 23c focuses on the sound [ɦ], which appears at the end of the word. It is a pulmonic egressive, glottal, voiceless sound which is of 0.13 seconds, 64 dB, 265 Hz.	Here, [ɦ] appears at the end of the word. It’s 0.2 seconds. It has no audible release. The atypical IPA is [bʷɐ̃ˤh̃]. Other features include: labialized [bʷ], nasalized [ɐ̃ˤ] with creaky voice and rising-falling tone. Note: e [ɦ] = atypical, omission (no audible release)

Data Display 24 (a)

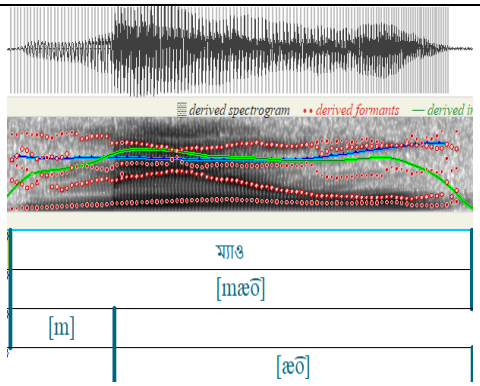
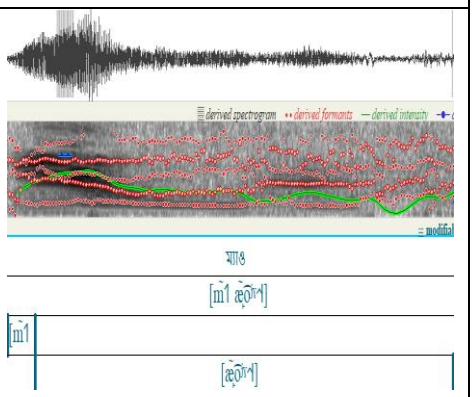
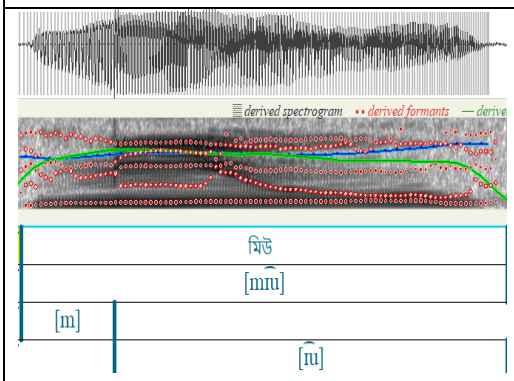
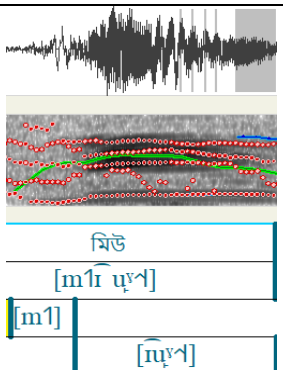
Typical Speech	*Atypical Speech*
	

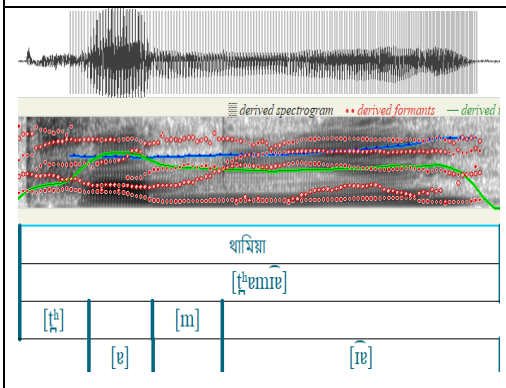
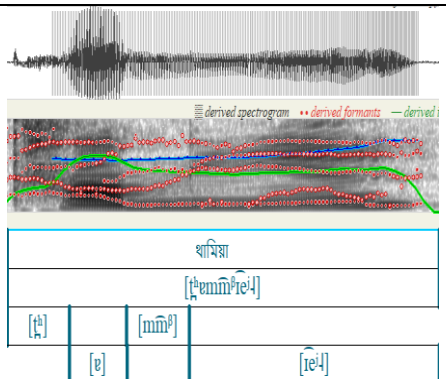
Figure 89 (a): Oscillogram of ম্যাও, [mæ͡o]	Figure 89 (b): Oscillogram of ম্যাও, [m̃ɪ̞æ̝͡oʲˠˤ]
It shows a PRAAT illustration of the word ম্যাও which is displayed in the Interval Tier 01: Bangla Text Word 'ম্যাও', and its transcription is in Interval Tier 02: IPA: [mæ͡o]. Point Tier 01: Consonants [m] and Point Tier 02: Vowel: [æ͡o], 24a focuses on [m], which appears at the beginning. It is a pulmonic egressive, bilabial, voiced sound which is of 0.13 seconds, 73 dB, 236 Hz.	Here, [m] appears at the beginning of the word. It's 0.3 seconds, 56 dB, 201 Hz. It shows nasalization and rising tone. The atypical IPA is [m̃ɪ̞æ̝͡oʲˠˤ]. Other features include: nasalized velarized palatalized retracted tongue root position [æ̝͡oʲˠˤ] with rising-falling tone. Note: b [m] = atypical, distortion (nasalization and rising tone)

Data Display 24 (b)

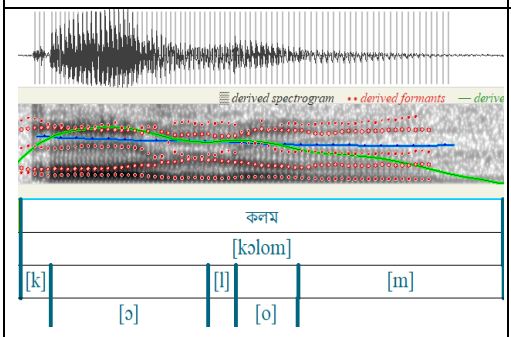
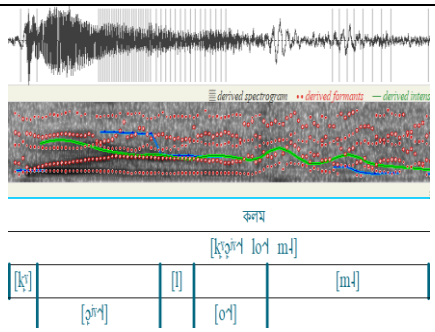
Typical Speech	*Atypical Speech*
	
Figure 90 (a): Oscillogram of মিউ, [mɪ͡u]	Figure 90 (b): Oscillogram of মিউ, [mɪ̞͡ʊˠˤ]
It shows a PRAAT illustration of the word মিউ which is displayed in the Interval Tier 01: Bangla Text Word 'মিউ', and its transcription is in Interval Tier 02: IPA: [mɪ͡u]. Point Tier 01: Consonants [m] and Point Tier 02: Vowel: [ɪ͡u], 24b focuses on	Here, [m] appears at the beginning of the word. It's 0.12 seconds, 68 dB, 205 Hz. It has rising tone. The atypical IPA is [mɪ̞͡ʊˠˤ]. Other features include: retracted tongue root position with velarization and rising-

the sound [m], which appears at the beginning of the word. It is a pulmonic egressive, bilabial, voiced sound which is of 0.12 seconds, 70 dB, 237 Hz.	falling tone for [i͡uˬˊ]. Note: b [m] = atypical, distortion (rising tone)

Data Display 24 (c)

Typical Speech	*Atypical Speech*
	
Figure 91 (a): Oscillogram of থামিয়া, [t̪ʰɐmɪɐ] It shows a PRAAT illustration of the word থামিয়া which is displayed in the Interval Tier 01: Bangla Text Word 'থামিয়া', and its transcription is in Interval Tier 02: IPA: [t̪ʰɐmɪɐ]. Point Tier 01: Consonants [t̪ʰ], [m] and Point Tier 02: Vowel: [ɐ], [ɪɐ], 24c focuses on the sound [m], which appears in the middle of the word. It is a pulmonic egressive, bilabial, voiced sound which is of 0.1 seconds, 72 dB, 239 Hz.	Figure 91 (b): Oscillogram of থামিয়া, [t̪ʰɐmm͡ᵝɪe̞ˈ] Here, [m] appears in the middle of the word. It's 0.08 seconds, 62 dB, 198 Hz. It has double articulation and lips compression. The atypical IPA is [t̪ʰɐmm͡ᵝɪe̞ˈ]. Other features include: palatalized [ɪe̞ˈ] with low tone. Note: m [m] = atypical, distortion (lips compression), addition (double articulation)

Data Display 24 (d)

Typical Speech	*Atypical Speech*
	
Figure 92 (a): Oscillogram of কলম, [kɔlom] It shows a PRAAT illustration of the word কলম which is displayed in the Interval Tier 01: Bangla Text Word 'কলম', and its transcription is in Interval Tier 02: IPA: [kɔlom]. Point Tier 01: Consonants [k], [l], [m] and Point Tier 02: Vowel: [ɔ], [o], 24d focuses on the sound [m], which appears at the end of the word. It is a pulmonic egressive, bilabial, voiced sound which is of 0.2 seconds, 66 dB, 187 Hz.	Figure 92 (b): Oscillogram of কলম, [k̟ʸɔ̟ʲʸˤloˤmɻ] Here, [m] appears at the end of the word. It's 0.3 seconds, 64 dB, 186 Hz. It has low tone. The atypical IPA is [k̟ʸɔ̟ʲʸˤloˤmɻ]. Other features include: retracted tongue root position with velarization [k̟ʸ], retracted tongue root position with velarization and palatalization with rising-falling tone for [ɔ̟ʲʸˤ], rising-falling tone for [oˤ], and low tone for [mɻ]. Note: e [m] = atypical, distortion (low tone)

Data Display 25 (a)

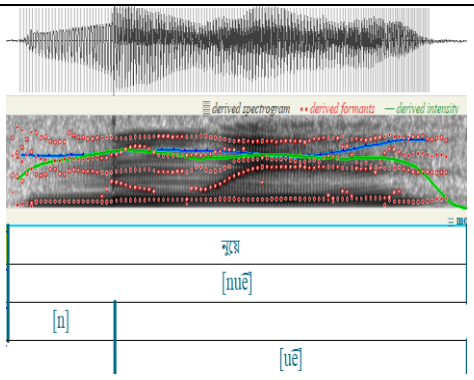
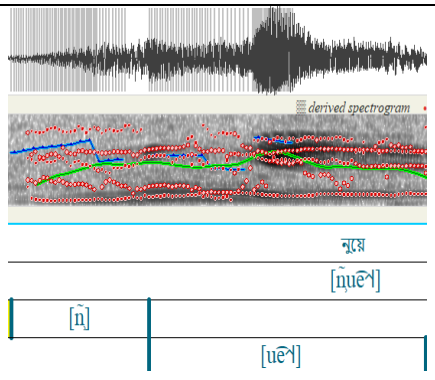
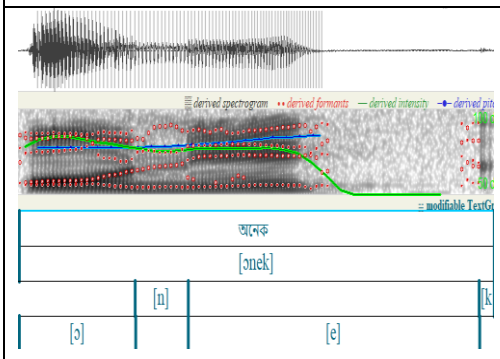
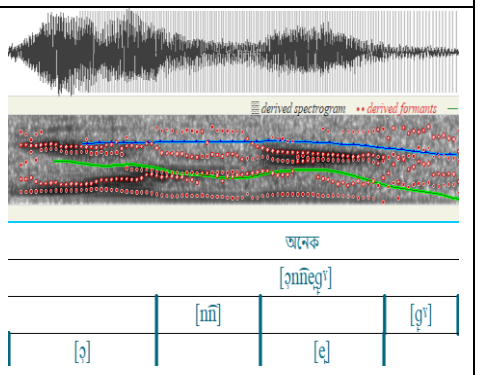
Typical Speech	*Atypical Speech*
	

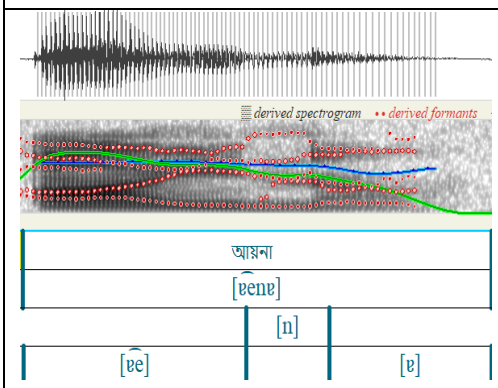
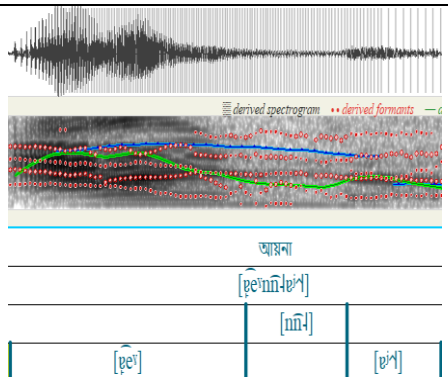
Figure 93 (a): Oscillogram of নুয়ে, [nue͡]	Figure 93 (b): Oscillogram of নুয়ে, [n̪ue͡ˤ]
It shows a PRAAT illustration of the word নুয়ে which is displayed in the Interval Tier 01: Bangla Text Word 'নুয়ে', and its transcription is in Interval Tier 02: IPA: [nue͡]. Point Tier 01: Consonants /n/ and Point Tier 02: Vowel: [ue͡], 25a focuses on the sound [n], which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.14 seconds, 76 dB, 238 Hz.	Here, [n] appears at the beginning of the word. It's 0.2 seconds, 60 dB, 198 Hz. It shows more roundedness and nasalization. The atypical IPA is [n̪ue͡ˤ]. Other features include: rising-falling tone for [ue͡ˤ]. Note: b [n] = atypical, distortion (more roundedness and nasalization)

Data Display 25 (b)

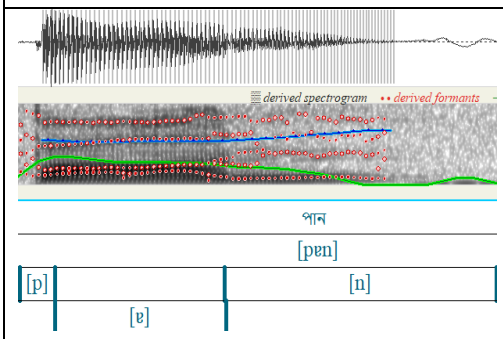
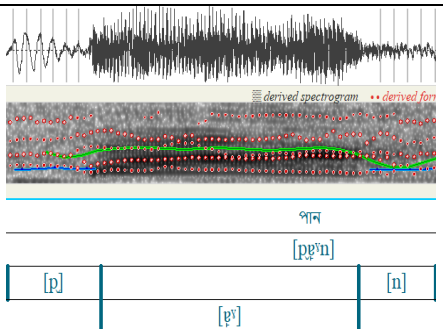
Typical Speech	*Atypical Speech*
	
Figure 94 (a): Oscillogram of অনেক, [ɔnek] It shows a PRAAT illustration of the word অনেক which is displayed in the Interval Tier 01: Bangla Text Word 'অনেক', and its transcription is in Interval Tier 02: IPA: [ɔnek]. Point Tier 01: Consonants [n], [k] and	Figure 94 (b): Oscillogram of অনেক, [ɔ̹nn̪e̪gʸ] Here, [n] appears in the middle of the word. It's 0.1 seconds, 64 dB, 203 Hz. It shows double articulation. The atypical IPA is [ɔ̹nn̪e̪gʸ]. Other features include: more roundedness for [ɔ̹],

Point Tier 02: Vowel: [ɔ], [e], 25b focuses on [n], which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.06 seconds, 75 dB, 235 Hz.	retracted tongue-root position for [e̟], retracted tongue-root position and velarization and substitution for [g̟ˠ]. Note: m [n] = atypical, addition (double articulation)

Data Display 25 (c)

Typical Speech	*Atypical Speech*
	
Figure 95 (a): Oscillogram of আয়না, [ɐ͡enɐ]	Figure 95 (b): Oscillogram of আয়না, [e̟ˠn͡nɭɐʲˤ]
It shows a PRAAT illustration of the word আয়না which is displayed in the Interval Tier 01: Bangla Text Word ‘আয়না’, and its transcription is in Interval Tier 02: IPA: [ɐ͡enɐ]. Point Tier 01: Consonants [n], and Point Tier 02: Vowel: [ɐ], [ɐ͡e], 25c focuses on the sound [n], which appears at the end of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.06 seconds, 75 dB, 235 Hz.	Here, [n] appears at the end of the word. It’s 0.1 seconds, 64 dB, 203 Hz. It double articulation and low tone. The atypical IPA is [e̟ˠn͡nɭɐʲˤ]. Other features include: retracted tongue root position and velarization for [e̟ˠ], palatalization and rising-falling tone for [ɐʲˤ]. Note: e [n] = atypical, distortion (low tone), addition (double articulation)

Data Display 25 (d)

Typical Speech	*Atypical Speech*
	
Figure 96 (a): Oscillogram of পান, [pɐn] It shows a PRAAT illustration of the word পান which is displayed in the Interval Tier 01: Bangla Text Word 'পান', and its transcription is in Interval Tier 02: IPA: [pɐn]. Point Tier 01: Consonants [p], [n], and Point Tier 02: Vowel: [ɐ], 25d focuses on the sound [n], which appears at the end of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.06 seconds, 75 dB, 235 Hz.	Figure 96 (b): Oscillogram of পান, [pp̰ʸn] Here, [n] appears at the end of the word. It's 0.1 seconds, 64 dB, 203 Hz. It has a typical [n] sound. The atypical IPA is [pp̰ʸn]. Other features include: voiced [p̰], velarization and retracted tongue-root position for [p̰ʸ]. Note: e [n] = typical

Data Display 26 (a)

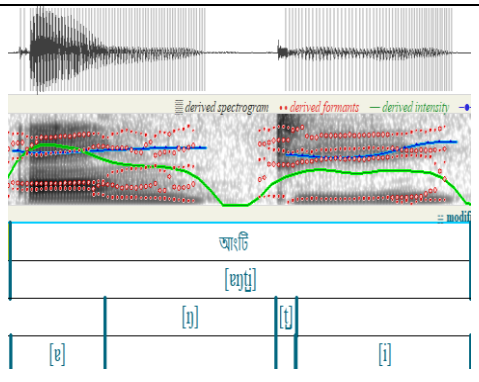
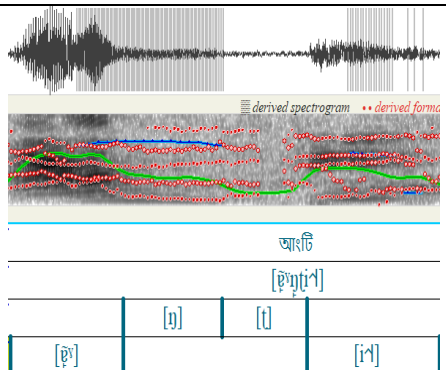
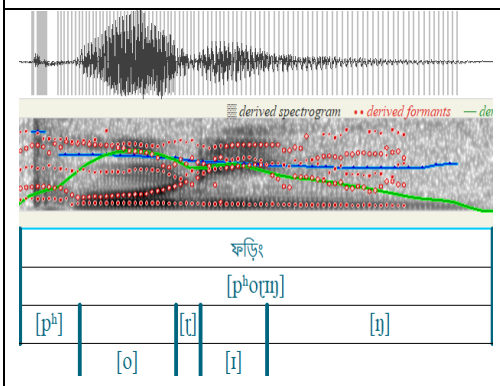
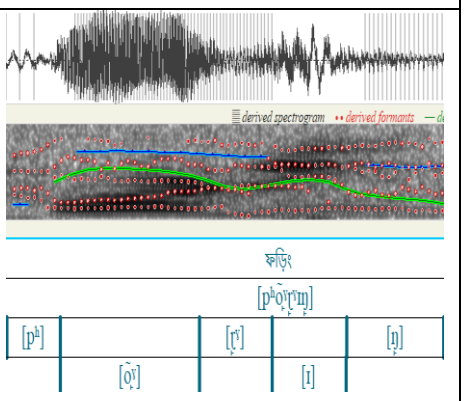
Typical Speech	*Atypical Speech*
	

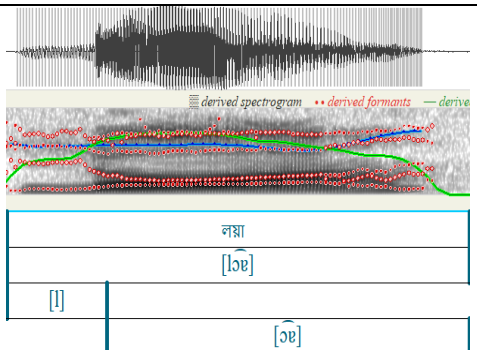
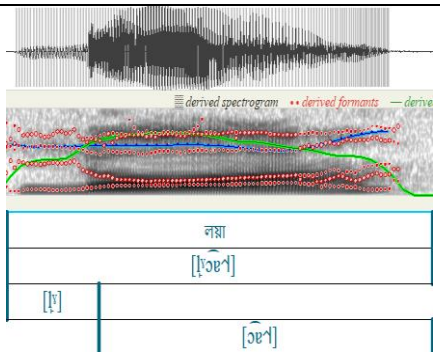
Figure 97 (a): Oscillogram of আংটি, [ɐŋʈi]	Figure 97 (b): Oscillogram of আংটি, [ɐ̃ˠŋ̟ʈiˤˀ]
It shows a PRAAT illustration of the word আংটি which is displayed in the Interval Tier 01: Bangla Text Word ‘আংটি’, and its transcription is in Interval Tier 02: IPA: [ɐŋʈi]. Point Tier 01: Consonants [ŋ], [ʈ] and Point Tier 02: Vowel: [ɐ], [i] 26a focuses on the sound [ŋ], which appears in the middle of the word. It is a pulmonic egressive, velar, voiced sound which is of 0.23 seconds, 68 dB, 283 Hz.	Here, [ŋ] appears in the middle of the word. It’s 0.4 seconds, 61 dB, 209 Hz. It has retracted tongue root position. The atypical IPA is [ɐ̃ˠŋ̟ʈiˤˀ]. Other features include: velarization nasalization and retracted tongue root position for [ɐ̃ˠ], rising-falling for [iˤˀ]. Note: m [ŋ] = atypical, distortion (retracted tongue root position)

Data Display 26 (b)

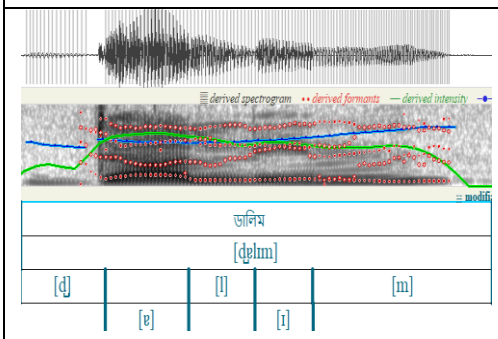
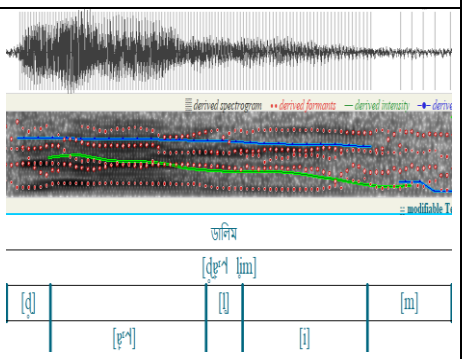
Typical Speech	*Atypical Speech*
	
Figure 98 (a): Oscillogram of ফড়িং, [pʰoɽɪŋ]	Figure 98 (b): Oscillogram of ফড়িং, [pʰõˠɽ̟ˠɪŋ̟]
It shows a PRAAT illustration of the word ফড়িং which is displayed in the Interval Tier 01: Bangla Text Word ‘ফড়িং’, and its transcription is in Interval Tier 02: IPA: [pʰoɽɪŋ]. Point Tier 01: Consonants [pʰ], [ɽ], [ŋ] and	Here, [ŋ] appears at the end of the word. It’s 0.3 seconds, 50 dB, 171 Hz. It has retracted tongue-root position. The atypical IPA is [pʰõˠɽ̟ˠɪŋ̟]. Other features include: nasalization, velarization and

Point Tier 02: Vowel: [o], [ɪ] 26b focuses on the sound [ŋ], which appears at the end of the word. It is a pulmonic egressive, velar, voiced sound which is of 0.25 seconds, 62 dB, 179 Hz.	retracted tongue root position for [õˠ], velarization and retracted tongue root position for [t̪ˠ]. Note: e [ŋ] = atypical, distortion (retracted tongue root position)

Data Display 27 (a)

Typical Speech	*Atypical Speech*
	
Figure 99 (a): Oscillogram of লয়া, [l͡ɔɐ] It shows a PRAAT illustration of the word লয়া which is displayed in the Interval Tier 01: Bangla Text Word 'লয়া', and its transcription is in Interval Tier 02: IPA: [l͡ɔɐ]. Point Tier 01: Consonants [l] and Point Tier 02: Vowel: [ɔ͡ɐ], 27a focuses on the sound [l], which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.13 seconds, 76 dB, 232 Hz.	Figure 99 (b): Oscillogram of লয়া, [l̪ˠɔ͡ɐˠ] Here, [l] appears at the beginning of the word. It's 0.2 seconds, 72 dB, 206 Hz. It has velarization and retracted tongue root position. The atypical IPA is [l̪ˠɔ͡ɐˠ]. Other features include: rising-falling for [ɔ͡ɐˠ]. Note: b [l] = atypical, distortion (velarization and retracted tongue root position)

Data Display 27 (b)

Typical Speech	*Atypical Speech*
	
Figure 100 (a): Oscillogram of ডালিম, [ɖɐlɪm]	Figure 100 (b): Oscillogram of ডালিম, [ɖ̟ɐ̟ˠˤl̪i̪m]
It shows a PRAAT illustration of the word ডালিম which is displayed in the Interval Tier 01: Bangla Text Word 'ডালিম', and its transcription is in Interval Tier 02: IPA: [ɖɐlɪm]. Point Tier 01: Consonants [ɖ], [l], [m] and Point Tier 02: Vowel: [ɐ], [ɪ], 27b focuses on the sound [l], which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.08 seconds, 77 dB, 222 Hz.	Here, [l] appears in the middle of the word. It's 0.12 seconds, 63 dB, 187 Hz. It shows voicelessness. The atypical IPA is [ɖ̟ɐ̟ˠˤl̪i̪m]. Other features include: velarization and retracted tongue root position for [ɐ̟ˠˤ] with rising-falling tone. Note: m [l] = atypical, distortion (voicelessness)

Data Display 27 (c)

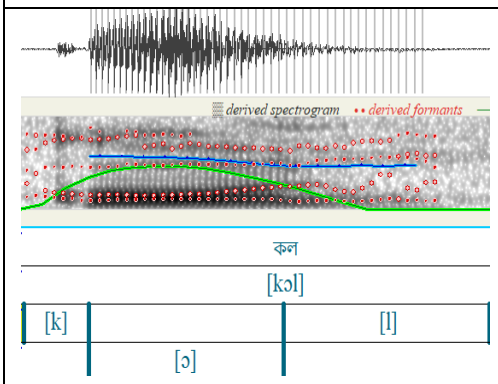
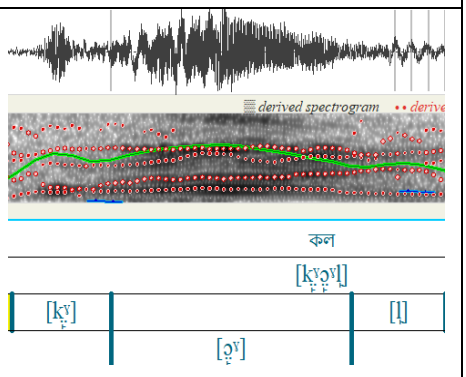
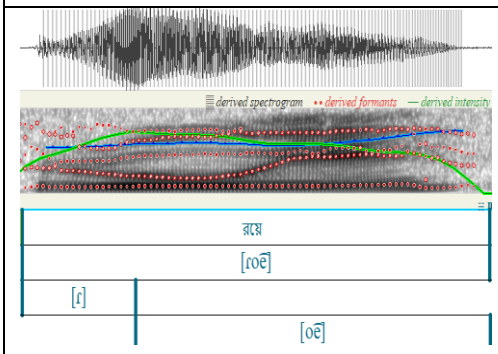
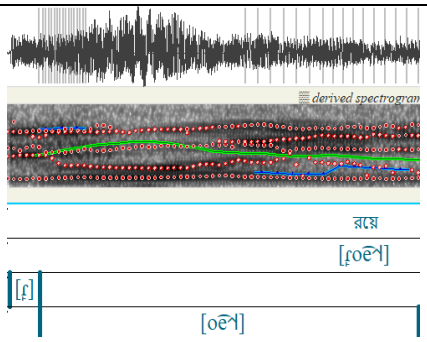
Typical Speech	*Atypical Speech*
	

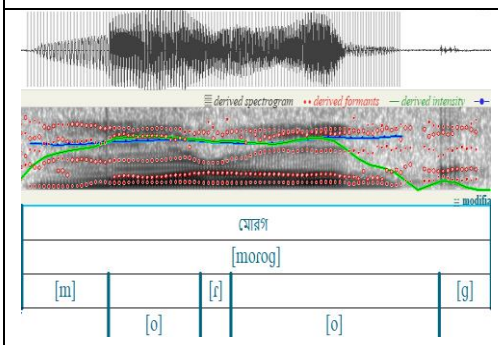
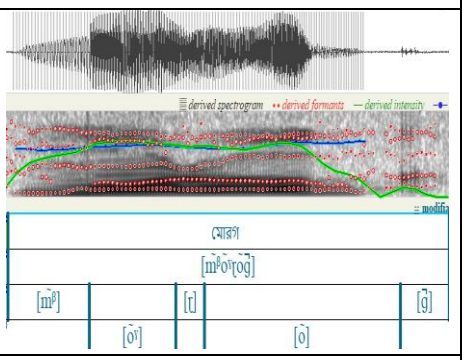
Figure 101 (a): Oscillogram of কল, [kɔl]	Figure 101 (b): Oscillogram of কল, [k̟ˠɰ̟ˠl̪]
It shows a PRAAT illustration of the word কল which is displayed in the Interval Tier 01: Bangla Text Word ‘কল’, and its transcription is in Interval Tier 02: IPA: [kɔl]. Point Tier 01: Consonants [k], [l] and Point Tier 02: Vowel: [ɔ], 27c focuses on [l], which appears at the end of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.08 seconds, 77 dB, 222 Hz.	Here, [l] appears at the end of the word. It’s 0.12 seconds, 63 dB, 187 Hz. It has creaky voice, retracted tongue root position and velarization. The atypical IPA is [k̟ˠɰ̟ˠl̪]. Other features include: retracted tongue root position, creaky voice, and velarization for [ɰ̟ˠ], and retracted tongue root position for [l̪]. Note: e [l] = atypical, distortion (creaky voice, retracted tongue root position and velarization)

Data Display 28 (a)

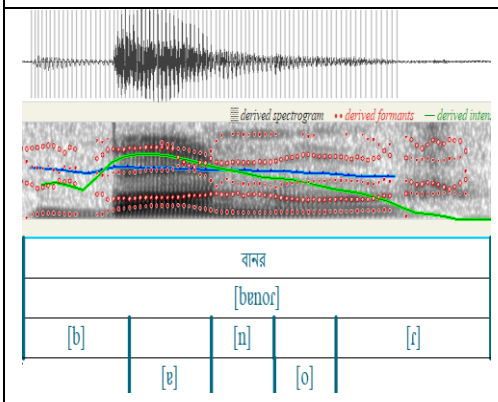
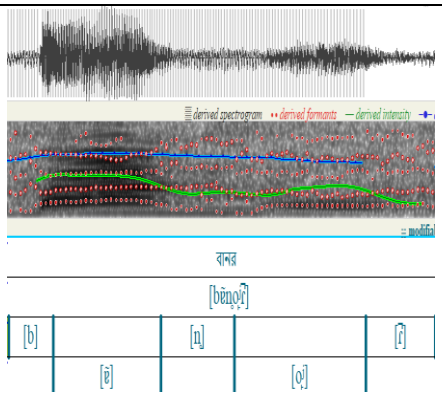
Typical Speech	*Atypical Speech*
	
Figure 102 (a): Oscillogram of রয়ে, [ɾo͡e]	Figure 102 (b): Oscillogram of রয়ে, [ɾo͡eˤ]
It shows a PRAAT illustration of the word রয়ে which is displayed in the Interval Tier 01: Bangla Text Word ‘রয়ে’, and its transcription is in Interval Tier 02: IPA: [ɾo͡e]. Point Tier 01: Consonants [ɾ] and Point	Here, [ɾ] appears at the beginning of the word. It’s 0.3 seconds, 65 dB, 191 Hz. It has retracted tongue root position. The atypical IPA is [ɾo͡eˤ]. Other features include: rising-falling for [o͡eˤ].

Tier 02: Vowel: [o͡e], 28a focuses on the sound [ɾ], which appears at the beginning of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiced sound which is of 0.12 seconds, 77 dB, 225 Hz.	Note: b [ɾ] = atypical, distortion (retracted tongue root position)

Data Display 28 (b)

Typical Speech	*Atypical Speech*
	
Figure 103 (a): Oscillogram of মোরগ, [moɾog]	Figure 103 (b): Oscillogram of মোরগ, [m̃ᵝõʸɽõg̃]
It shows a PRAAT illustration of the word মোরগ which is displayed in the Interval Tier 01: Bangla Text Word 'মোরগ', and its transcription is in Interval Tier 02: IPA: [moɾog], Point Tier 01: Consonants [m], [ɾ], [g] and Point Tier 02: Vowel: [o], 28b focuses on [ɾ], which appears in the middle of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiced sound which is of 0.04 seconds, 78 dB, 245 Hz.	Here, [ɾ] appears in the middle of the word. It's 0.3 seconds. It has substitution with [ɽ]. The atypical IPA is [m̃ᵝõʸɽõg̃]. Other features include: nasalized and compressed lips for [m̃ᵝ], nasalized and velarized [õʸ], nasalized [õ], no audible release of [g̃]. Note: m [ɾ] = atypical, substitution (substitution with [ɽ])

Data Display 28 (c)

Typical Speech	*Atypical Speech*
	
Figure 104 (a): Oscillogram of বানর, [bɐnoɾ]	Figure 104 (b): Oscillogram of বানর, [bɐ̃n̥o˞ɾ̃]
It shows a PRAAT illustration of the word বানর which is displayed in the Interval Tier 01: Bangla Text Word 'বানর', and its transcription is in Interval Tier 02: IPA: [bɐnoɾ], Point Tier 01: Consonants [b], [n], [ɾ] and Point Tier 02: Vowel: [ɐ], [o], 28c focuses on [ɾ], which appears at the end. It is pulmonic egressive, post-alveolar or palato-alveolar, voiced, 0.18 seconds, 60 dB, 167 Hz.	Here, [ɾ] appears at the end of the word. It's 0.2 seconds. It has no audible release. The atypical IPA is [bɐ̃n̥o˞ɾ̃]. Other features include: nasalized [ɐ̃], voiceless [n̥], palatalized retracted tongue root position for [o˞ʲ]. Note: e [ɾ] = atypical, omission (no audible release)

Data Display 29 (a)

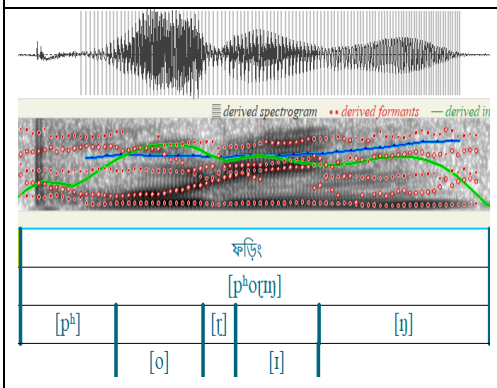
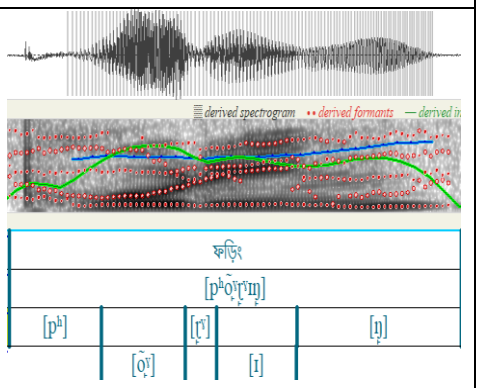
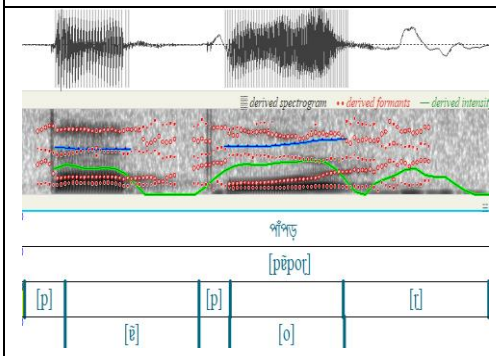
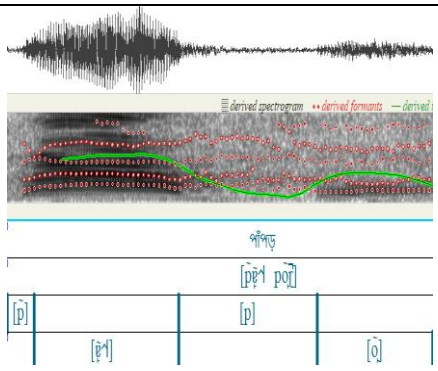
Typical Speech	*Atypical Speech*
	

Figure 105 (a): Oscillogram of ফড়িং, [pʰoɽɪŋ] It shows a PRAAT illustration of the word ফড়িং which is displayed in the Interval Tier 01: Bangla Text Word ‘ফড়িং’, and its transcription is in Interval Tier 02: IPA: [pʰoɽɪŋ]. Point Tier 01: Consonants [pʰ], [ɽ], [ŋ] and Point Tier 02: Vowel: [o], [ɪ] 29a focuses on [ɽ], appears in the middle, pulmonic egressive, velar, voiced, 0.03 seconds, 77 dB, 244 Hz.	Figure 105 (b): Oscillogram of ফড়িং, [pʰõˠɽ̞ˠɪŋ̞] Here, [ɽ] appears in the middle of the word. It’s 0.3 seconds, 50 dB, 171 Hz. It has velarization and retracted tongue root position for [ɽ̞ˠ]. The atypical IPA is [pʰõˠɽ̞ˠɪŋ̞]. Other features include: nasalization, velarization and retracted tongue root position for [õˠ], retracted tongue root position for [ŋ̞]. Note: m [ɽ] = atypical, distortion (velarization and retracted tongue root position for [ɽ̞ˠ])

Data Display 29 (b)

Typical Speech	*Atypical Speech*
	
Figure 106 (a): Oscillogram of পাঁপড়, [pɐ̃poɽ] It shows a PRAAT illustration of the word পাঁপড় which is displayed in the Interval Tier 01: Bangla Text Word ‘পাঁপড়’, and its transcription is in Interval Tier 02: IPA: [pɐ̃poɽ]. Point	Figure 106 (b): Oscillogram of পাঁপড়, [p̃ɐ̞ˠpo̞ɽ̞] Here, [ɽ] appears at the end of the word. It’s 0.08 seconds. It has no audible release. The atypical IPA is [p̃ɐ̞ˠpo̞ɽ̞]. Other features include: nasalized [p̃], nasalized retracted tongue root position

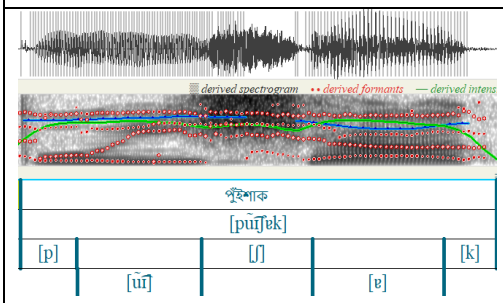
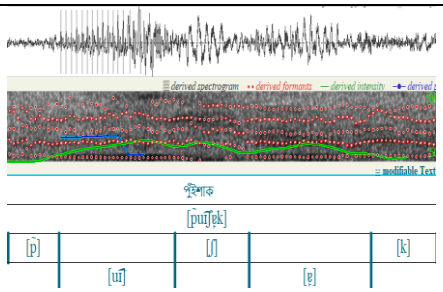
Tier 01: Consonants [p], [p], [ɾ] and Point Tier 02: Vowel: [ɐ̃], [o] 29b focuses on [ɾ], appears at the end, pulmonic egressive, velar, voiced, 0.03 seconds, 77 dB, 244 Hz.	with rising-falling for [ɐ̟̃˥˩], nasalized retracted tongue root position for [õ̟]. Note: e [ɾ] = atypical, omission (no audible release)

Patient Sl No. 01 (Spasmodic)

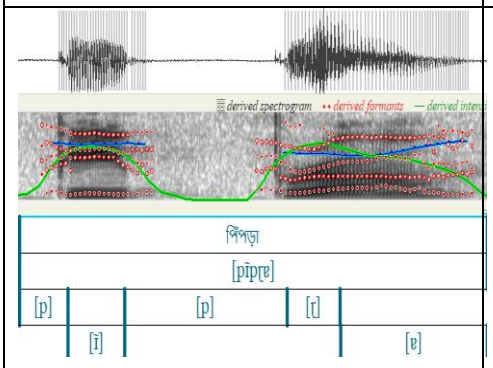
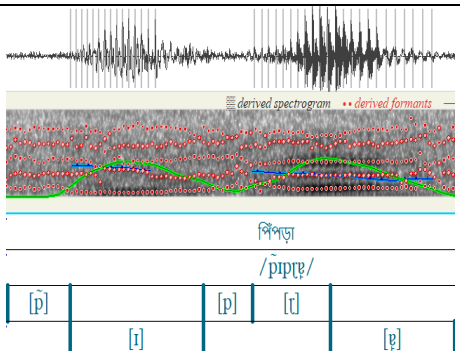
General Information and Diagnosis	***Name:*** *Kamal Uddin*	***Age:*** *55*	***Sex:*** *Male*
Present Day *2025* *Non-recurring*	Patient experienced gradual progression of headache on the right side aggravated during coughing, vomiting, eye pain, vertigo and has been diagnosed with glioblastoma at right temporo-parieto-occipital lobe ICSOL, perilesional edema, mass effect with midline displacement. ***On Nervous System Examination*** (received info) GCS (E4V5M6) The V (verbal response) score: patient is oriented, able to speak on command and coherently, content is intact Cranial Nerves V, VII, IX, X, XII are crucial for speech, voice, swallowing: no swallowing difficulties, voice and speech are on command (speech data to be analyzed) Motor System (UL, LL, Reflexes, Plantar, Clonus): reflects motor pathways, UMN lesions can also involve corticobulbar tracts leading to slurred speech or even Aphasia if lesion is cortical and left-sided (speech data to be analyzed)		

Figure 107: General Information of Patient 01

Data Display 1 (a)

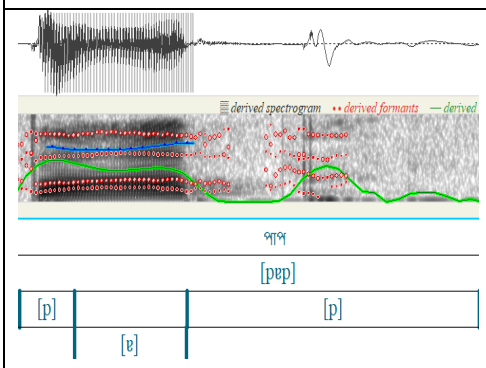
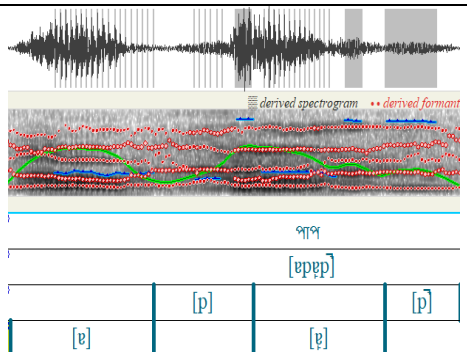
Typical Speech	*Atypical Speech*
	
Figure 108 (a): Oscillogram of পুঁইশাক, [pũĩʃɐk]	Figure 108 (b): Oscillogram of পুঁইশাক, [p̃uĩʃɐ̟k]
It shows a PRAAT illustration of the word পুঁইশাক which is displayed in the Interval Tier 01: Bangla Text Word 'পুঁইশাক', and its transcription is in Interval Tier 02: IPA: [pũĩʃɐk], Point Tier 01: Consonants [p], [ʃ], [k] and Point Tier 02: Vowel: [ɐ] 1a focuses on the sound, [p] which appears at the beginning of the word. It is a pulmonic egressive, bilabial, voiceless sound which is of 0.07 seconds, 79 dB, 293 Hz.	Here, [p] appears at the beginning of the word. It's 0.16 seconds, 67 dB, 222 Hz. It is a typical [p] sound. The atypical IPA is [p̃uĩʃɐ̟k]. The other features include: retracted tongue root position for [ɐ̟], as in, distortion. Note: b [p] = typical

Data Display 1 (b)

Typical Speech	*Atypical Speech*
	
Figure 109 (a): Oscillogram of	Figure 109 (b): Oscillogram of

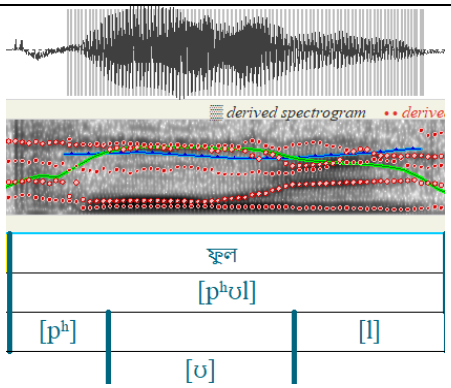
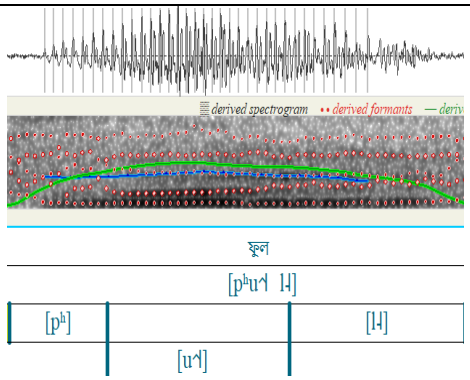
পিঁপড়া, [pĩpɽɐ]	পিঁপড়া, [p̃ɪpɽɐ̟]
It shows a PRAAT illustration of the word পিঁপড়া which is displayed in the Interval Tier 01: Bangla Text Word 'পিঁপড়া', and its transcription is in Interval Tier 02: IPA: [pĩpɽɐ], Point Tier 01: Consonants [p], [p], [ɽ] and Point Tier 02: Vowel: [ĩ], [ɐ] 1b focuses on the sound, [p] which appears in the middle of the word. It is a pulmonic egressive, bilabial, voiceless sound which is of 0.2 seconds, 90 dB, 150 Hz.	Here, [p] appears in the middle of the word. It's 0.04 seconds, 63 dB, 230 Hz. It is a typical [p] sound. The atypical IPA is [p̃ɪpɽɐ̟]. The other features include: retracted tongue root position for [ɐ̟]. Note: m [p] = typical

Data Display 1 (c)

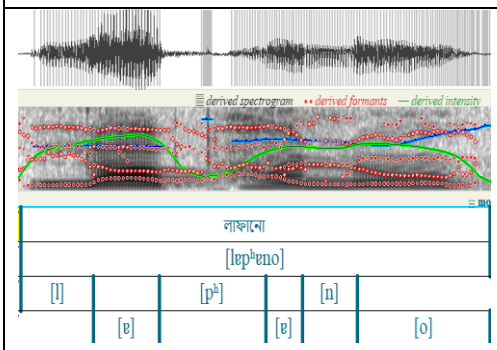
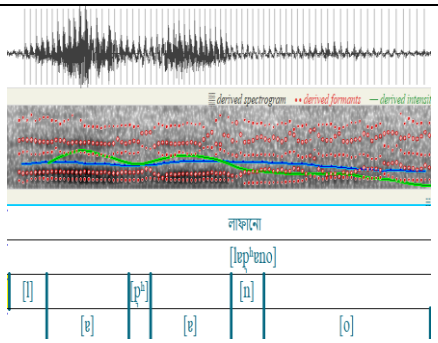
Typical Speech	*Atypical Speech*
	
Figure 110 (a): Oscillogram of পাপ, [pɐp] It shows a PRAAT illustration of the word পাপ which is displayed in the Interval Tier 01: Bangla Text Word 'পাপ', and its transcription is in Interval Tier 02: IPA: [pɐp], Point Tier 01: Consonants [p], [p]	Figure 110 (b): Oscillogram of পাপ, [ɐp̟p̄] Here, [p] appears at the end of the word. It's 0.04 seconds, 63 dB, 230 Hz. It has no audible release. The atypical IPA is [ɐp̟p̄]. Other features include: retracted tongue root position for [ɐ̟], also addition of another [ɐ] at the beginning.

and Point Tier 02: Vowel: [ɐ] 1c focuses on the sound, [p] which appears at the end of the word. It is a pulmonic egressive, bilabial, voiceless sound which is of 0.07 seconds, 80 dB, 258 Hz.	Note: e [p] = atypical, omission (no audible release)

Data Display 2 (a)

Typical Speech	*Atypical Speech*
	
Figure 111 (a): Oscillogram of ফুল, [pʰul] It shows a PRAAT illustration of the word ফুল which is displayed in the Interval Tier 01: Bangla Text Word 'ফুল', and its transcription is in Interval Tier 02: IPA: [pʰul], Point Tier 01: Consonants [pʰ], [l] and Point Tier 02: Vowel: [u] 2a focuses on the sound, [pʰ] which appears at the beginning of the word. It is a pulmonic egressive, bilabial, voiceless sound which is of 0.09 seconds, 76 dB, 293 Hz.	Figure 111 (b): Oscillogram of ফুল, [pʰuˤlɬ] Here, [pʰ] appears at the beginning of the word. It's 0.19 seconds, 57 dB, 226 Hz. It shows typical [pʰ] sound. The atypical IPA is [pʰuˤlɬ]. Other features include: rising-falling of the [uˤ] and low tone for [lɬ]. Note: b [pʰ] = typical

Data Display 2 (b)

Typical Speech	*Atypical Speech*
	
Figure 112 (a): Oscillogram of লাফানো, [lɐpʰɐno]	Figure 112 (b): Oscillogram of লাফানো, [lɐp̣ʰɐno]
It shows a PRAAT illustration of the word লাফানো which is displayed in the Interval Tier 01: Bangla Text Word 'লাফানো', and its transcription is in Interval Tier 02: IPA: [lɐpʰɐno], Point Tier 01: Consonants [l], [pʰ], [n] and Point Tier 02: Vowel: [ɐ], [o] 2b focuses on the sound, [pʰ] which appears in the middle of the word. It is a pulmonic egressive, bilabial, voiceless sound which is of 0.16 seconds, 58 dB, 299 Hz.	Here, [pʰ] appears in the middle of the word. It's 0.2 seconds, 50 dB, 209 Hz. It shows weak articulation. The atypical IPA is [lɐp̣ʰɐno]. No other features present. Note: b [pʰ] = atypical, distortion (weak articulation)

Data Display 2 (c)

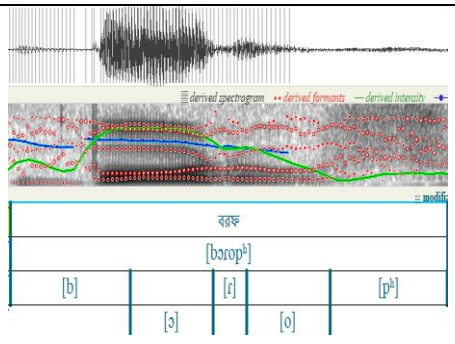
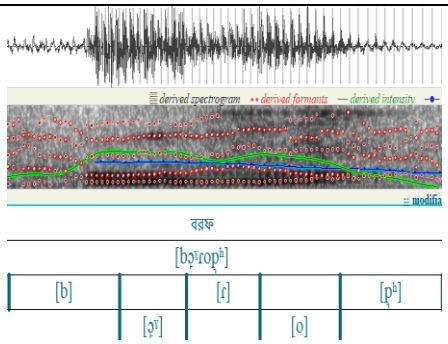
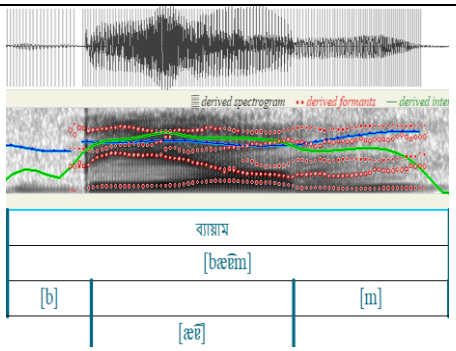
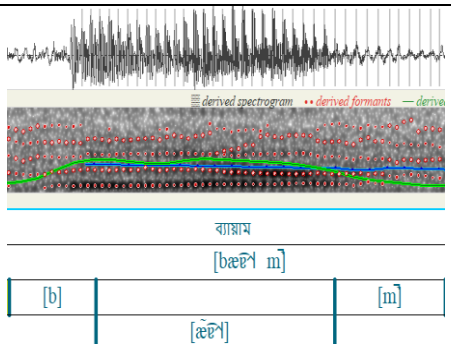
Typical Speech	*Atypical Speech*
	

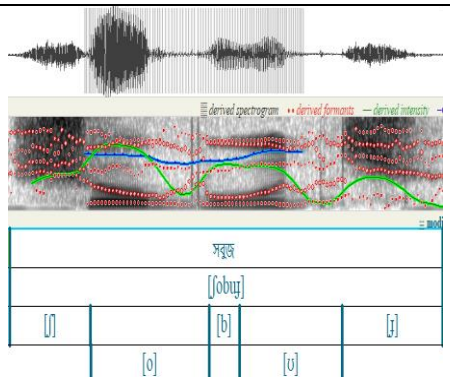
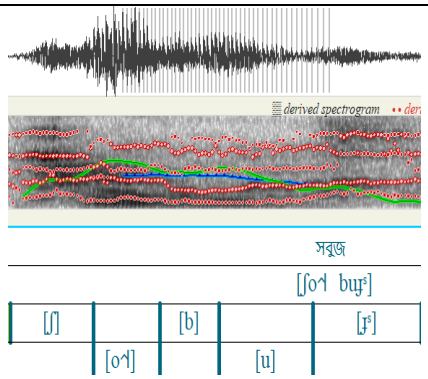
Figure 113 (a): Oscillogram of বরফ, [bɔɾopʰ] It shows a PRAAT illustration of the word বরফ which is displayed in the Interval Tier 01: Bangla Text Word 'বরফ', and its transcription is in Interval Tier 02: IPA: [bɔɾopʰ], Point Tier 01: Consonants [b], [ɾ], [pʰ] and Point Tier 02: Vowel: [ɔ], [o] 2c focuses on the sound, [pʰ] which appears at the end of the word. It is a pulmonic egressive, bilabial, voiceless sound which is of 0.16 seconds, 67 dB, 182 Hz.	Figure 113 (b): Oscillogram of বরফ, [bɔ̟ˠɾop̚ʰ] Here, [pʰ] appears at the end of the word. It's 0.32 seconds, 50 dB, 160 Hz. It shows weak articulation. The atypical IPA is [bɔ̟ˠɾop̚ʰ]. Other features include: , double articulation of retracted tongue position and velarization of [ɔ̟ˠ]. Note: e [pʰ] = atypical, distortion (weak articulation)

Data Display 3 (a)

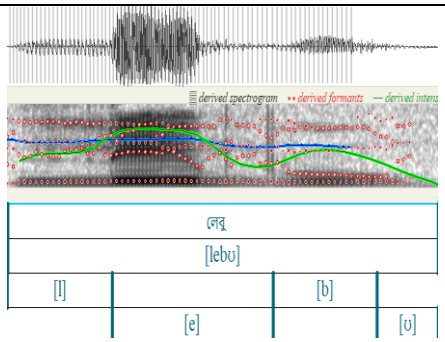
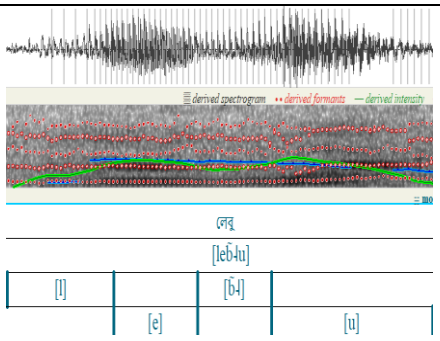
Typical Speech	*Atypical Speech*
	
Figure 114 (a): Oscillogram of ব্যায়াম, [bæ̃m] It shows a PRAAT illustration of the word ব্যায়াম which is displayed in the Interval Tier 01: Bangla Text Word 'ব্যায়াম', and its transcription is in Interval Tier 02: IPA: [bæ̃m], Point Tier 01: Consonants [b], [m]	Figure 114 (b): Oscillogram of ব্যায়াম, [bæ̃ˠm̃] Here, [b] appears at the beginning of the word. It's 0.23 seconds, 50 dB, 169 Hz. It is a typical [b] sound. The atypical IPA is [bæ̃ˠm̃]. Other features include: nasalization and rising-falling for [æ̃ˠ] and no audible release of

and Point Tier 02: Vowel: [æʊ̯] 3a focuses on the sound, [b] which appears at the beginning of the word. It is a pulmonic egressive, bilabial, voiced sound which is of 0.12 seconds, 62 dB, 197 Hz.	[m̄]. Note: b [b] = typical

Data Display 3 (b)

Typical Speech	*Atypical Speech*
	
Figure 115 (a): Oscillogram of সবুজ, [ʃobuɟ]	Figure 115 (b): Oscillogram of সবুজ, [ʃo৲buɟˢ]
It shows a PRAAT illustration of the word সবুজ which is displayed in the Interval Tier 01: Bangla Text Word 'সবুজ', and its transcription is in Interval Tier 02: IPA: [ʃobuɟ], Point Tier 01: Consonants [ʃ], [b], [ɟ] and Point Tier 02: Vowel: [o], [u] 3b focuses on the sound, [b] which appears in the middle of the word. It is a pulmonic egressive, bilabial, voiced sound which is of 0.05 seconds, 74 dB, 217 Hz.	Here, [b] appears in the middle of the word. It's 0.11 seconds, 67 dB, 194 Hz. It is a typical [b] sound. The atypical IPA is [ʃo৲buɟs]. Other features include: rising-falling of the [o৲] and fricative release with [ɟˢ]. Note: m [b] = typical

Data Display 3 (c)

Typical Speech	*Atypical Speech*
	
Figure 116 (a): Oscillogram of লেবু, [lebu]	Figure 116 (b): Oscillogram of লেবু, [leb̃ɻu]
It shows a PRAAT illustration of the word লেবু which is displayed in the Interval Tier 01: Bangla Text Word 'লেবু', and its transcription is in Interval Tier 02: IPA: [lebu], Point Tier 01: Consonants [l], [b] and Point Tier 02: Vowel: [e], [u] 3c focuses on the sound, [b] which appears at the end of the word. It is a pulmonic egressive, bilabial, voiced sound which is of 0.11 seconds, 70 dB, 198 Hz.	Here, [b] appears at the end of the word. It's 0.08 seconds, 50 dB, 183 Hz. It shows nasalization and low tone. The atypical IPA is [leb̃ɻu]. No other features present. Note: e [b] = atypical, distortion (nasalization and low tone)

Data Display 4 (a)

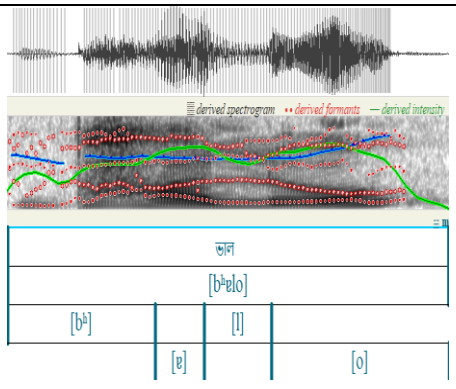
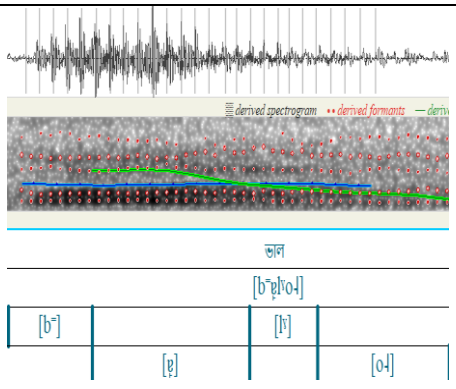
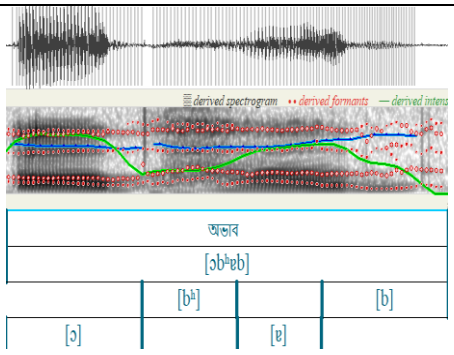
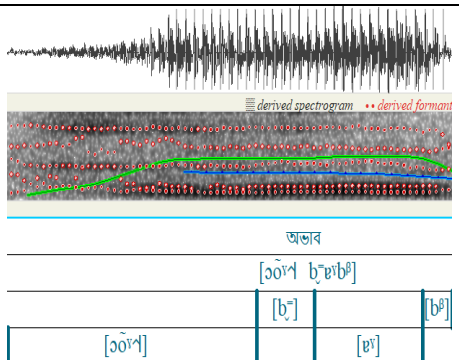
Typical Speech	*Atypical Speech*
	

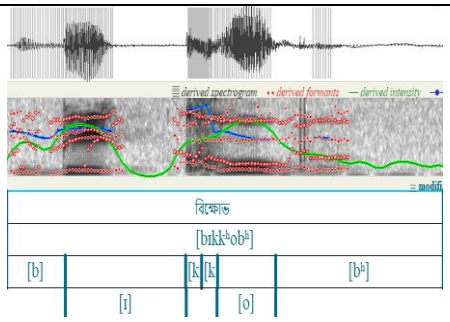
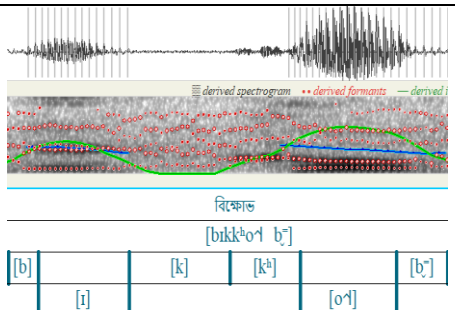
Figure 117 (a): Oscillogram of ভাল, [bʱɐlo] It shows a PRAAT illustration of the word ভাল which is displayed in the Interval Tier 01: Bangla Text Word ‘ভাল’, and its transcription is in Interval Tier 02: IPA: [bʱɐlo]. Point Tier 01: Consonants [bʱ], [l] and Point Tier 02: Vowel: [ɐ], [o] 4a focuses on the sound, [bʱ] which appears at the beginning of the word. It is a pulmonic egressive, bilabial, voiced sound which is of 0.21 seconds, 70 dB, 239 Hz.	Figure 117 (b): Oscillogram of ভাল, [b̪̈ɻlʸo˩] Here, [bʱ] appears at the beginning of the word. It’s 0.21 seconds, 50 dB, 189 Hz. It is an unaspirated sound. The atypical IPA is [b̪̈ɻlʸo˩]. Other features include: retracted tongue root position of [ɻ], velarization with [lʸ], and low tone with [o˩]. Note: b [bʱ] = atypical, distortion (unaspirated), also could be noted as omission

Data Display 4 (b)

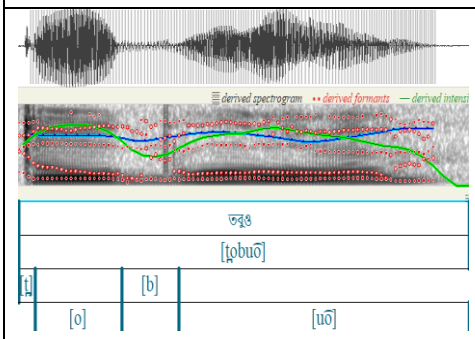
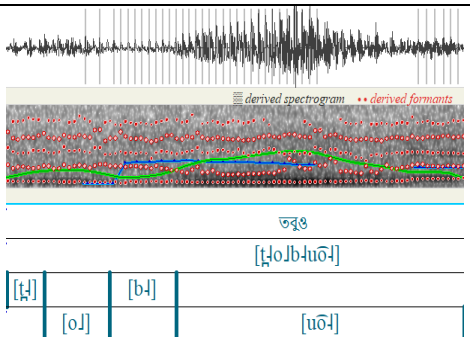
Typical Speech	*Atypical Speech*
	
Figure 118 (a): Oscillogram of অভাব, [ɔbʱɐb] It shows a PRAAT illustration of the word অভাব which is displayed in the Interval Tier 01: Bangla Text Word ‘অভাব’, and its transcription is in Interval Tier 02: IPA: [ɔbʱɐb]. Point Tier 01: Consonants [bʱ], [b]	Figure 118 (b): Oscillogram of অভাব, [ɔõʸˤ˥b̪̈̆ɐʸbᵝ] Here, [bʱ] appears in the middle of the word. It’s 0.3 seconds, 52 dB, 176 Hz. It shows unaspirated voicing. The atypical IPA is [ɔõʸˤ˥b̪̈̆ɐʸbᵝ]. Other features include: nasalization, velarization, and rising-falling with [õʸˤ˥],

and Point Tier 02: Vowel: [ɔ], [ɐ] 4b focuses on the sound, [bʱ] which appears in the middle of the word. It is a pulmonic egressive, bilabial, voiced sound which is of 0.12 seconds, 67 dB, 206 Hz.	velarization with [ɐˠ], lip compression with [bᵝ]. Note: m [bʱ] = atypical, distortion (unaspirated voicing), also could be noted as omission due to unaspiration

Data Display 4 (c)

Typical Speech	*Atypical Speech*
	
Figure 119 (a): Oscillogram of বিক্ষোভ, [bɪkkʰobʱ]	Figure 119 (b): Oscillogram of বিক্ষোভ, [bɪkkʰoˤb˭˭ˉ]
It shows a PRAAT illustration of the word বিক্ষোভ which is displayed in the Interval Tier 01: Bangla Text Word ‘বিক্ষোভ’, and its transcription is in Interval Tier 02: IPA: [bɪkkʰobʱ]. Point Tier 01: Consonants [b], [k], [kʰ], [bʱ] and Point Tier 02: Vowel: [ɪ], [o] 4c focuses on the sound, [bʱ] which appears at the end of the word. It is a pulmonic egressive, bilabial, voiced sound which is of 0.34 seconds, 67 dB, 194 Hz.	Here, [bʱ] appears at the end of the word. It’s 0.23 seconds, 50 dB, 164 Hz. It has unaspirated voicing. The atypical IPA is [bɪkkʰoˤb˭˭ˉ]. Other features include rising-falling with [oˤ]. Note: e [bʱ] = atypical, distortion (unaspirated voicing), also could be noted as omission due to unaspiration

Data Display 5 (a)

Typical Speech	*Atypical Speech*
	
Figure 120 (a): Oscillogram of তবুও, [t̪obuo͡]	Figure 120 (b): Oscillogram of তবুও, [t̪ɬo˩bɬuo͡ɬ]
It shows a PRAAT illustration of the word তবুও which is displayed in the Interval Tier 01: Bangla Text Word 'তবুও', and its transcription is in Interval Tier 02: IPA: [t̪obuo͡] Point Tier 01: Consonants [t̪], [b] and Point Tier 02: Vowel: [o], [uo͡], 5a focuses on the sound, [t̪] which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.08 seconds, 80 dB, 278 Hz.	Here, [t̪] appears at the beginning of the word. It's 0.09 seconds, 60 dB, 384 Hz. It is low tone. The atypical IPA is [t̪ɬo˩bɬuo͡ɬ]. Other features include: extra-low tone with [o˩], low toned [bɬ] and [uo͡ɬ]. Note: b [t̪] = atypical, distortion (low tone)

Data Display 5 (b)

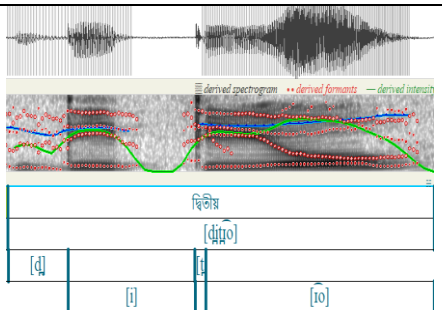
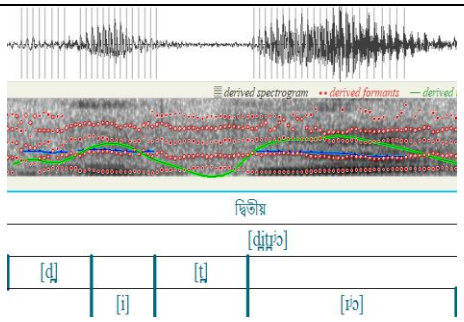
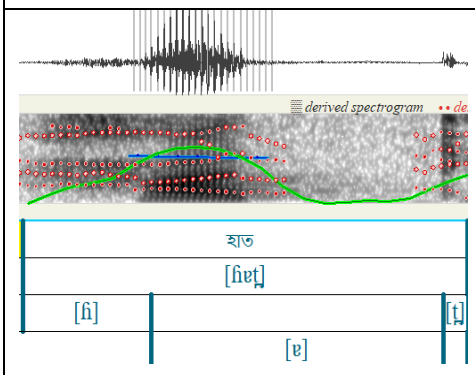
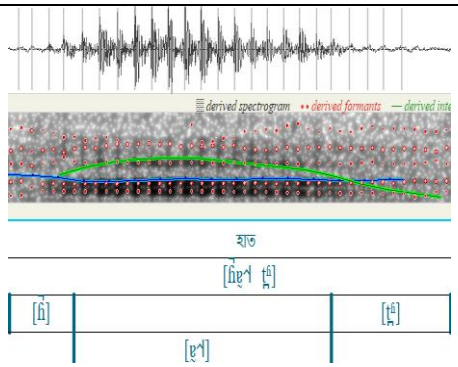
Typical Speech	*Atypical Speech*
	

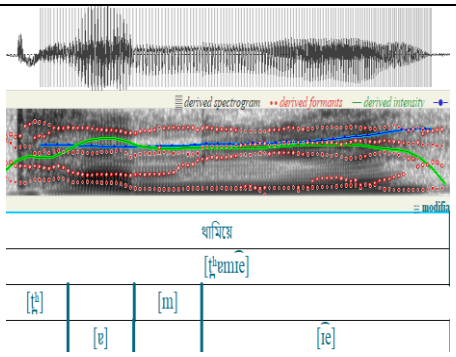
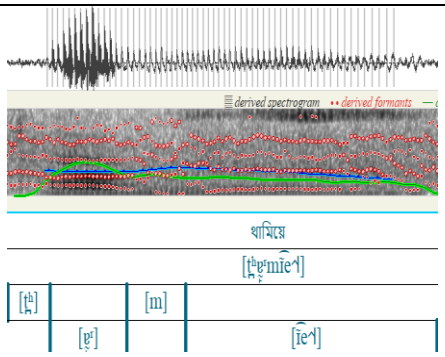
Figure 121 (a): Oscillogram of দ্বিতীয়, [d̪ɪt̪ɪo͡]	Figure 121 (b): Oscillogram of দ্বিতীয়, [d̪ɪt̪ʲɔ]
It shows a PRAAT illustration of the word দ্বিতীয় which is displayed in the Interval Tier 01: Bangla Text Word 'দ্বিতীয়', and its transcription is in Interval Tier 02: IPA: [d̪ɪt̪ɪo͡] Point Tier 01: Consonants [d̪], [t̪] and Point Tier 02: Vowel: [i], [ɪo͡], 5b focuses on the sound, [t̪] which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.39 seconds, 79 dB, 274 Hz.	Here, [t̪] appears in the middle of the word. It's 0.22 seconds, 50 dB, 185 Hz. It is a typical sound. The atypical IPA is [d̪ɪt̪ʲɔ]. Other features include: palatalized [ʲ]. Note: m [t̪] = typical

Data Display 5 (c)

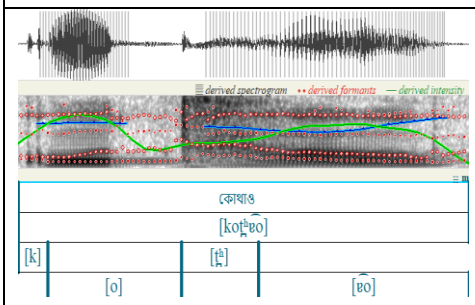
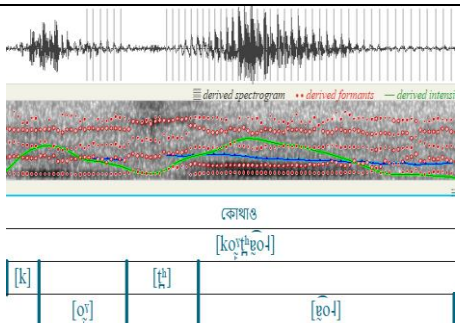
Typical Speech	*Atypical Speech*
	
Figure 122 (a): Oscillogram of হাত, [ɦɐt̪]	Figure 122 (b): Oscillogram of হাত, [ɦ̰ɐ̰ˀt̪ʰ]
It shows a PRAAT illustration of the word হাত which is displayed in the Interval Tier 01: Bangla Text Word 'হাত', and its transcription is in Interval Tier 02: IPA: [ɦɐt̪]	Here, [t̪] appears at the end of the word. It's 0.22 seconds, 50 dB, 285 Hz. It has breathy-voice. The atypical IPA is [ɦ̰ɐ̰ˀt̪ʰ]. Other features include: no audible release

Point Tier 01: Consonants [ɦ], [t̪] and Point Tier 02: Vowel: [ɐ], 5c focuses on the sound, [t̪] which appears at the end of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.39 seconds, 79 dB, 274 Hz.	of [ɦ̀], rising-falling with [ɐ̯ˤ]. Note: e [t̪] = atypical, distortion (breathy-voice)

Data Display 6 (a)

Typical Speech	*Atypical Speech*
	
Figure 123 (a): Oscillogram of থামিয়ে, [t̪ʰɐmɪe͡]	Figure 123 (b): Oscillogram of থামিয়ে, [t̪ʰɐ̯ʳmĩe͡ˤ]
It shows a PRAAT illustration of the word থামিয়ে which is displayed in the Interval Tier 01: Bangla Text Word 'থামিয়ে', and its transcription is in Interval Tier 02: IPA: [t̪ʰɐmɪe͡] Point Tier 01: Consonants [t̪ʰ], [m] and Point Tier 02: Vowel: [ɐ], [ɪe͡], 6a focuses on the sound, [t̪ʰ] which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.08 seconds, 71 dB, 246 Hz.	Here, [t̪ʰ] appears at the beginning of the word. It's 0.13 seconds, 55 dB, 185 Hz. It is a typical [t̪ʰ] sound. The atypical IPA is [t̪ʰɐ̯ʳmĩe͡ˤ]. Other features include: creaky-voice, rhotic sound and retracted tongue root position with [ɐ̯ʳ], nasalization and rising-falling with [ĩe͡ˤ]. Note: b [t̪ʰ] = typical

Data Display 6 (b)

Typical Speech	*Atypical Speech*
	
Figure 124 (a): Oscillogram of কোথাও, [kot̪ʰɐ͡o]	Figure 124 (b): Oscillogram of কোথাও, [kọ̰ʏt̪ʰɐ̰͡o˩]
It shows a PRAAT illustration of the word কোথাও which is displayed in the Interval Tier 01: Bangla Text Word 'কোথাও', and its transcription is in Interval Tier 02: IPA: [kot̪ʰɐ͡o] Point Tier 01: Consonants [k], [t̪ʰ] and Point Tier 02: Vowel: [o], [ɐ͡o], 6b focuses on the sound, [t̪ʰ] which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.09 seconds, 67 dB, 232 Hz.	Here, [t̪ʰ] appears in the middle of the word. It's 0.23 seconds, 60 dB, 184 Hz. It shows a typical sound. The atypical IPA is [kọ̰ʏt̪ʰɐ̰͡o˩]. Other features include: creaky-voice, velarization and retracted tongue root position with [ọ̰ʏ], creaky-voice and low tone for [ɐ̰͡o˩]. Note: m [t̪ʰ] = typical

Data Display 6 (c)

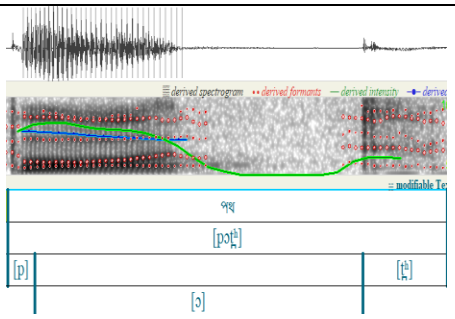
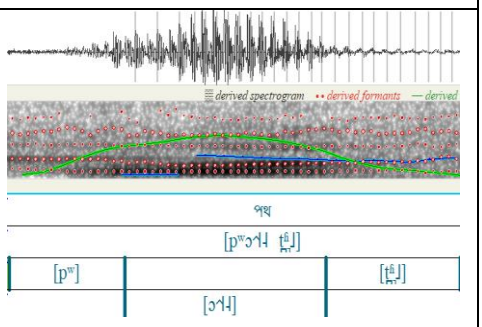
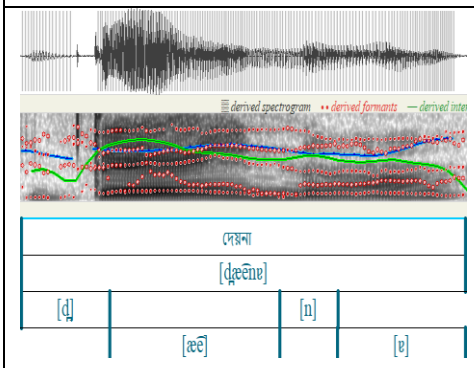
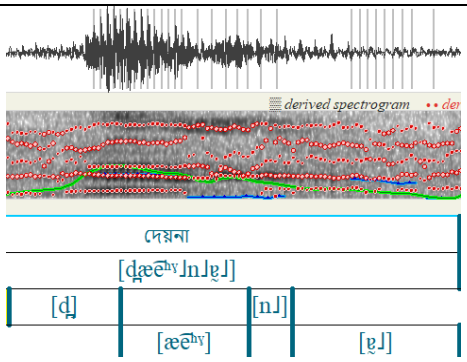
Typical Speech	*Atypical Speech*
	

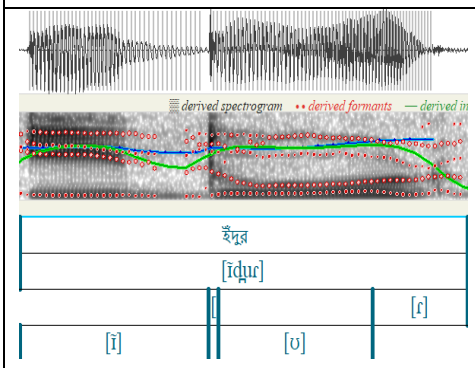
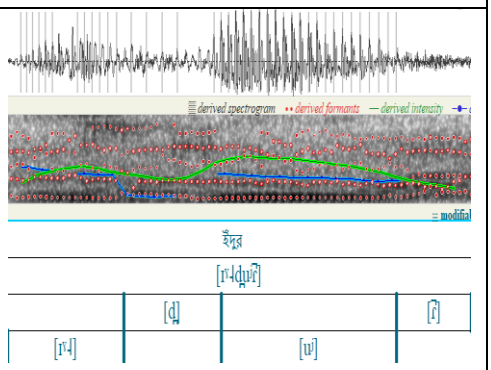
Figure 125 (a): Oscillogram of পথ, [pɔt̪ʰ]	Figure 125 (b): Oscillogram of পথ, [pʷɔ˦˩˧t̪ʱ̬˩]
It shows a PRAAT illustration of the word পথ which is displayed in the Interval Tier 01: Bangla Text Word 'পথ', and its transcription is in Interval Tier 02: IPA: [pɔt̪ʰ] Point Tier 01: Consonants [p], [t̪ʰ] and Point Tier 02: Vowel: [ɔ], 6c focuses on the sound, [t̪ʰ] which appears at the end of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.08 seconds, 60 dB, 173 Hz.	Here, [t̪ʰ] appears at the end of the word. It's 0.48 seconds, 69 dB, 257 Hz. It shows extra-low tone, breathy-voice and with weak articulation with [t̪ʱ̬˩]. The atypical IPA is [pʷɔ˦˩˧t̪ʱ̬˩]. Other features include: labialized [pʷ], rising-falling and low tone with [ɔ˦˩˧]. Note: e [t̪ʰ] = atypical, distortion (extra-low tone, breathy-voice and with weak articulation)

Data Display 7 (a)

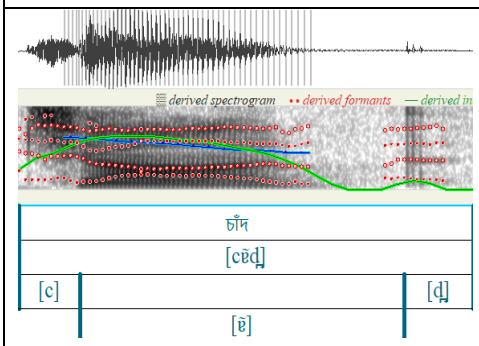
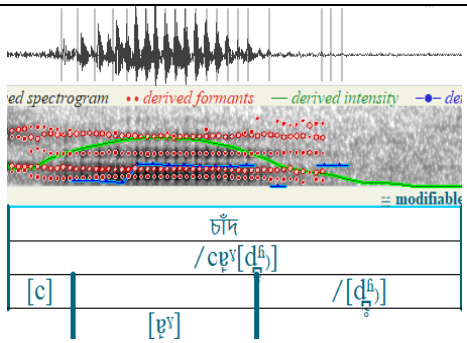
Typical Speech	*Atypical Speech*
	
Figure 126 (a): Oscillogram of দেয়না, [d̪æ̃ɛnɐ]	Figure 126 (b): Oscillogram of দেয়না, [d̪æe̯ʰʏ˩n˩ɻ˩]
It shows a PRAAT illustration of the word দেয়না which is displayed in the Interval Tier 01: Bangla Text Word 'দেয়না', and its transcription is in Interval Tier 02: IPA: [d̪æ̃ɛnɐ] Point Tier 01:	Here, [d̪] appears at the beginning of the word. It's 0.13 seconds, 70 dB, 184 Hz. It shows a typical [d̪] sound. The atypical IPA is [d̪æe̯ʰʏ˩n˩ɻ˩]. Other features include: velarization, aspiration and extra-low tone with [æe̯ʰʏ˩], extra-

Consonants [d̪], [n] and Point Tier 02: Vowel: [ɐ], [æ͡e], 7a focuses on the sound, [d̪] which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.13 seconds, 67 dB, 194 Hz.	low tone with [n˩], and creaky-voice and extra-low tone with [ɐ̰˩]. Note: b [d̪] = typical

Data Display 7 (b)

Typical Speech	*Atypical Speech*
	
Figure 127 (a): Oscillogram of ইঁদুর, [ĭd̪ur] It shows a PRAAT illustration of the word ইঁদুর which is displayed in the Interval Tier 01: Bangla Text Word 'ইঁদুর', and its transcription is in Interval Tier 02: IPA: [ĭd̪ur] Point Tier 01: Consonants [d̪], [ɾ] and Point Tier 02: Vowel: [ĭ], [u], 7b focuses on the sound, [d̪] which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.33 seconds, 79 dB, 258 Hz.	Figure 127 (b): Oscillogram of ইঁদুর, [ɪˠɬd̪uʲɾ̄] Here, [d̪] appears in the middle of the word. It's 0.06 seconds, 59 dB, 182 Hz. It shows typical sound. The atypical IPA is [ɪˠɬd̪uʲɾ̄]. Other features include: velarization and low tone with [ɪˠɬ], palatalization with [uʲ] and no audible release of [ɾ̄]. Note: m [d̪] = typical

Data Display 7 (c)

Typical Speech	*Atypical Speech*
	
Figure 128 (a): Oscillogram of চাঁদ, [cɛ̃d̪]	Figure 128 (b): Oscillogram of চাঁদ, [cɐˠ(d̪ʱ̰)]
It shows a PRAAT illustration of the word চাঁদ which is displayed in the Interval Tier 01: Bangla Text Word 'চাঁদ', and its transcription is in Interval Tier 02: IPA: [cɛ̃d̪], Point Tier 01: Consonants [c], [d̪] and Point Tier 02: Vowel: [ɛ̃], 7c focuses on the sound, [d̪] which appears at the end of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.07 seconds, 50 dB, 167 Hz.	Here, [d̪] appears at the end of the word. It's 0.3 seconds, 64 dB, 152 Hz. It shows partial devoicing, aspiration and creaky-voice. The atypical IPA is [cɐˠ(d̪ʱ̰)]. Other features include: retracted tongue root position and velarization with [ɐˠ]. Note: e [d̪] = atypical, distortion (partial devoicing, aspiration and creaky-voice), also could be noted for addition for aspiration

Data Display 8 (a)

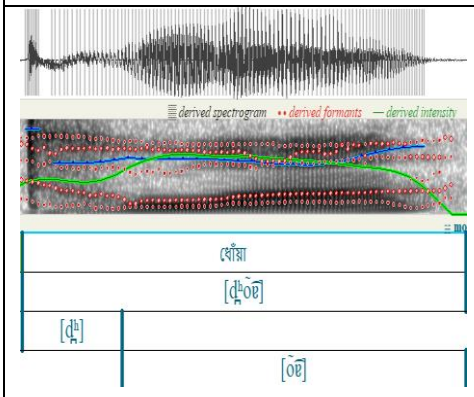
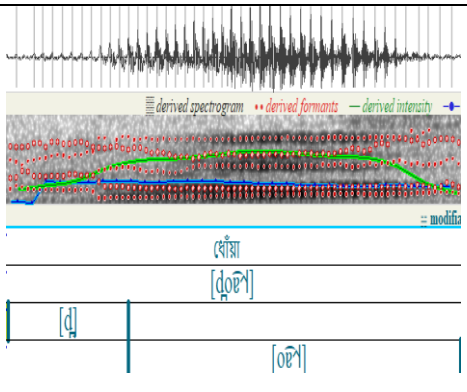
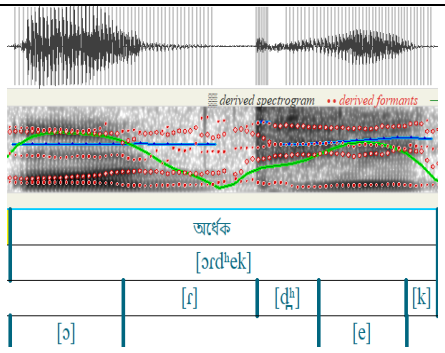
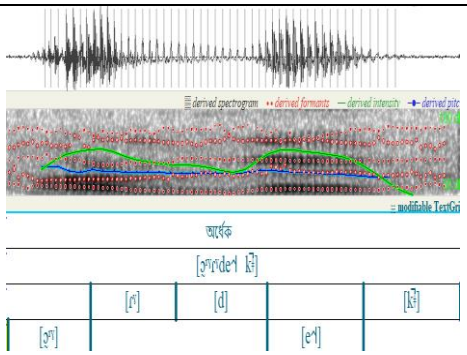
Typical Speech	*Atypical Speech*
	

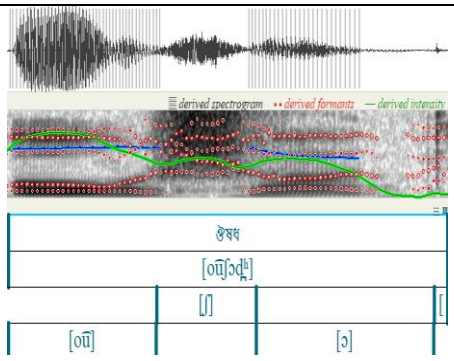
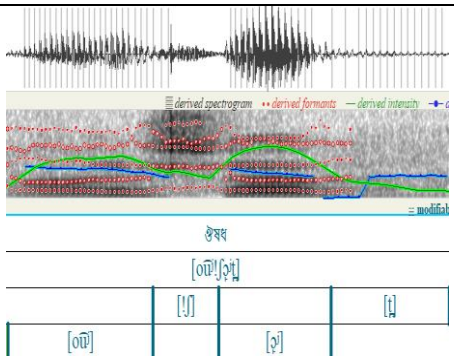
Figure 129 (a): Oscillogram of ধোঁয়া, [d̪ʱõʊ̯]	Figure 129 (b): Oscillogram of ধোঁয়া, [d̪o͡ʊ̯ˤ]
It shows a PRAAT illustration of the word ধোঁয়া which is displayed in the Interval Tier 01: Bangla Text Word 'ধোঁয়া', and its transcription is in Interval Tier 02: IPA: [d̪ʱõʊ̯], Point Tier 01: Consonants [d̪ʱ] and Point Tier 02: Vowel: [õʊ̯], 8a focuses on the sound, [d̪ʱ] which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.11 seconds, 67 dB, 223 Hz.	Here, [d̪ʱ] appears at the beginning of the word. It's 0.23 seconds, 57 dB, 189 Hz. It shows substitution with a [d̪]. The atypical IPA is [d̪o͡ʊ̯ˤ]. Other features include: rising-falling with [o͡ʊ̯ˤ]. Note: b [d̪ʱ] = atypical, substitution (substitution with a [d̪])

Data Display 8 (b)

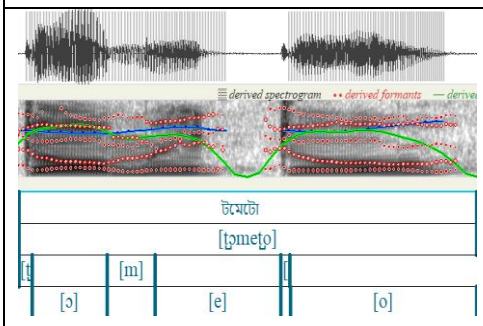
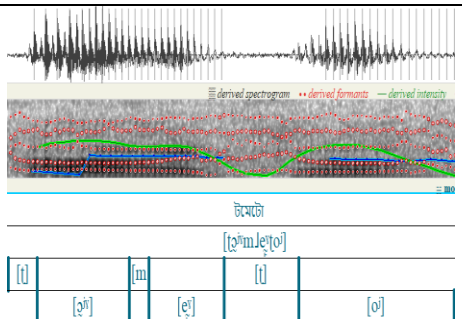
Typical Speech	*Atypical Speech*
	
Figure 130 (a): Oscillogram of অর্ধেক, [ɔrd̪ʱek]	Figure 130 (b): Oscillogram of অর্ধেক, [ɔ̰ʳʸɾʸd̰eˤlk̚ʲ]
It shows a PRAAT illustration of the word অর্ধেক which is displayed in the Interval Tier 01: Bangla Text Word 'অর্ধেক', and its transcription is in Interval Tier 02: IPA: [ɔrd̪ʱek], Point Tier 01:	Here, [d̪ʱ] appears in the middle of the word. It's 0.13 seconds, 65 dB, 161 Hz. It shows substitution with devoiced [d̰]. The atypical IPA is [ɔ̰ʳʸɾʸd̰eˤlk̚ʲ]. Other features include: creaky-voiced, velarized, rhotic [ɔ̰ʳʸ], velarized [ɾʸ], rising-falling

Consonants [ɾ], [d̪ʱ], [k] and Point Tier 02: Vowel: [ɔ], [e], 8b focuses on the sound, [d̪ʱ] which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.07 seconds, 66 dB, 232 Hz.	with [eˤ], no audible release but a palatal click with [k̟ǂ]. Note: m [d̪ʱ] = atypical, substitution (substitution with devoiced [d̪̥])

Data Display 8 (c)

Typical Speech	*Atypical Speech*
	
Figure 131 (a): Oscillogram of ঔষধ, [o͡uʃɔd̪ʱ]	Figure 131 (b): Oscillogram of ঔষধ, [o͡uʲ!ʃɔ̟ʲt̪]
It shows a PRAAT illustration of the word ঔষধ which is displayed in the Interval Tier 01: Bangla Text Word 'ঔষধ', and its transcription is in Interval Tier 02: IPA: [o͡uʃɔd̪ʱ], Point Tier 01: Consonants [ʃ], [d̪ʱ] and Point Tier 02: Vowel: [ɔ], [o͡u], 8c focuses on the sound, [d̪ʱ] which appears at the end of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.64 seconds, 52 dB, 174 Hz.	Here, [d̪ʱ] appears at the end of the word. It's 0.11 seconds, 53 dB, 174 Hz. It shows substitution with [t̪]. The atypical IPA is [o͡uʲ!ʃɔ̟ʲt̪]. Other features include: palatalization and post-alveolar click with [o͡uʲ!], palatalization and retracted tongue root position with [ɔ̟ʲ]. Note: e [d̪ʱ] = atypical, substitution (substitution with with [t̪]).

Data Display 9 (a)

Typical Speech	*Atypical Speech*
	
Figure 132 (a): Oscillogram of টমেটো, [ʈɔmeʈo]	Figure 132 (b): Oscillogram of টমেটো, [ʈɔ̹ʲʸmɻe̞̹ʸʈoʲ]
It shows a PRAAT illustration of the word টমেটো which is displayed in the Interval Tier 01: Bangla Text Word 'টমেটো', and its transcription is in Interval Tier 02: IPA: [ʈɔmeʈo], Point Tier 01: Consonants [ʈ], [m], [ʈ] and Point Tier 02: Vowel: [ɔ], [e], [o], 9a focuses on the sound, [ʈ] which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.12 seconds, 71 dB, 266 Hz.	Here, [ʈ] appears at the beginning of the word. It's 0.11 seconds, 66 dB, 200 Hz. It is a typical sound. The atypical IPA is [ʈɔ̹ʲʸmɻe̞̹ʸʈoʲ]. Other features: rising-creaky-voice, palatalization, and velarization with [ɔ̹ʲʸ], extra-low tone with [mɻ], retracted tongue root position, creaky voice, and velarization with [e̞̹ʸ], palatalization with [oʲ]. Note: b [ʈ] = typical

Data Display 9 (b)

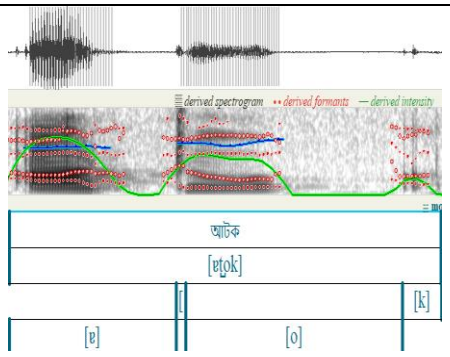
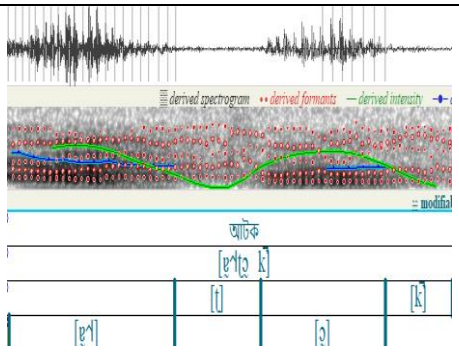
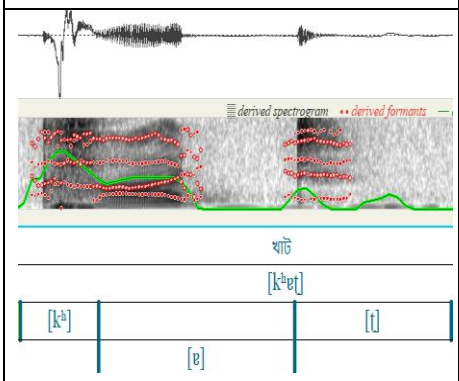
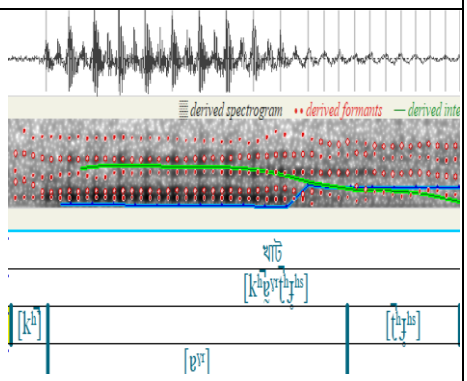
Typical Speech	*Atypical Speech*
	

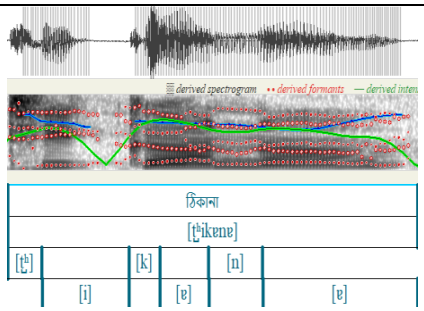
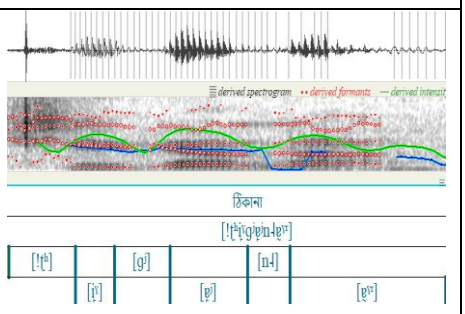
Figure 133 (a): Oscillogram of আটক, [ɐt̪ok]	Figure 133 (b): Oscillogram of আটক, [ɐˤt̪ɔ̰k̚]
It shows a PRAAT illustration of the word আটক which is displayed in the Interval Tier 01: Bangla Text Word 'আটক', and its transcription is in Interval Tier 02: IPA: [ɐt̪ok]. Point Tier 01: Consonants [t̪], [k] and Point Tier 02: Vowel: [ɐ], [o], 9b focuses on the sound, [t̪] which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.38 seconds, 67 dB, 258 Hz.	Here, [t̪] appears in the middle of the word. It's 0.5 seconds, 60 dB, 178 Hz. It has a typical sound . The atypical IPA is [ɐˤt̪ɔ̰k̚]. Other features include: creaky-voice and rising-falling with [ɐˤ], creaky-voice with [ɔ̰], and no audible release with [k̚]. Note: m [t̪] = typical

Data Display 9 (c)

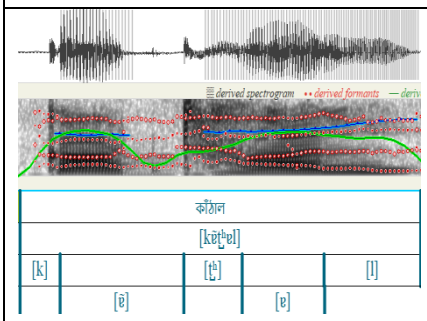
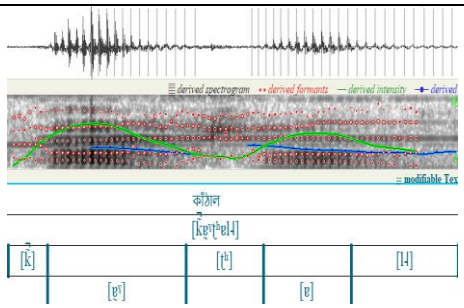
Typical Speech	*Atypical Speech*
	
Figure 134 (a): Oscillogram of খাট, [kʰɐt̪]	Figure 134 (b): Oscillogram of খাট, [kʰɐ̰ʏʳt̪ʰɻ̊ʰˢ]
It shows a PRAAT illustration of the word খাট which is displayed in the Interval Tier 01: Bangla Text Word 'খাট', and its transcription is in Interval Tier	Here, [t̪] appears at the end of the word. It's 0.5 seconds, 60 dB, 178 Hz. It has no audible release. The atypical IPA is [kʰɐ̰ʏʳt̪ʰɻ̊ʰˢ]. Other features include: no audible

02: IPA: [kʰɐʈ]. Point Tier 01: Consonants [kʰ], [ʈ] and Point Tier 02: Vowel: [ɐ], 9c focuses on the sound, [ʈ] which appears at the end of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.38 seconds, 67 dB, 258 Hz.	release with [k̚ʰ], velarization, creaky-voiced rhotic [ɻ̰ʸʳ], voiceless fricative release with [ɻ̊ʰˢ]. Note: e [ʈ] = atypical, omission (no audible release)

Data Display 10 (a)

Typical Speech	*Atypical Speech*
	
Figure 135 (a): Oscillogram of ঠিকানা, [ʈʰikɐnɐ]	Figure 135 (b): Oscillogram of ঠিকানা, [!ʈʰi̟ʸgʲɸʲn↓ɻ̰ʸʳ]
It shows a PRAAT illustration of the word ঠিকানা which is displayed in the Interval Tier 01: Bangla Text Word 'ঠিকানা', and its transcription is in Interval Tier 02: IPA: [ʈʰikɐnɐ], Point Tier 01: Consonants [ʈʰ], [k], [n] and Point Tier 02: Vowel: [i], [ɐ], 10a focuses on the sound, [ʈʰ] which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.05 seconds, 71 dB, 356 Hz.	Here, [ʈʰ] appears at the beginning of the word. It's 0.17 seconds, 60 dB, 209 Hz. It has post-alveolar click. The atypical IPA is [!ʈʰi̟ʸgʲɸʲn↓ɻ̰ʸʳ]. Other features: velarized retracted tongue root position with [i̟ʸ], substitution with palatalized [gʲ], palatalized retracted tongue position with [ɸʲ], low voiced [n↓], velarized, creaky voiced, rhotic [ɻ̰ʸʳ]. Note: b [ʈʰ] = atypical, distortion (post-alveolar click), also noted for addition

Data Display 10 (b)

Typical Speech	*Atypical Speech*
	
Figure 136 (a): Oscillogram of কাঁঠাল, [kɐ̃ʈʰɐl]	Figure 136 (b): Oscillogram of কাঁঠাল, [k̃ɐ̃ᵛʈʰɐlɻ]
It shows a PRAAT illustration of the word কাঁঠাল which displays the Interval Tier 01: Bangla Text Word 'কাঁঠাল', Interval Tier 02: Transcription, IPA: [kɐ̃ʈʰɐl], Point Tier 01: Consonants [k], [ʈʰ], [l], Point Tier 02: Vowels: [ɐ̃], [ɐ] 10b focuses on the sound, [ʈʰ] which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.09 seconds, 69 dB, 218 Hz.	Here, [ʈʰ] appears in the middle of the word. It's 0.15 seconds, 73 dB, 197 Hz. It shows a typical sound. The atypical IPA is [k̃ɐ̃ᵛʈʰɐlɻ]. Other features include: no audible release of [k̃], velarized creaky-voice of [ɐ̃ᵛ], and low toned [lɻ]. Note: m [ʈʰ] = typical

Data Display 10 (c)

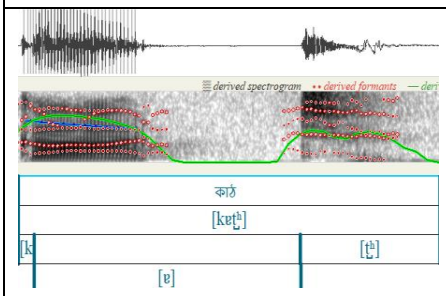
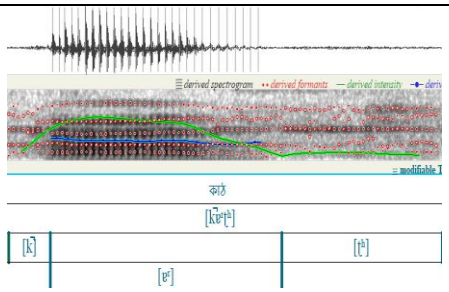
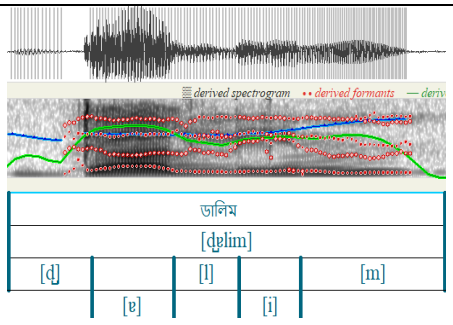
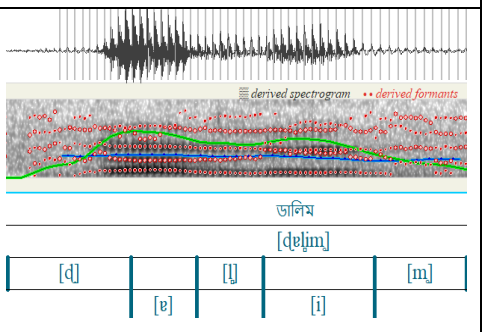
Typical Speech	*Atypical Speech*
	

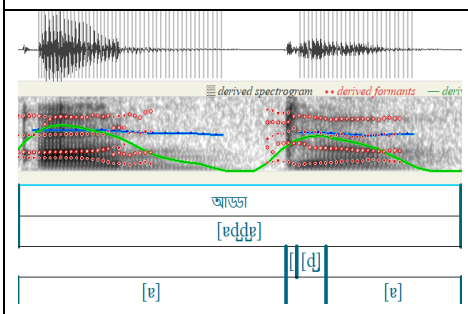
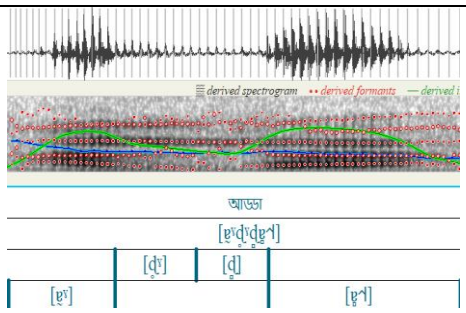
Figure 137 (a): Oscillogram of কাঠ, [kɐʈʰ]	Figure 137 (b): Oscillogram of কাঠ, [k̄ɐʳʈʰ]
It shows a PRAAT illustration of the word কাঠ which is displayed in the Interval Tier 01: Bangla Text Word 'কাঠ', and its transcription is in Interval Tier 02: IPA: [kɐʈʰ]. Point Tier 01: Consonants [k], [ʈʰ] and Point Tier 02: Vowel: [ɐ], 10c focuses on the sound, [ʈʰ] which appears at the end of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.7 seconds, 67 dB, 190 Hz.	Here, [ʈʰ] appears at the end of the word. It's 0.17 seconds, 63 dB, 183 Hz. It shows typical sound. The atypical IPA is [k̄ɐʳʈʰ]. Other features include: no audible release with [k̄], rhotic [ɐʳ]. Note: e [ʈʰ] = typical

Data Display 11 (a)

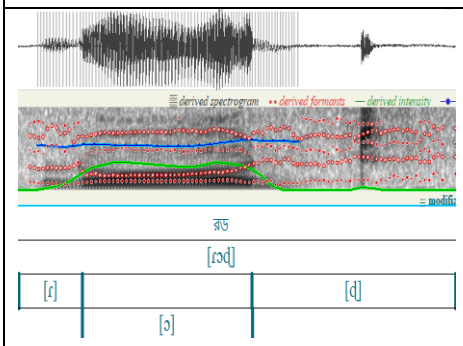
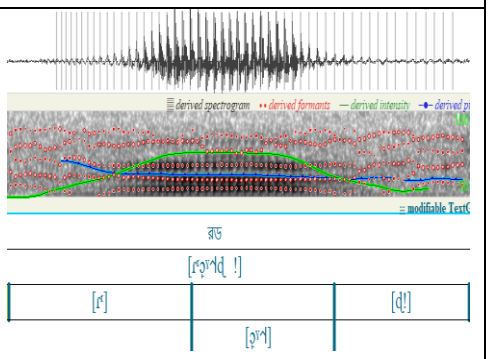
Typical Speech	*Atypical Speech*
	
Figure 138 (a): Oscillogram of ডালিম, [ɖɐlim] It shows a PRAAT illustration of the word ডালিম which is displayed in the Interval Tier 01: Bangla Text Word 'ডালিম', and its transcription is in Interval Tier 02: IPA: [ɖɐlim]	Figure 138 (b): Oscillogram of ডালিম, [ɖɐl̪iṃ] Here, [ɖ] appears at the beginning of the word. It's 0.12 seconds, 66 dB, 228 Hz. It has a typical sound. The atypical IPA is [ɖɐl̪iṃ]. Other features include: laminal [l̪], and

Point Tier 01: Consonants [ɖ], [l], [m] and Point Tier 02: Vowel: [ɐ], [i], 11a focuses on the sound, [ɖ] which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.12 seconds, 67 dB, 191 Hz.	voiceless [m̥]. Note: b [ɖ] = typical

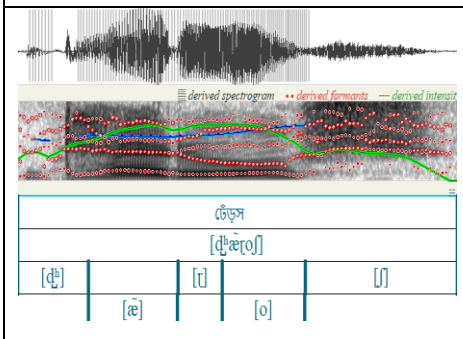
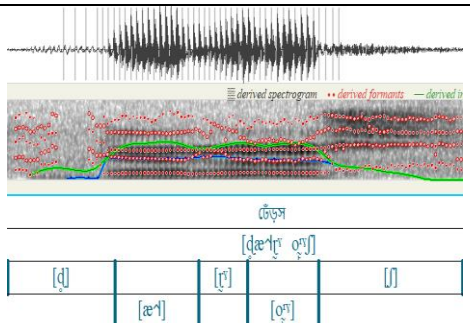
Data Display 11 (b)

Typical Speech	*Atypical Speech*
	
Figure 139 (a): Oscillogram of আড্ডা, [ɐɖɖɐ] It shows a PRAAT illustration of the word আড্ডা which is displayed in the Interval Tier 01: Bangla Text Word 'আড্ডা', and its transcription is in Interval Tier 02: IPA: [ɐɖɖɐ], Point Tier 01: Consonants [ɖ], [ɖ], and Point Tier 02: Vowel: [ɐ], 11b focuses on the sound, [ɖ] which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.45 seconds, 73 dB, 207 Hz.	Figure 139 (b): Oscillogram of আড্ডা, [ɡˠɖ̟ˠɖ̪ɡˠˤ] Here, [ɖ] appears in the middle of the word. It's 0.65 seconds, 70 dB, 181 Hz. It has laminal [ɖ̪] sound. The atypical IPA is [ɡˠɖ̟ˠɖ̪ɡˠˤ]. Other features include: velarized creaky-voiced [ɡˠ], velarized voiceless [ɖ̟ˠ], laminal rising-falling with [ɡˠˤ]. Note: m [ɖ] = atypical, distortion (laminal)

Data Display 11 (c)

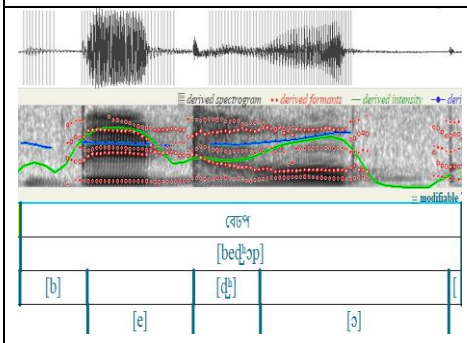
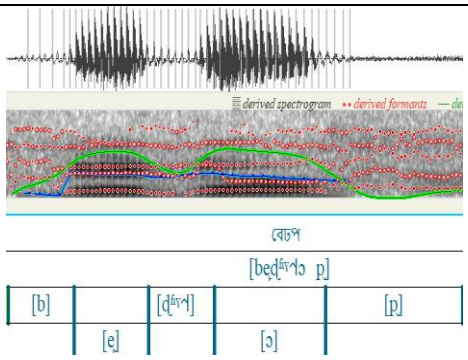
Typical Speech	*Atypical Speech*
	
Figure 140 (a): Oscillogram of রড, [ɾɔɖ]	Figure 140 (b): Oscillogram of রড, [ɾʳɻʸˤɖ!]
It shows a PRAAT illustration of the word রড which is displayed in the Interval Tier 01: Bangla Text Word 'রড', and its transcription is in Interval Tier 02: IPA: [ɾɔɖ], Point Tier 01: Consonants [ɾ], [ɖ], and Point Tier 02: Vowel: [ɔ], 11c focuses on the sound, [ɖ] which appears at the end of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.45 seconds, 73 dB, 207 Hz.	Here, [ɖ] appears at the end of the word. It's 0.65 seconds, 70 dB, 181 Hz. It has a post-alveolar click. The atypical IPA is [ɾʳɻʸˤɖ!]. Other features include: rhotic [ɾʳ], velarized rising-falling retracted tongue root position with [ɻʸˤ]. Note: e [ɖ] = atypical, distortion (post-alveolar click), also could be noted as addition

Data Display 12 (a)

Typical Speech	*Atypical Speech*
	
Figure 141 (a): Oscillogram of	Figure 141 (b): Oscillogram of

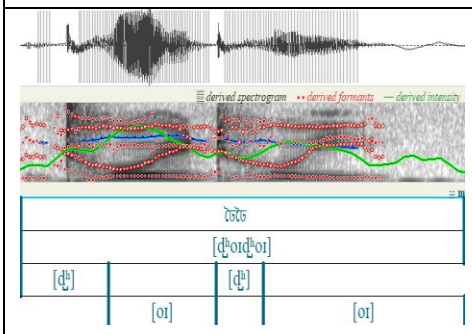
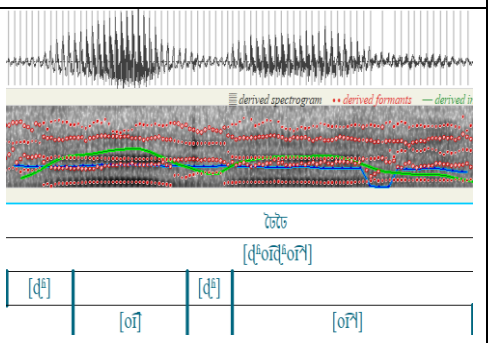
ঢেঁড়স, [ɖʱæ̃ɽoʃ]	ঢেঁড়স, [ɖ̤æˤɻ̃ʏo̰ʳʏʃ]
It shows a PRAAT illustration of the word ঢেঁড়স which is displayed in the Interval Tier 01: Bangla Text Word ‘ঢেঁড়স’, and its transcription is in Interval Tier 02: IPA: [ɖʱæ̃ɽoʃ]. Point Tier 01: Consonants [ɖʱ], [ɽ], [ʃ] and Point Tier 02: Vowel: [æ̃], [o], 12a focuses on the sound, [ɖʱ] which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.11 seconds, 60 dB, 202 Hz.	Here, [ɖʱ] appears at the beginning of the word. It’s 0.23 seconds, 76 dB, 160 Hz. It has substitution with voiceless [ɖ̤]. The atypical IPA is [ɖ̤æˤɻ̃ʏo̰ʳʏʃ]. Other features: rising-falling with [æˤ], velarized creaky-voiced [ɻ̃ʏ], velarized, rhotic, retracted tongue root position with creaky voice for [o̰ʳʏ]. Note: b [ɖʱ] = atypical, substitution (substitution with voiceless)

Data Display 12 (b)

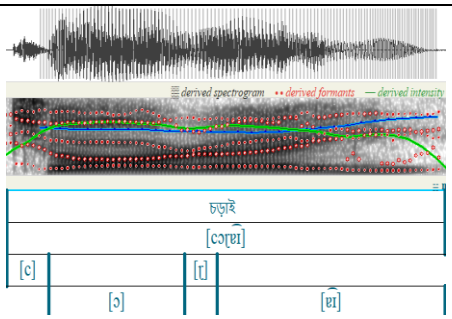
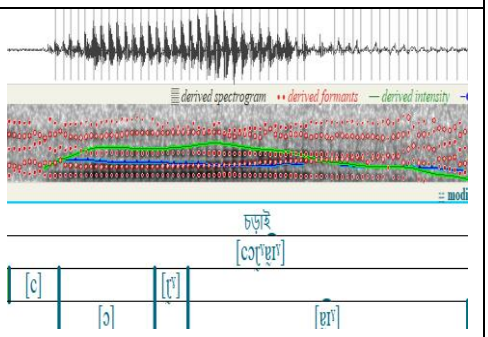
Typical Speech	*Atypical Speech*
	
Figure 142 (a): Oscillogram of বেচপ, [bɛɖʱɔp] It shows a PRAAT illustration of the word বেচপ which is displayed in the Interval Tier 01: Bangla Text Word ‘বেচপ’, and its transcription is in Interval Tier 02: IPA: [bɛɖʱɔp], Point Tier 01:	Figure 142 (a): Oscillogram of বেচপ, [bɛ̤ɖʱʏˤɔp̰] Here, [ɖʱ] appears in the middle of the word. It’s 0.3 seconds, 64 dB, 166 Hz. It has velarized [ɖʱʏˤ] with rising-falling tone. The atypical IPA is [bɛ̤ɖʱʏˤɔp̰]. Other features include: retracted tongue root position of [ɛ̤] and voiced [p̰].

Consonants [b], [ɖʱ], [p] and Point Tier 02: Vowel: [e], [ɔ], 12b focuses on the sound, [ɖʱ] which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.09 seconds, 68 dB, 212 Hz.	Note: m [ɖʱ] = atypical, distortion (velarized [ɖʱˠˤ] with rising-falling tone)

Data Display 12 (c)

Typical Speech	*Atypical Speech*
	
Figure 143 (a): Oscillogram of ঢেঢেে, [ɖʱo͡ɪɖʱo͡ɪ]	Figure 143 (b): Oscillogram of ঢেঢেে, [ɖʱo͡ɪɖʱo͡ɪˤˠ]
It shows a PRAAT illustration of the word ঢেঢেে which is displayed in the Interval Tier 01: Bangla Text Word 'ঢেঢেে', and its transcription is in Interval Tier 02: IPA: [ɖʱo͡ɪɖʱo͡ɪ], Point Tier 01: Consonants [ɖʱ], [ɖʱ] and Point Tier 02: Vowel: [o͡ɪ], 12c focuses on the sound, [ɖʱ] which appears at the end of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.08 seconds, 66 dB, 199 Hz.	Here, [ɖʱ] appears at the end of the word. It's 0.3 seconds, 60 dB, 183 Hz. It has a typical sound. The atypical IPA is [ɖʱo͡ɪɖʱo͡ɪˤˠ]. Other features include: rising-falling of the [o͡ɪˤˠ]. Note: e [ɖʱ] = typical

Data Display 13 (a)

Typical Speech	*Atypical Speech*
	
Figure 144 (a): Oscillogram of চড়াই, [cɔɽ͡ʁɪ]	Figure 144 (b): Oscillogram of চড়াই, [cɔɽ̰ˠɣ͡ɪˠ]
It shows a PRAAT illustration of the word চড়াই which is displayed in the Interval Tier 01: Bangla Text Word 'চড়াই', and its transcription is in Interval Tier 02: IPA: [cɔɽ͡ʁɪ], Point Tier 01: Consonants [c], [ɽ] and Point Tier 02: Vowel: [ɔ], [͡ʁɪ], 13a focuses on the sound, [c] or [t̪ɕ] which appears at the beginning of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiceless sound which is of 0.05 seconds, 73 dB, 271 Hz.	Here, [c] or [t̪ɕ] appears at the beginning of the word. It's 0.3 seconds, 63 dB, 211 Hz. It has a typical [c] or [t̪ɕ] sound. The atypical IPA is [cɔɽ̰ˠɣ͡ɪˠ]. Other features include: velarized, creaky-voiced [ɽ̰ˠ] and [ɣ͡ɪˠ]. Note: b [c] = typical

Data Display 13 (b)

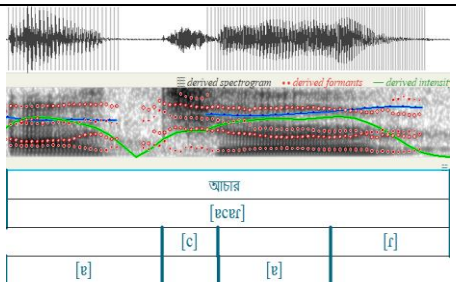
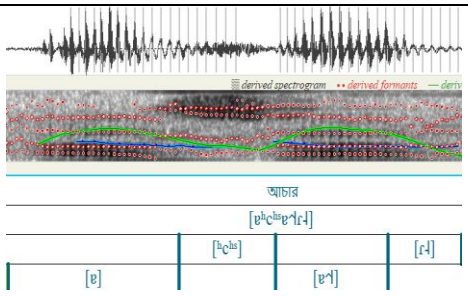
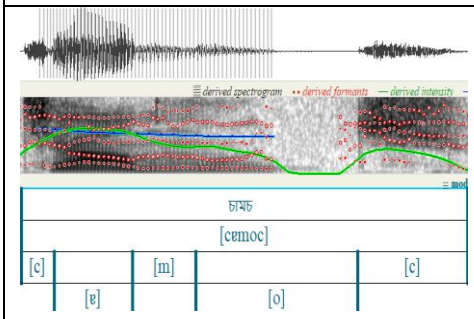
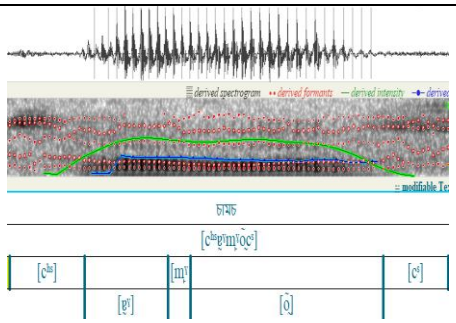
Typical Speech	*Atypical Speech*
	

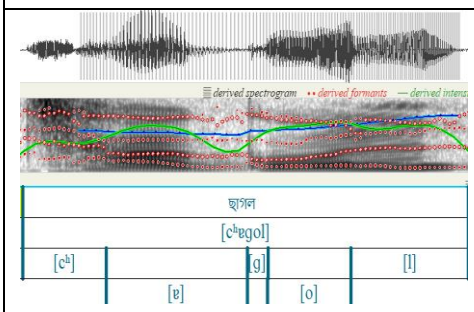
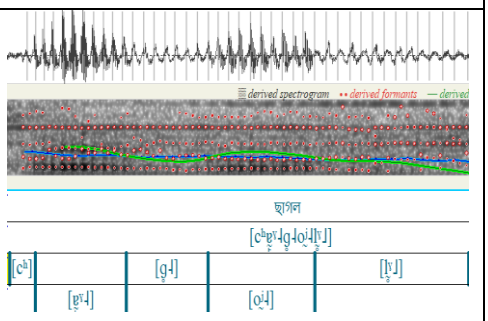
Figure 145 (a): Oscillogram of আচার, [ɐcɐɾ] It shows a PRAAT illustration of the word আচার which is displayed in the Interval Tier 01: Bangla Text Word 'আচার', and its transcription is in Interval Tier 02: IPA: [ɐcɐɾ], Point Tier 01: Consonants [c], [ɾ] and Point Tier 02: Vowel: [ɐ], 13b focuses on the sound, [c] or [t͡ɕ] which appears in the middle of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiceless sound which is of 0.07 seconds, 60 dB, 270 Hz.	Figure 145 (b): Oscillogram of আচার, [ɐʰcʰˢɐˤɾˌ] Here, [c] or [t͡ɕ] appears in the middle of the word. It's 0.21 seconds, 66 dB, 188 Hz. It shows substitution and a fricative release with [cʰˢ]. The atypical IPA is [ɐʰcʰˢɐˤɾˌ]. Other features include: rising-falling with [ɐˤ] and low tone with [ɾˌ]. Note: m [c] = atypical, substitution, also could be noted for distortion (due to fricative release) and/or addition

Data Display 13 (c)

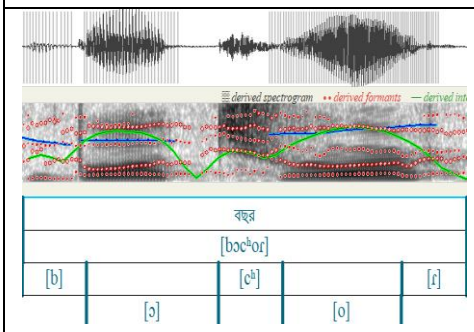
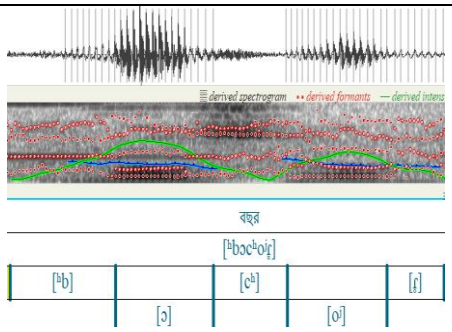
Typical Speech	*Atypical Speech*
	
Figure 146 (a): Oscillogram of চামচ, [cɐmoc] It shows a PRAAT illustration of the word চামচ which is displayed in the Interval Tier 01: Bangla Text Word 'চামচ', and its transcription is in Interval Tier 02: IPA: [cɐmoc],	Figure 146 (b): Oscillogram of চামচ, [cʰˢɐ̯ˠm̩ˠo̰cˢ] Here, [c] or [t͡ɕ] appears at the end of the word. It's 0.12 seconds, 60 dB, 224 Hz. It has a fricative release. The atypical IPA is [cʰˢɐ̯ˠm̩ˠo̰cˢ]. Other features include:

Point Tier 01: Consonants [c], [m], [c] and Point Tier 02: Vowel: [ɐ], [o], 13c focuses on, [c] or [t̪ɕ] which appears at the end. It is pulmonic egressive, post-alveolar or palato-alveolar, voiceless, 0.04 seconds, 71 dB, 248 Hz.	fricative release and substitution with [cʰˢ], velarized creaky voiced [g̰ˠ], velarized retracted tongue root position with [m̰ˠ], nasalized creaky-voiced [õ̰]. Note: e [c] = atypical, distortion (due to fricative release) and/or addition

Data Display 14 (a)

Typical Speech	*Atypical Speech*
	
Figure 147 (a): Oscillogram of ছাগল, [cʰɐgol]	Figure 147 (b): Oscillogram of ছাগল, [cʰg̰ˠɻgˠɻo̰ʲɻl̰ˠɻ]
It shows a PRAAT illustration of the word ছাগল which is displayed in the Interval Tier 01: Bangla Text Word ‘ছাগল’, and its transcription is in Interval Tier 02: IPA: [cʰɐgol], Point Tier 01: Consonants [cʰ], [g], [l] and Point Tier 02: Vowel: [ɐ], [o] 14a focuses on the sound, [cʰ] or [t̪ɕʰ] which appears at the beginning of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiceless sound which is of 0.11 seconds, 70 dB, 237 Hz.	Here, [cʰ] or [t̪ɕʰ] appears at the beginning of the word. It’s 0.3 seconds, 67 dB, 188 Hz. It has a typical sound. The atypical IPA is [cʰg̰ˠɻgˠɻo̰ʲɻl̰ˠɻ]. Other features include: velarized , retracted tongue root position, creaky voice and low tone for [g̰ˠɻ], low-toned, voiceless [gˠɻ], palatalization, low tone and creaky voice for [o̰ʲɻ], velarized, extra-low toned, creaky-voiced, voiceless [l̰ˠɻ]. Note: b [cʰ] = typical

Data Display 14 (b)

Typical Speech	*Atypical Speech*
	
Figure 148 (a): Oscillogram of বছর, [bɔcʰoɾ] It shows a PRAAT illustration of the word বছর which is displayed in the Interval Tier 01: Bangla Text Word ‘বছর’, and its transcription is in Interval Tier 02: IPA: [bɔcʰoɾ], Point Tier 01: Consonants [b], [cʰ], [ɾ] and Point Tier 02: Vowel: [ɔ], [o], 14b focuses on [cʰ] or [t̪ɕʰ] which appears in the middle of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiceless sound, of 0.09 seconds, 68 dB, 267 Hz.	Figure 148 (b): Oscillogram of বছর, [ʰbɔcʰoi̯ɾ̥] Here, [cʰ] or [t̪ɕʰ] appears in the middle of the word. It’s 0.21 seconds, 60 dB, 190 Hz. It is a typical sound. The atypical IPA is [ʰbɔcʰoi̯ɾ̥]. Other features include: pre-aspiration with [ʰb], palatalization with [oi̯], and voicelessness with [ɾ̥]. Note: m [cʰ] = typical

Data Display 14 (c)

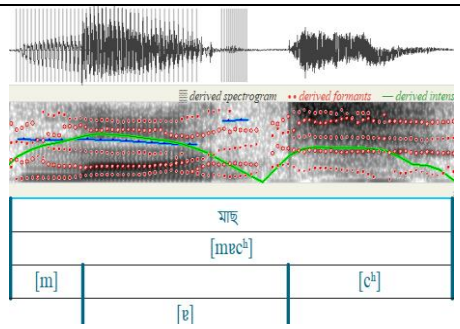
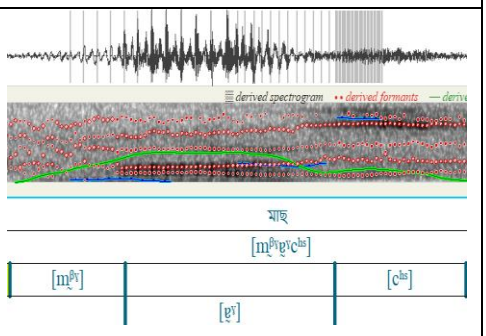
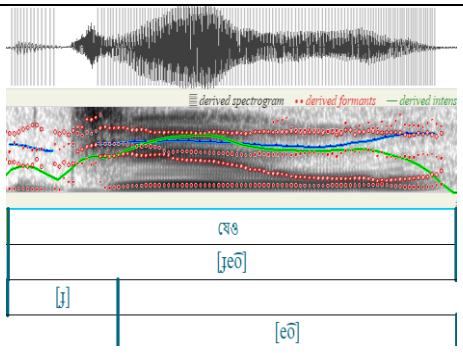
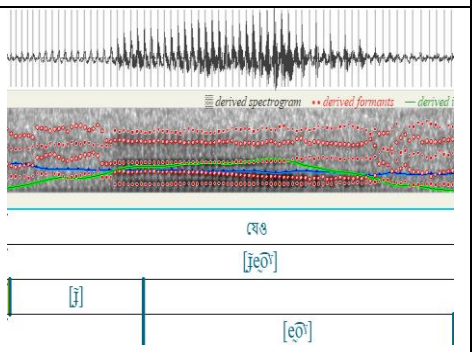
Typical Speech	*Atypical Speech*
	

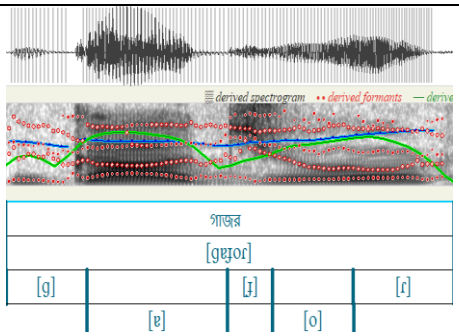
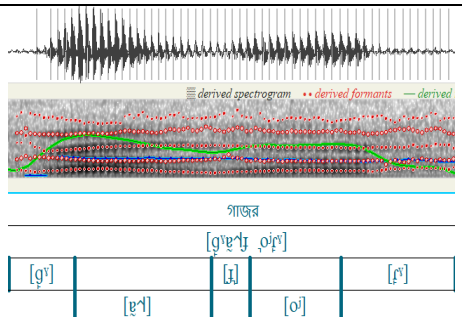
Figure 149 (a): Oscillogram of মাছ, [mɐcʰ] It shows a PRAAT illustration of the word মাছ which is displayed in the Interval Tier 01: Bangla Text Word 'মাছ', and its transcription is in Interval Tier 02: IPA: [mɐcʰ]. Point Tier 01: Consonants [m], [cʰ] and Point Tier 02: Vowel: [ɐ], 14c focuses on the sound, [cʰ] or [t̪ɕʰ] which appears at the end of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiceless sound which is of 0.19 seconds, 71 dB, 183 Hz.	Figure 149 (b): Oscillogram of মাছ, [m̪ᵝʸɣ̞ʸcʰˢ] Here, [cʰ] or [t̪ɕʰ] appears at the end of the word. It's 0.53 seconds, 69 dB, 199 Hz. It has a fricative release. The atypical IPA is [m̪ᵝʸɣ̞ʸcʰˢ]. Other features include: creaky-voiced, velarization and lip compression with [m̪ᵝʸ], velarization, creaky-voiced with [ɣ̞ʸ]. Note: e [cʰ] = atypical, distortion (due to fricative release) and/or addition

Data Display 15 (a)

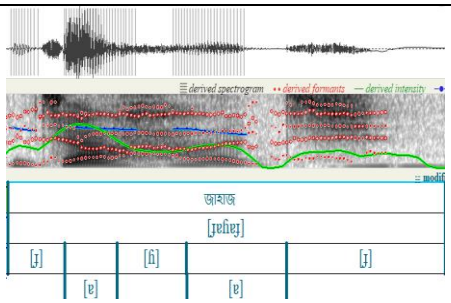
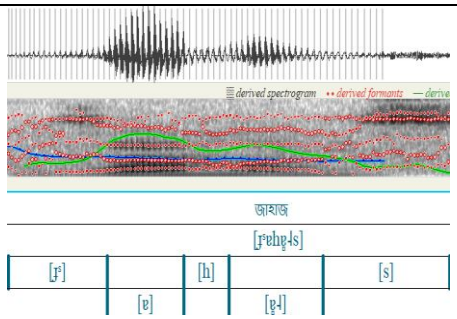
Typical Speech	*Atypical Speech*
	
Figure 150 (a): Oscillogram of যেও, [ɟe͡o] It shows a PRAAT illustration of the word যেও which is displayed in the Interval Tier 01: Bangla Text Word 'যেও', and its transcription is in Interval Tier 02: IPA: [ɟe͡o].	Figure 150 (b): Oscillogram of যেও, [ɟ̃ẹ͡oʸ] Here, [ɟ] or [d̠ʑ] appears at the beginning of the word. It's 0.21 seconds, 61 dB, 191 Hz. It shows nasalization. The atypical IPA is [ɟ̃ẹ͡oʸ]. Other features include: creaky-voice, velarization with

Point Tier 01: Consonants [ɟ] and Point Tier 02: Vowel: [e͡o], 15a focuses on, [ɟ] or [d̪ʑ] which appears at the beginning of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiced sound which is of 0.15 seconds, 61 dB, 208 Hz.	[e̤o͡ʸ]. Note: b [ɟ] = atypical, distortion (due to nasalization)

Data Display 15 (b)

Typical Speech	*Atypical Speech*
	
Figure 151 (a): Oscillogram of গাজর, [gɐɟoɾ] It shows a PRAAT illustration of the word গাজর which is displayed in the Interval Tier 01: Bangla Text Word ‘গাজর’, and its transcription is in Interval Tier 02: IPA: [gɐɟoɾ]. Point Tier 01: Consonants [g], [ɟ], [ɾ] and Point Tier 02: Vowel: [ɐ], [o], 15b focuses on the sound, [ɟ] or [d̪ʑ] which appears in the middle of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiced sound which is of 0.06 seconds, 56 dB, 208 Hz.	Figure 151 (b): Oscillogram of গাজর, [g̤ʸɐˤɟ̤oʲɾ̤ʸ] Here, [ɟ] or [d̪ʑ] appears in the middle of the word. It’s 0.14 seconds, 56 dB, 184 Hz. It has weak articulation. The atypical IPA is [g̤ʸɐˤɟ̤oʲɾ̤ʸ]. Other features include: velarization, retracted tongue-root position with [g̤ʸ], rising-falling, creaky-voice with [ɐˤ], palatalization with [oʲ], velarization and retracted tongue root position with [ɾ̤ʸ]. Note: m [ɟ] = atypical, distortion (due to weak articulation)

Data Display 15 (c)

Typical Speech	*Atypical Speech*
	
Figure 152 (a): Oscillogram of জাহাজ, [ɟɐhɐɟ]	Figure 152 (b): Oscillogram of জাহাজ, [ɟˢɐhɐ̟ɬs]
It shows a PRAAT illustration of the word জাহাজ which is displayed in the Interval Tier 01: Bangla Text Word 'জাহাজ', and its transcription is in Interval Tier 02: IPA: [ɟɐhɐɟ]. Point Tier 01: Consonants [ɟ], [h], [ɟ] and Point Tier 02: Vowel: [ɐ], 15c focuses on the sound, [ɟ] or [d̪ʑ] which appears at the end of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiced sound which is of 0.09 seconds, 62 dB, 200 Hz.	Here, [ɟ] or [d̪ʑ] appears at the end of the word. It's 0.13 seconds, 60 dB, 192 Hz. It has substitution with [s]. The atypical IPA is [ɟˢɐhɐ̟ɬs]. Other features include: fricative release with [ɟˢ], laminal low tone with [ɐ̟ɬ]. Note: e [ɟ] = atypical, substitution (with [s])

Data Display 16 (a)

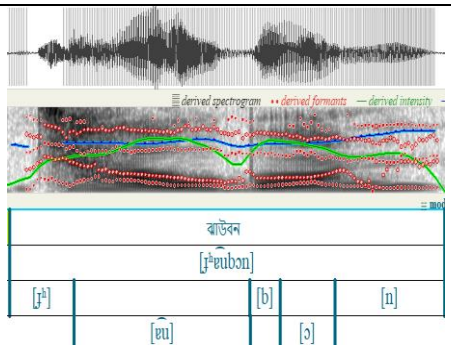
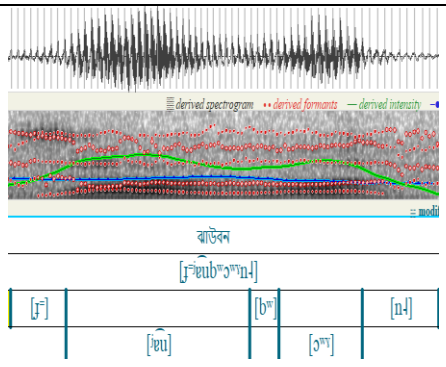
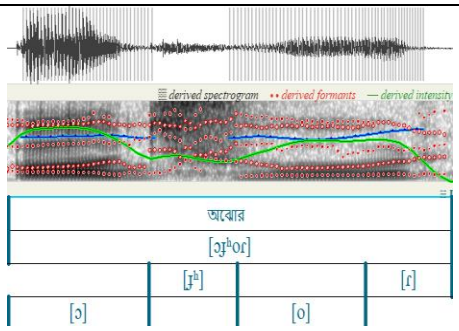
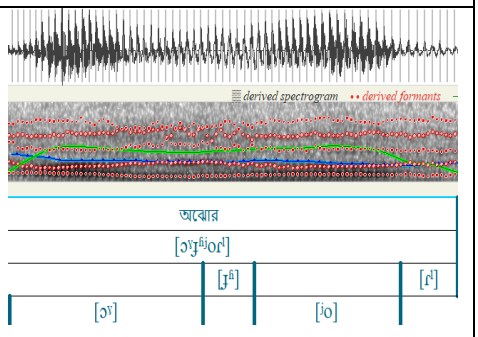
Typical Speech	*Atypical Speech*
	

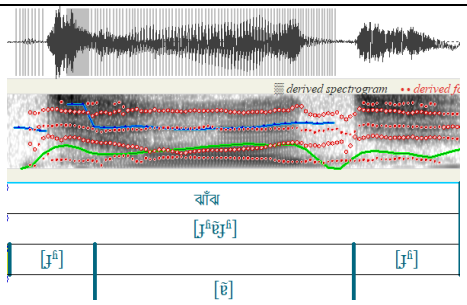
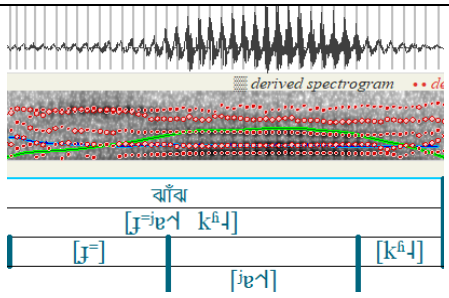
Figure 153 (a): Oscillogram of ঝাউবন, [ɟʱɐ͡ubɔn]	Figure 153 (b): Oscillogram of ঝাউবন, [ɟ⁼ʲɐ͡ubʷɔʷʸn̪ˌ]
It shows a PRAAT illustration of the word ঝাউবন which is displayed in the Interval Tier 01: Bangla Text Word ‘ঝাউবন’, and its transcription is in Interval Tier 02: IPA: [ɟʱɐ͡ubɔn]. Point Tier 01: Consonants [ɟʱ], [b], [n] and Point Tier 02: Vowel: [ɔ], [ɐ͡u], 16a focuses on the sound, [ɟʱ] or [dʑʱ] which appears at the beginning of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiced sound which is of 0.11 seconds, 62 dB, 224 Hz.	Here, [ɟʱ] or [dʑʱ] appears at the beginning of the word. It’s 0.34 seconds, 58 dB, 187 Hz. It is unaspirated. The atypical IPA is [ɟ⁼ʲɐ͡ubʷɔʷʸn̪ˌ]. Other features include: pre-palatalization with [ʲɐ͡u], labialization with [bʷ], labialization and velarization with [ɔʷʸ], low voice with [n̪ˌ]. Note: b [ɟʱ] = atypical, distortion (unaspirated), also could be noted as omission

Data Display 16 (b)

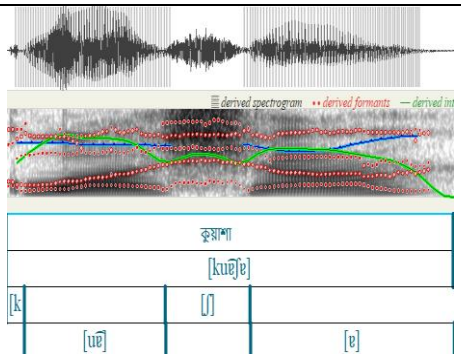
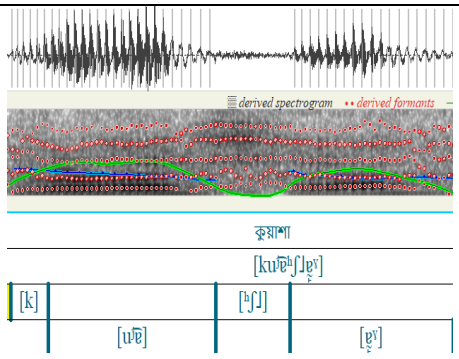
Typical Speech	*Atypical Speech*
	
Figure 154 (a): Oscillogram of অঝোর, [ɔɟʱoɾ]	Figure 154 (b): Oscillogram of অঝোর, [ɔʸɟʱʲoɾˡ]
It shows a PRAAT illustration of the word অঝোর which is displayed in the Interval Tier 01: Bangla Text Word ‘অঝোর’, and its transcription is in Interval Tier 02: IPA: [ɔɟʱoɾ]. Point Tier 01: Consonants [ɟʱ], [ɾ]	Here, [ɟʱ] or [dʑʱ] appears in the middle of the word. It’s 0.1 seconds, 53 dB, 167 Hz. It is a typical sound. The atypical IPA is [ɔʸɟʱʲoɾˡ]. Other features include: velarization with [ɔʸ], pre-

and Point Tier 02: Vowel: [ɔ], [o], 16b focuses on the sound, [ɻʱ] or [d̪ʑʱ] which appears in the middle of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiced sound which is of 0.11 seconds, 64 dB, 224 Hz.	palatalization with [ʲo], and lateral release with [ɾˡ]. Note: m [ɻʱ] = typical

Data Display 16 (c)

Typical Speech	*Atypical Speech*
	
Figure 155 (a): Oscillogram of ঝাঁঝ, [ɻʱɐ̃ɻʱ] It shows a PRAAT illustration of the word ঝাঁঝ which is displayed in the Interval Tier 01: Bangla Text Word ‘ঝাঁঝ’, and its transcription is in Interval Tier 02: IPA: [ɻʱɐ̃ɻʱ]. Point Tier 01: Consonants [ɻʱ] and Point Tier 02: Vowel: [ɐ̃], 16c focuses on the sound, [ɻʱ] or [d̪ʑʱ] which appears at the end of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiced sound which is of 0.11 seconds, 64 dB, 224 Hz.	Figure 155 (b): Oscillogram of ঝাঁঝ, [ɻ⁼ʲɐˤ˥kʱɬ] Here, [ɻʱ] or [dʑʱ] appears at the end of the word. It’s 0.11 seconds, 53 dB, 167 Hz. It shows substitution, breathy voice, and low tone with [kʱɬ] . The atypical IPA is [ɻ⁼ʲɐˤ˥kʱɬ]. Other features include: unaspirated sound with [ɻ⁼], pre-palatalization and rising-falling with [ʲɐˤ˥]. Note: e [ɻʱ] = atypical, substitution, also could be noted for distortion (breathy voice, and low tone)

Data Display 17 (a)

Typical Speech	*Atypical Speech*
	
Figure 156 (a): Oscillogram of কুয়াশা, [kuɐ͡ɐʃɐ]	Figure 156 (b): Oscillogram of কুয়াশা, [kuʲɐ͡ʰʃɻ̟ɐ̟ˠ]
It shows a PRAAT illustration of the word কুয়াশা which is displayed in the Interval Tier 01: Bangla Text Word 'কুয়াশা', and its transcription is in Interval Tier 02: IPA: [kuɐ͡ɐʃɐ]. Point Tier 01: Consonants [k], [ʃ] and Point Tier 02: Vowel: [ɐ], [uɐ͡], 17a focuses on the sound, [k] which appears at the beginning of the word. It is a pulmonic egressive, velar, voiceless sound which is of 0.08 seconds, 70 dB, 273 Hz.	Here, [k] appears at the beginning of the word. It's 0.09 seconds, 58 dB, 217 Hz. It is a typical [k] sound. The atypical IPA is [kʊ̟͡ɐˤʃɻ̟ɐ̟ˠ]. Other features: palatalization and aspiration with [uʲɐ͡ʰ], extra-low tone of [ʃɻ], retracted tongue root position, creaky voice and velarization of [ɻ̟ɐ̟ˠ]. Note: b [k] = typical

Data Display 17 (b)

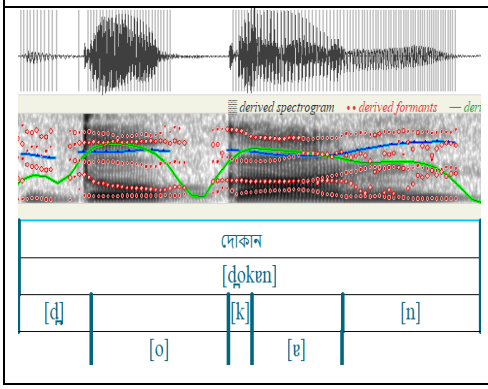
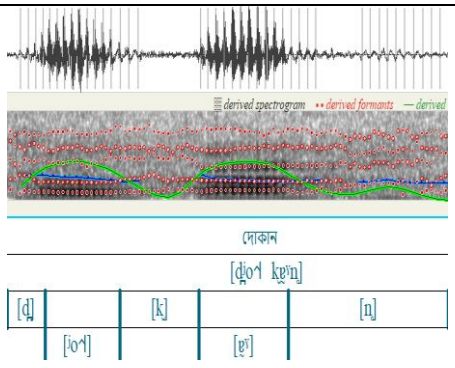
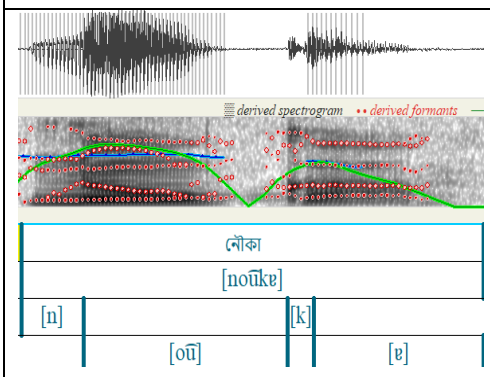
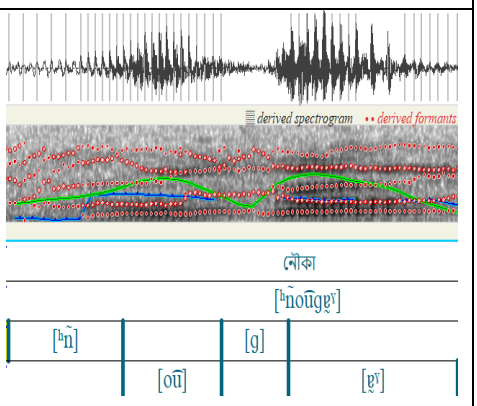
Typical Speech	*Atypical Speech*
	

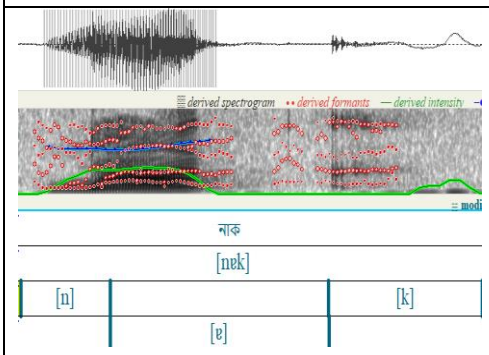
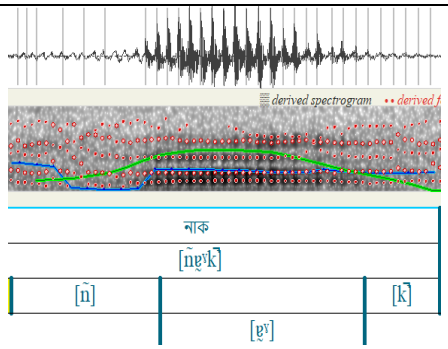
Figure 157 (a): Oscillogram of দোকান, [d̪okɐn]	Figure 157 (b): Oscillogram of দোকান, [d̪ʲoˤkx̟ɐˠn̥]
It shows a PRAAT illustration of the word দোকান which is displayed in the Interval Tier 01: Bangla Text Word 'দোকান', and its transcription is in Interval Tier 02: IPA: [d̪okɐn]. Point Tier 01: Consonants [d̪], [k], [n] and Point Tier 02: Vowel: [o], [ɐ], 17b focuses on the sound, [k] which appears in the middle of the word. It is a pulmonic egressive, velar, voiceless sound which is of 0.4 seconds, 77 dB, 255 Hz.	Here, [k] appears in the middle of the word. It's 0.11 seconds, 62 dB, 196 Hz. It has a voiced [k] sound. The atypical IPA is [d̪ʲoˤkx̟ɐˠn̥]. Other features include: pre-palatalization and rising-falling with [ʲoˤ], velarization and creaky voice with [ɐˠ], voiceless [n̥]. Note: m [k] = atypical, distortion (voiced)

Data Display 17 (c)

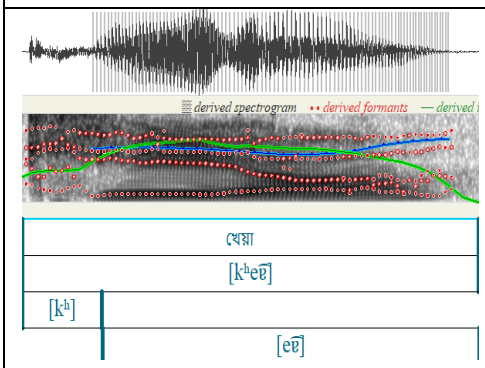
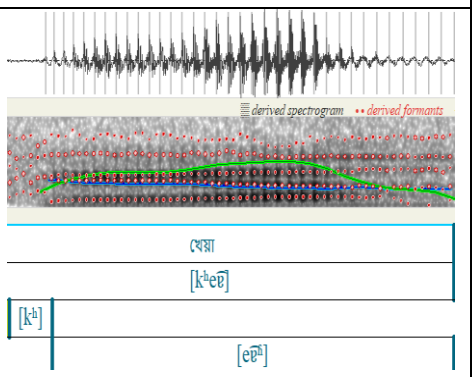
Typical Speech	*Atypical Speech*
	
Figure 158 (a): Oscillogram of নৌকা, [no͡ukɐ]	Figure 158 (b): Oscillogram of নৌকা, [ʰño͡ugɐˠ]
It shows a PRAAT illustration of the word নৌকা which is displayed in the Interval Tier 01: Bangla Text Word 'নৌকা', and its transcription is in Interval Tier 02: IPA: [no͡ukɐ]. Point Tier 01: Consonants [n], [k]	Here, [k] appears at the end of the word. It's 0.11 seconds, 62 dB, 196 Hz. It shows substitution. The atypical IPA is [ʰño͡ugɐˠ]. Other features include: pre-aspiration, nasalization of [ʰñ], velarization

and Point Tier 02: Vowel: [ɐ], [o͡u], 17c focuses on the sound, [k] which appears at the end of the word. It is a pulmonic egressive, velar, voiceless sound which is of 0.4 seconds, 77 dB, 255 Hz.	and creaky-voice with [ɰ̰ˠ]. Note: e [k] = atypical, substitution

Data Display 17 (d)

Typical Speech	*Atypical Speech*
	
Figure 159 (a): Oscillogram of নাক, [nɐk] It shows a PRAAT illustration of the word নাক which is displayed in the Interval Tier 01: Bangla Text Word 'নাক', and its transcription is in Interval Tier 02: IPA: [nɐk]. Point Tier 01: Consonants [n], [k] and Point Tier 02: Vowel: [ɐ], 17d focuses on the sound, [k] which appears at the end of the word. It is a pulmonic egressive, velar, voiceless sound which is of 0.4 seconds, 77 dB, 255 Hz.	Figure 159 (b): Oscillogram of নাক, [ñɐ̰ˠk̚] Here, [k] appears at the end of the word. It's 0.11 seconds. It has no audible release. The atypical IPA is [ñɐ̰ˠk̚]. Other features include: nasalization of [ñ], velarization and creaky voice with [ɰ̰ˠ]. Note: e [k] = atypical, omission (no audible release)

Data Display 18 (a)

Typical Speech	*Atypical Speech*
	
Figure 160 (a): Oscillogram of খেয়া, [kʰe̯ɐ̯]	Figure 160 (b): Oscillogram of খেয়া, [kʰe̯ɐ̯ʱ]
It shows a PRAAT illustration of the word খেয়া which is displayed in the Interval Tier 01: Bangla Text Word 'খেয়া', and its transcription is in Interval Tier 02: IPA: [kʰe̯ɐ̯]. Point Tier 01: Consonants [kʰ] and Point Tier 02: Vowel: [e̯ɐ̯], 18a focuses on the sound [kʰ], which appears at the beginning of the word. It is a pulmonic egressive, velar, voiceless sound which is of 0.08 seconds, 67 dB, 261 Hz.	Here, [kʰ] appears at the beginning of the word. It's 0.18 seconds, 63 dB, 199 Hz. It shows a typical sound. The atypical IPA is [kʰe̯ɐ̯ʱ]. Other features include: breathy voice aspiration of [e̯ɐ̯ʱ]. Note: b [kʰ] = typical

Data Display 18 (b)

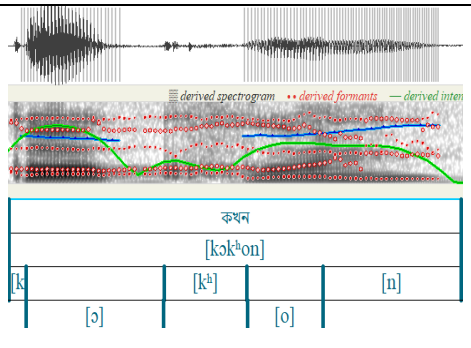
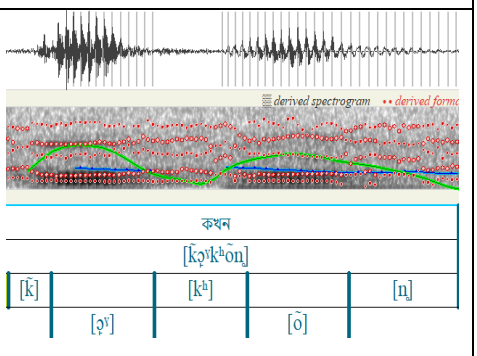
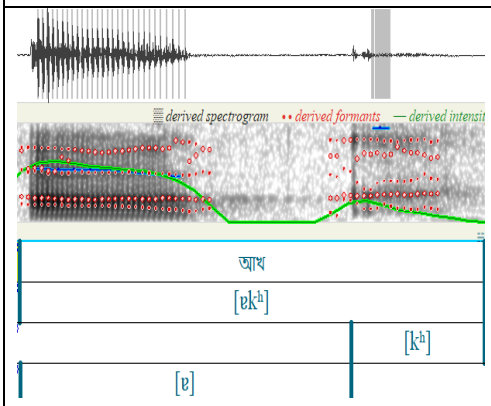
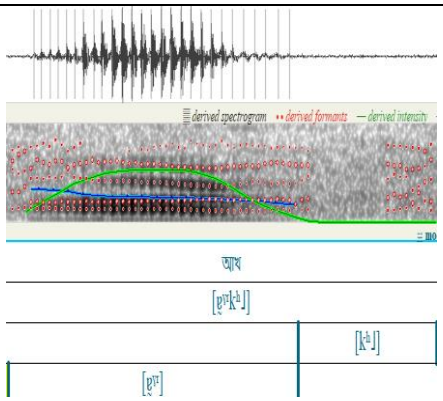
Typical Speech	*Atypical Speech*
	

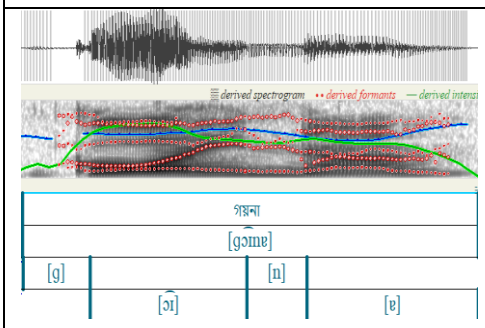
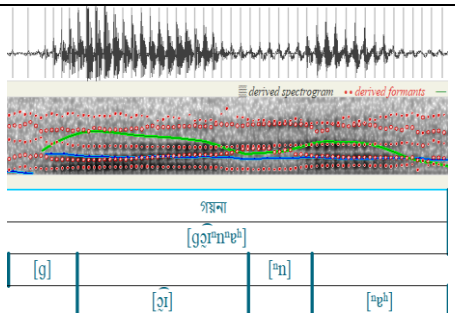
Figure 161 (a): Oscillogram of কখন, [kɔkʰon]	Figure 161 (b): Oscillogram of কখন, [k̃ɔ̰ʏkʰõn̰]
It shows a PRAAT illustration of the word কখন which is displayed in the Interval Tier 01: Bangla Text Word 'কখন', and its transcription is in Interval Tier 02: IPA: [kɔkʰon]. Point Tier 01: Consonants [k], [kʰ], [n] and Point Tier 02: Vowel: [ɔ], [o], 18b focuses on the sound [kʰ], which appears in the middle of the word. It is a pulmonic egressive, velar, voiceless sound which is of 0.1 seconds, 59 dB, 251 Hz.	Here, [kʰ] appears in the middle of the word. It's 0.3 seconds, 60 dB, 194 Hz. It shows nasalization. The atypical IPA is [k̃ɔ̰ʏkʰõn̰]. Other features include: velarization and retracted tongue root position with [ɔ̰ʏ], nasalization of [õ], and voicelessness of [n̰]. Note: m [kʰ] = atypical, distortion (nasalization)

Data Display 18 (c)

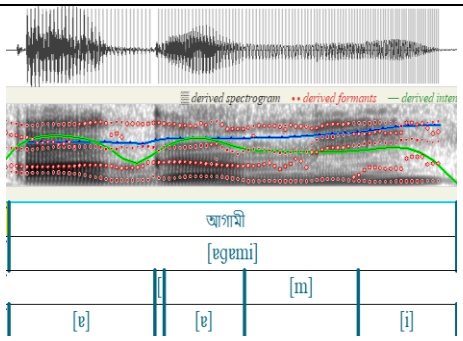
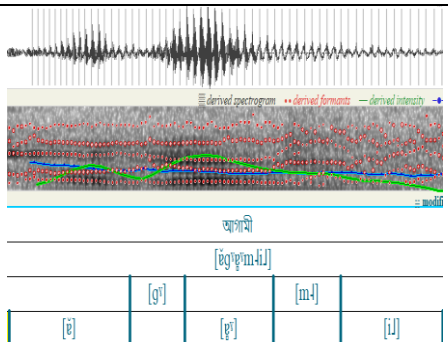
Typical Speech	*Atypical Speech*
	
Figure 162 (a): Oscillogram of আখ, [ɐkʰ]	Figure 162 (b): Oscillogram of আখ, [ɐ̯ʏrkʰ˩]
It shows a PRAAT illustration of the word আখ which is displayed in the Interval Tier 01: Bangla Text Word 'আখ', and its transcription is in Interval Tier 02: IPA: [ɐkʰ]. Point	Here, [kʰ] appears at the end of the word. It's 0.3 seconds, 57 dB, 181 Hz. It has extra low tone. The atypical IPA is [ɐ̯ʏrkʰ˩]. Other features include: velarization, rhotic feature and creaky voice

Tier 01: Consonants [kʰ] and Point Tier 02: Vowel: [ɐ], 18c focuses on the sound [kʰ], which appears at the end of the word. It is a pulmonic egressive, velar, voiceless sound which is of 0.12 seconds, 56 dB, 178 Hz.	with [ɡ̟ʸʳ]. Note: e [kʰ] = atypical, distortion (extra low tone)

Data Display 19 (a)

Typical Speech	*Atypical Speech*
	
Figure 163 (a): Oscillogram of গয়না, [gɔ͡ɪnɐ] It shows a PRAAT illustration of the word গয়না which is displayed in the Interval Tier 01: Bangla Text Word 'গয়না', and its transcription is in Interval Tier 02: IPA: [gɔ͡ɪnɐ]. Point Tier 01: Consonants [g], [n] and Point Tier 02: Vowel: [ɐ], [ɔ͡ɪ], 19a focuses on the sound [g], which appears at the beginning of the word. It is a pulmonic egressive, velar, voiced sound which is of 0.09 seconds, 67 dB, 202 Hz.	Figure 163 (b): Oscillogram of গয়না, [gɔ̟͡ɪⁿnⁿɐʰ] Here, [g] appears at the beginning of the word. It's 0.05 seconds, 67 dB, 199 Hz. It shows a typical sound. The atypical IPA is [gɔ̟͡ɪⁿnⁿɐʰ]. Other features include: creaky voiced [ɔ̟͡ɪ], pre-nasal release [ⁿn], pre-nasal release and aspiration with [ⁿɐʰ]. Note: b [g] = typical

Data Display 19 (b)

Typical Speech	*Atypical Speech*
	
Figure 164 (a): Oscillogram of আগামী, [ɐgɐmi]	Figure 164 (b): Oscillogram of আগামী, [ɐ̆gˠɐ̟ˠmɬi˩]
It shows a PRAAT illustration of the word আগামী which is displayed in the Interval Tier 01: Bangla Text Word 'আগামী', and its transcription is in Interval Tier 02: IPA: [ɐgɐmi]. Point Tier 01: Consonants [g], [m] and Point Tier 02: Vowel: [ɐ], [i], 19b focuses on the sound [g], which appears in the middle of the word. It is a pulmonic egressive, velar, voiced sound which is of 0.3 seconds, 72 dB, 239 Hz.	Here, [g] appears in the middle of the word. It's 0.07 seconds, 63 dB, 200 Hz. It has velarization. The atypical IPA is [ɐ̆gˠɐ̟ˠmɬi˩]. Other features include: rising tone for [ɐ̆], velarized laminal [ɐ̟ˠ], low toned [mɬ], and extra low toned [i˩]. Note: m [g] = atypical, distortion (velarization)

Data Display 19 (c)

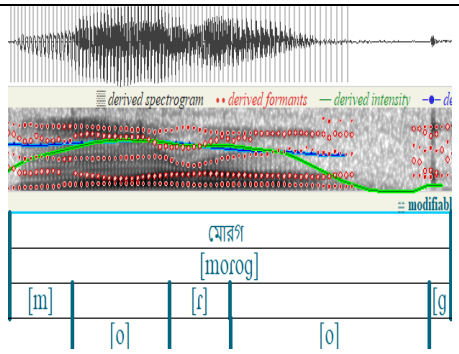
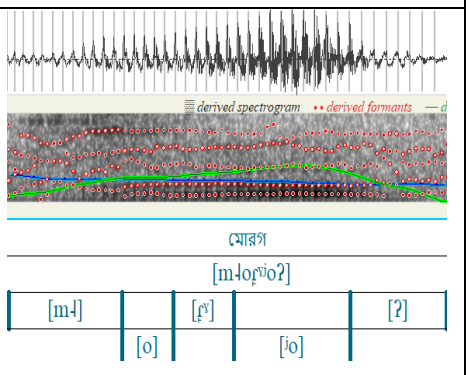
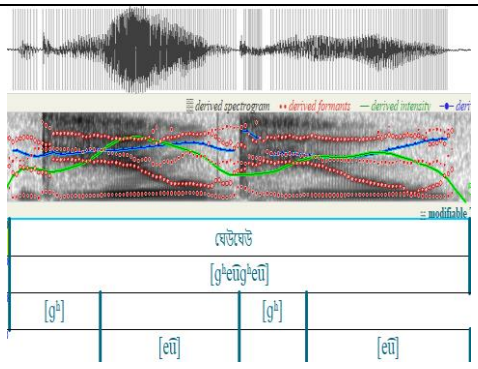
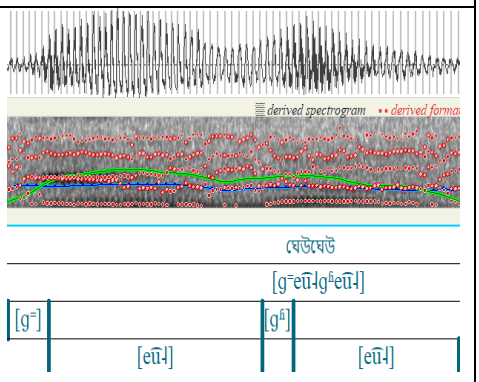
Typical Speech	*Atypical Speech*
	

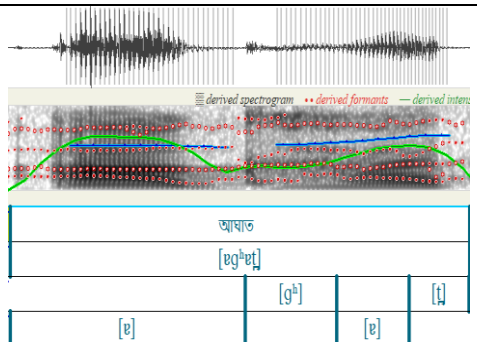
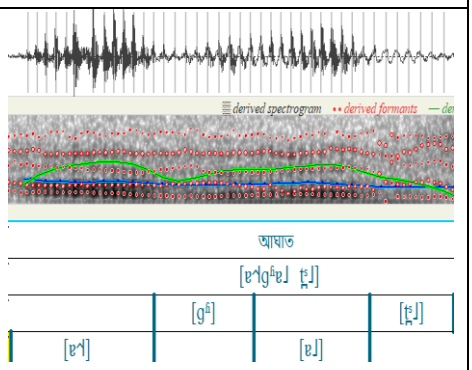
Figure 165 (a): Oscillogram of মোরগ, [moɾog] It shows a PRAAT illustration of the word মোরগ which is displayed in the Interval Tier 01: Bangla Text Word 'মোরগ', and its transcription is in Interval Tier 02: IPA: [moɾog]. Point Tier 01: Consonants [m], [ɾ], [g] and Point Tier 02: Vowel: [o], 19c focuses on the sound [g], which appears at the end of the word. It is a pulmonic egressive, velar, voiced sound which is of 0.6 seconds, 52 dB, 150 Hz.	Figure 165 (b): Oscillogram of মোরগ, [m˧oɾˠʲoʔ] Here, [g] appears at the end of the word. It's 0.3 seconds. It shows a substitution with a glottal stop. The atypical IPA is [m˧oɾˠʲoʔ]. Other features include: low tone with [m˧], velarization and retracted tongue root position with [ɾˠ], pre-palatalization with [ʲo]. Note: e [g] = atypical, substitution (with a glottal stop)

Data Display 20 (a)

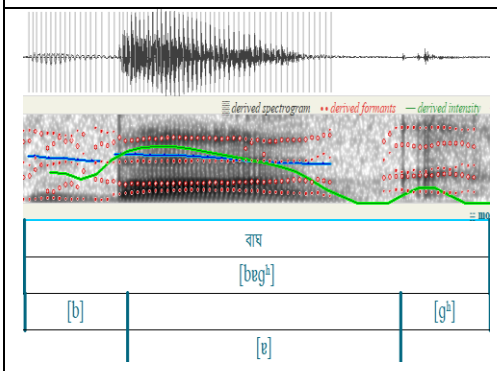
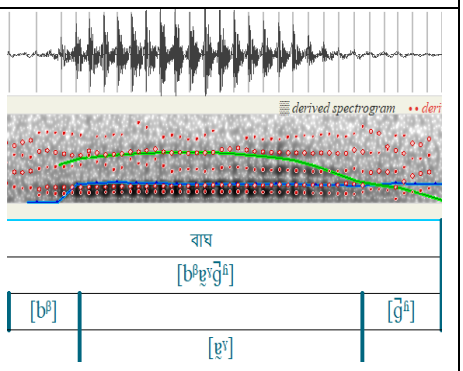
Typical Speech	*Atypical Speech*
	
Figure 166 (a): Oscillogram of ঘেউঘেউ, [gʱe͡ugʱe͡u] It shows a PRAAT illustration of the word ঘেউঘেউ which is displayed in the Interval Tier 01: Bangla Text Word 'ঘেউঘেউ', and its transcription is in Interval Tier 02: IPA: [gʱe͡ugʱe͡u]. Point Tier 01:	Figure 166 (b): Oscillogram of ঘেউঘেউ, [g⁼e͡u˧gʱe͡u˧] Here, [gʱ] appears at the beginning of the word. It's 0.2 seconds, 56 dB, 189 Hz. It shows substitution with unaspirated [g⁼]. The atypical IPA is [g⁼e͡u˧gʱe͡u˧]. Other features include: low tone for [e͡u˧].

Consonants [gʱ], [gʱ] and Point Tier 02: Vowel: [e͡u], 20a focuses on the sound [gʱ], which appears at the beginning of the word. It is a pulmonic egressive, velar, voiced sound which is of 0.23 seconds, 67 dB, 212 Hz.	Note: b [gʱ] = atypical, substitution (with unaspiration), it can also be noted as omission (of aspiration)

Data Display 20 (b)

Typical Speech	*Atypical Speech*
	
Figure 167 (a): Oscillogram of আঘাত, [ɐgʱɐt̪]	Figure 167 (b): Oscillogram of আঘাত, [ɐˤlgʱɐɻt̪ˢɻ]
It shows a PRAAT illustration of the word আঘাত which is displayed in the Interval Tier 01: Bangla Text Word 'আঘাত', and its transcription is in Interval Tier 02: IPA: [ɐgʱɐt̪]. Point Tier 01: Consonants [gʱ], [t̪] and Point Tier 02: Vowel: [ɐ], 20b focuses on the sound [gʱ], which appears in the middle of the word. It is a pulmonic egressive, velar, voiced sound which is of 0.34 seconds, 63 dB, 223 Hz.	Here, [gʱ] appears in the middle of the word. It's 0.2 seconds, 61 dB, 187 Hz. It has a typical sound. The atypical IPA is [ɐˤlgʱɐɻt̪ˢɻ]. Other features include: rising-falling with [ɐˤ], extra low tone with [ɐɻ], extra low tone and fricative release with [t̪ˢɻ]. Note: m [gʱ] = typical

Data Display 20 (c)

Typical Speech	*Atypical Speech*
	
Figure 168 (a): Oscillogram of বাঘ, [bɐgʱ]	Figure 168 (b): Oscillogram of বাঘ, [bᵝɸᵛg̈ʱ]
It shows a PRAAT illustration of the word বাঘ which is displayed in the Interval Tier 01: Bangla Text Word 'বাঘ', and its transcription is in Interval Tier 02: IPA: [bɐgʱ]. Point Tier 01: Consonants [b], [gʱ] and Point Tier 02: Vowel: [ɐ], 20c focuses on the sound [gʱ], which appears at the end of the word. It is a pulmonic egressive, velar, voiced sound which is of 0.09 seconds, 57 dB, 150 Hz.	Here, [gʱ] appears at the end of the word. It's 0.3 seconds. It has no audible release. The atypical IPA is [bᵝɸᵛg̈ʱ]. Other features include: lip compression with [bᵝ], velarization and creaky voice with [ɸᵛ]. Note: e [gʱ] = atypical, omission (no audible release)

Data Display 21 (a)

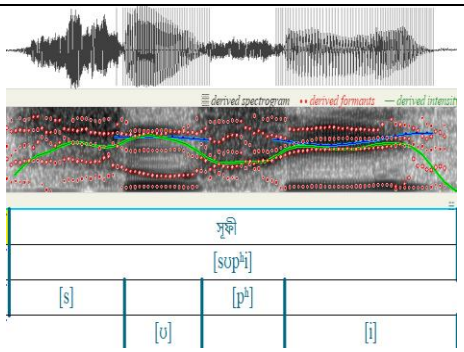
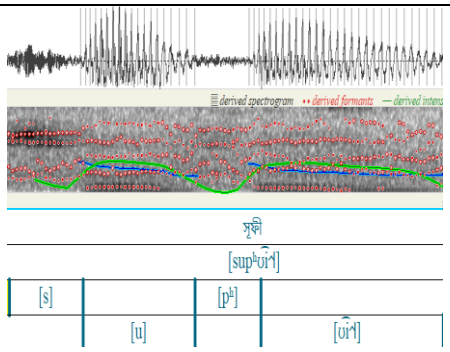
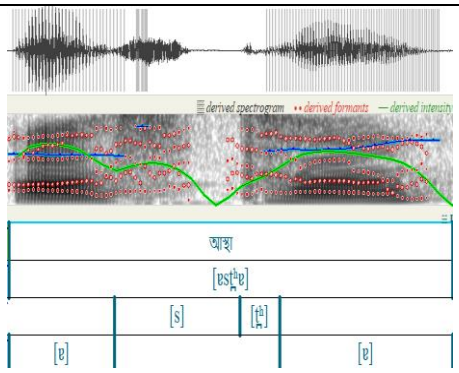
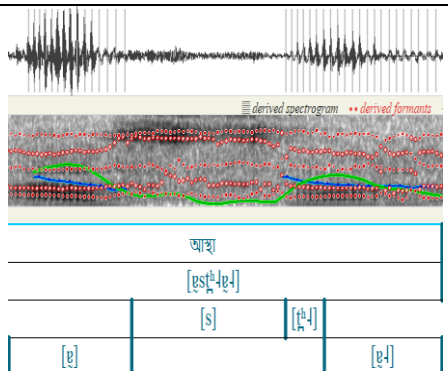
Typical Speech	*Atypical Speech*
	

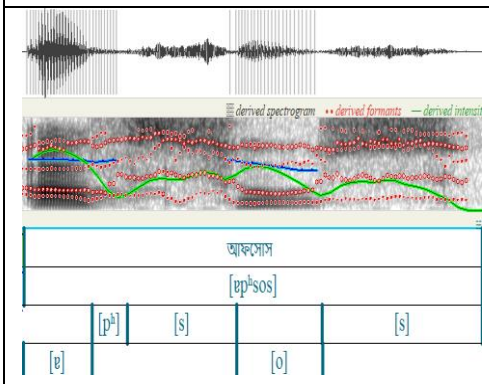
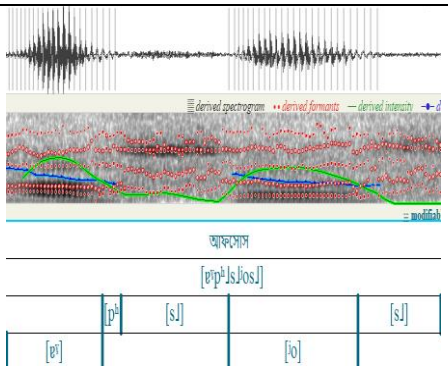
Figure 169 (a): Oscillogram of সূফী, [supʰi]	Figure 169 (b): Oscillogram of সূফী, [supʰʊ̀i˧]
It shows a PRAAT illustration of the word সূফী which is displayed in the Interval Tier 01: Bangla Text Word 'সূফী', and its transcription is in Interval Tier 02: IPA: [supʰi]. Point Tier 01: Consonants [s], [pʰ] and Point Tier 02: Vowel: [u], [i], 21a focuses on the sound [s], which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.22 seconds, 70 dB, 303 Hz.	Here, [s] appears at the beginning of the word. It's 0.3 seconds, 131 Hz, 58 dB. It shows typical [s] sound. The atypical IPA is [supʰʊ̀i˧]. Other features include: addition [ʊ̀], added with [i˧] with a rising-falling tone. Note: b [s] = typical

Data Display 21 (b)

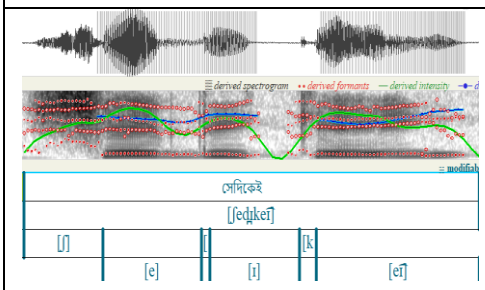
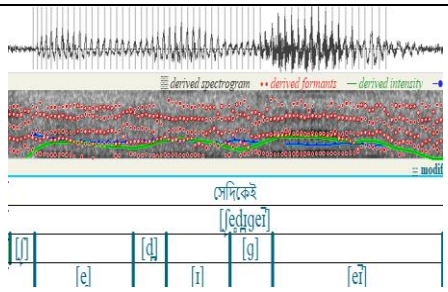
Typical Speech	*Atypical Speech*
	
Figure 170 (a): Oscillogram of আস্থা, [ɐst̪ʰɐ]	Figure 170 (b): Oscillogram of আস্থা, [ɐ̰st̪ʰɹ̰ɐ̰ɹ̰]
It shows a PRAAT illustration of the word আস্থা which is displayed in the Interval Tier 01: Bangla Text Word 'আস্থা', and its transcription is in Interval Tier 02: IPA: [ɐst̪ʰɐ]. Point Tier 01: Consonants [s], [t̪ʰ] and	Here, [s] appears in the middle of the word. It's 0.4 seconds, 60 dB, 183 Hz. It is a typical [s] sound. The atypical IPA is [ɐ̰st̪ʰɹ̰ɐ̰ɹ̰]. Other features include: creaky voiced with [ɐ̰] and creaky voiced

Point Tier 02: Vowel: [ɐ], 21b focuses on the sound [s], which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.16 seconds, 76 dB, 220 Hz.	low tone with [ɐ̗˩]. Note: m [s] = typical

Data Display 21 (c)

Typical Speech	*Atypical Speech*
	
Figure 171 (a): Oscillogram of আফসোস, [ɐpʰsos]	Figure 171 (b): Oscillogram of আফসোস, [ɐˠpʰ˩sʲ˩os˩]
It shows a PRAAT illustration of the word আফসোস which is displayed in the Interval Tier 01: Bangla Text Word 'আফসোস', and its transcription is in Interval Tier 02: IPA: [ɐpʰsos]. Point Tier 01: Consonants [pʰ], [s], [s] and Point Tier 02: Vowel: [ɐ], [o], 21c focuses on the sound [s], which appears at the end of the word. It is a pulmonic egressive, alveolar, voiceless sound which is of 0.16 seconds, 67 dB, 224 Hz.	Here, [s] appears at the end of the word. It's 0.2 seconds, 50 dB, 201 Hz. It has a typical [s] sound. The atypical IPA is [ɐˠpʰ˩sʲ˩os˩]. Other features include: velarization with [ɐˠ], extra low tone with [pʰ˩], and [sʲ˩], pre-palatalization [ʲo]. Note: e [s] = typical

Data Display 22 (a)

Typical Speech	*Atypical Speech*
	
Figure 172 (a): Oscillogram of সেদিকেই, [ʃeɖɪkeɪ̯]	Figure 172 (b): Oscillogram of সেদিকেই, [ʃ̟e̪ɖ̪ɪgeɪ̯̃]
It shows a PRAAT illustration of the word সেদিকেই which is displayed in the Interval Tier 01: Bangla Text Word 'সেদিকেই', and its transcription is in Interval Tier 02: IPA: [ʃeɖɪkeɪ̯]. Point Tier 01: Consonants [ʃ], [ɖ], [k] and Point Tier 02: Vowel: [e], [ɪ], [eɪ̯], 22a focuses on the sound [ʃ], which appears at the beginning of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiceless sound which is of 0.13 seconds, 76 dB, 281 Hz.	Here, [ʃ] appears at the beginning of the word. It's 0.3 seconds, 58 dB, 208 Hz. It has retracted tongue root position. The atypical IPA is [ʃ̟e̪ɖ̪ɪgeɪ̯̃]. Other features include: laminal [e̪], substitution with [g], and no audible release of [ɪ̃]. Note: b [ʃ] = atypical, distortion (retracted tongue root position)

Data Display 22 (b)

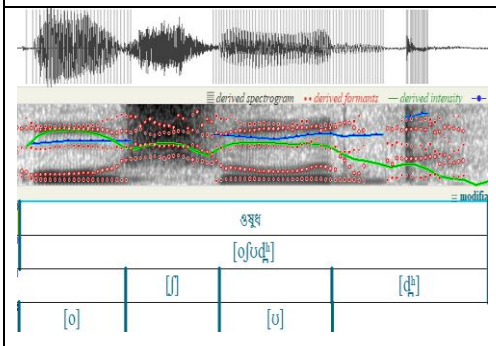
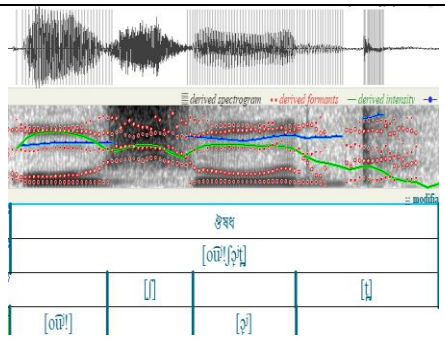
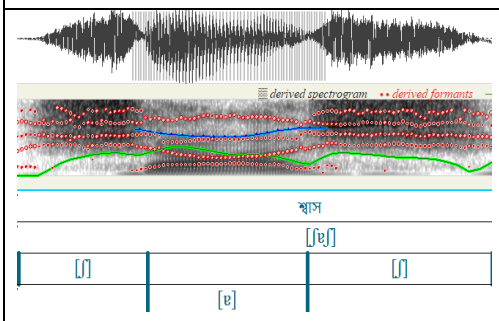
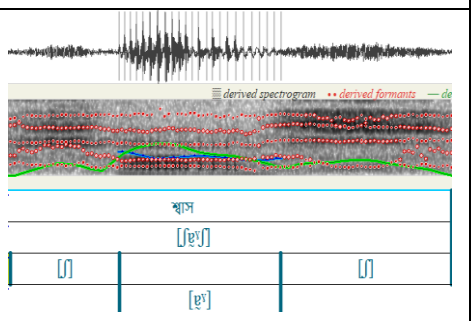
Typical Speech	*Atypical Speech*
	

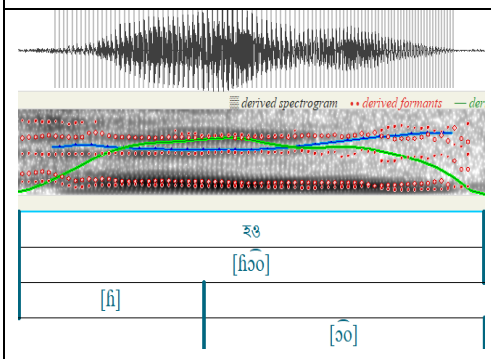
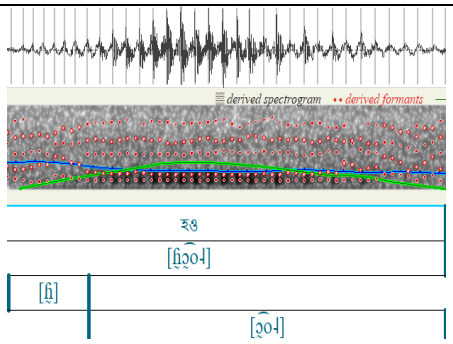
Figure 173 (a): Oscillogram of ওষুধ, [oʃuɖʰ]	Figure 173 (b): Oscillogram of ঔষধ, [o͡uʲˈʃ̟ʲt̪]
It shows a PRAAT illustration of the word ওষুধ which is displayed in the Interval Tier 01: Bangla Text Word ‘ওষুধ’, and its transcription is in Interval Tier 02: IPA: [oʃuɖʰ]. Point Tier 01: Consonants [ʃ], [ɖʰ] and Point Tier 02: Vowel: [o], [u] 22b focuses on the sound [ʃ], which appears in the middle of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiceless sound which is of 0.12 seconds, 72 dB, 283 Hz.	Here, [ʃ] appears in the middle of the word. It’s 0.11 seconds, 53 dB, 174 Hz. It shows a typical sound. The atypical IPA is [o͡uʲˈʃ̟ʲt̪]. Other features include: palatalization and post-alveolar click with [o͡uʲˈ], palatalization and retracted tongue root position with [ʃ̟ʲ], substitution with [t̪]. Note: m [ʃ] = typical

Data Display 22 (c)

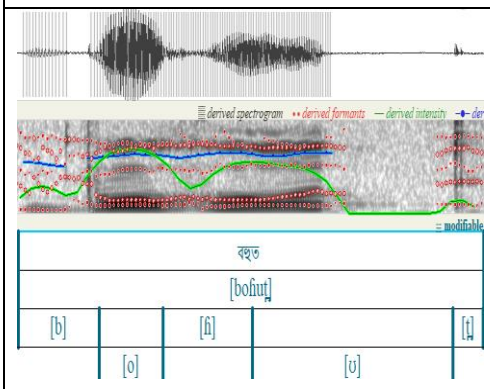
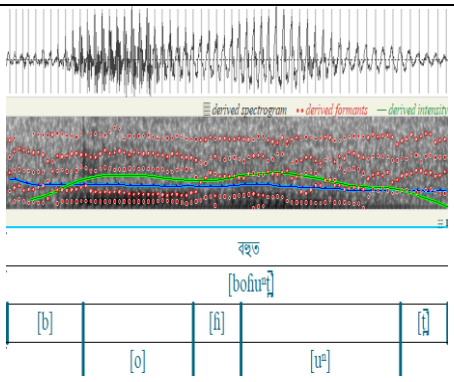
Typical Speech	*Atypical Speech*
	
Figure 174 (a): Oscillogram of শ্বাস, [ʃɐʃ]	Figure 174 (b): Oscillogram of শ্বাস, [ʃɐˠʃ]
It shows a PRAAT illustration of the word শ্বাস which is displayed in the Interval Tier 01: Bangla Text Word ‘শ্বাস’, and its transcription is in Interval Tier 02: IPA: [ʃɐʃ]. Point Tier 01: Consonants [ʃ], [ʃ] and	Here, [ʃ] appears at the end of the word. It’s 0.3 seconds, 60 dB, 183 Hz. It is a typical sound. The atypical IPA is [ʃɐˠʃ]. Other features include: velarization and creaky voice for [ɐˠ].

Point Tier 02: Vowel: [ɐ] 22c focuses on [ʃ], which appears at the end of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiceless sound which is of 0.12 seconds, 72 dB, 283 Hz.	Note: e [ʃ] = typical

Data Display 23 (a)

Typical Speech	*Atypical Speech*
	
Figure 175 (a): Oscillogram of হও, [ɦɔ͡o] It shows a PRAAT illustration of the word হও which is displayed in the Interval Tier 01: Bangla Text Word 'হও', and its transcription is in Interval Tier 02: IPA: [ɦɔ͡o]. Point Tier 01: Consonants [ɦ] and Point Tier 02: Vowel: [ɔ͡o], 23a focuses on the sound [ɦ], which appears at the beginning of the word. It is a pulmonic egressive, glottal, voiceless sound which is of 0.17 seconds, 78 dB, 224 Hz.	Figure 175 (b): Oscillogram of হও, [ɦ̰ɔ͡o˩] Here, [ɦ] appears at the beginning of the word. It's 0.2 seconds, 56 dB, 255 Hz. It shows creaky voice. The atypical IPA is [ɦ̰ɔ͡o˩]. Other features include: creaky voice and low tone with [ɔ͡o˩]. Note: b [ɦ] = atypical, distortion (creaky voice)

Data Display 23 (b)

Typical Speech	*Atypical Speech*
	
Figure 176 (a): Oscillogram of বহুত, [boɦut̪]	Figure 176 (b): Oscillogram of বহুত, [boɦuⁿt̪̄]
It shows a PRAAT illustration of the word বহুত which is displayed in the Interval Tier 01: Bangla Text Word 'বহুত', and its transcription is in Interval Tier 02: IPA: [boɦut̪]. Point Tier 01: Consonants [b], [ɦ], [t̪] and Point Tier 02: Vowel: [o], [u], 23b focuses on the sound [ɦ], which appears in the middle of the word. It is a pulmonic egressive, glottal, voiceless sound which is of 0.13 seconds, 64 dB, 265 Hz.	Here, [ɦ] appears in the middle of the word. It's 0.09 seconds, 65 dB, 183 Hz. It is a typical sound. The atypical IPA is [boɦuⁿt̪̄]. Other features include: nasal release of /uⁿ/ and no audible release of [t̪̄]. Note: m [ɦ] = typical

Data Display 23 (c)

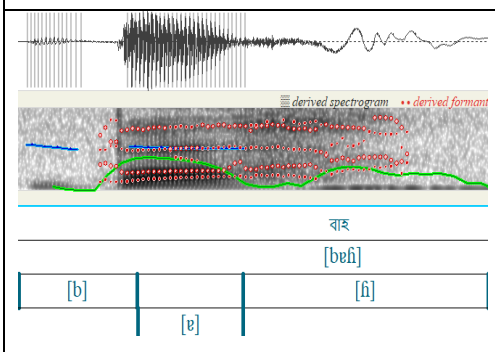
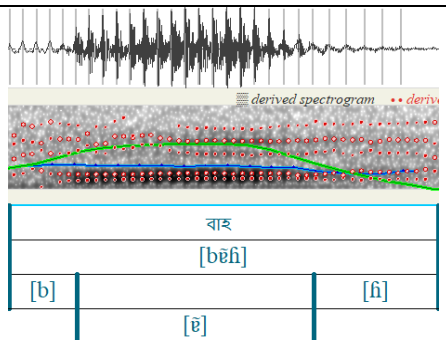
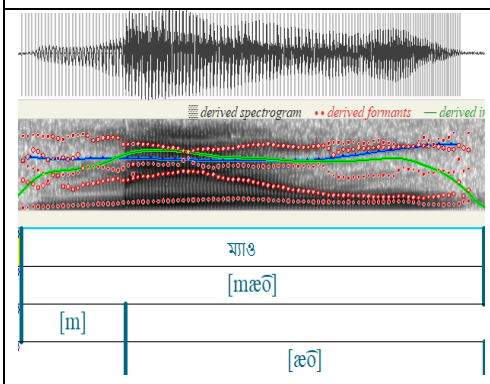
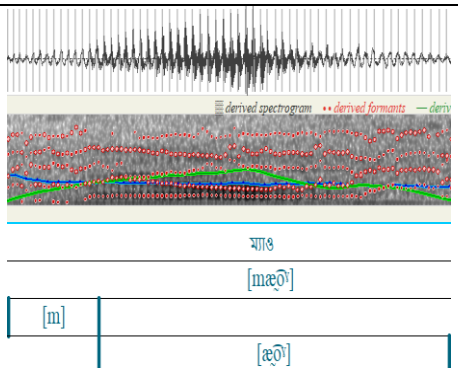
Typical Speech	*Atypical Speech*
	

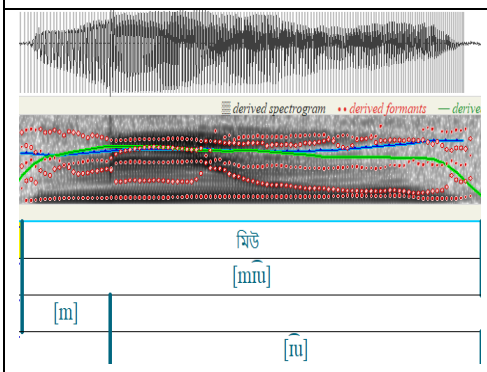
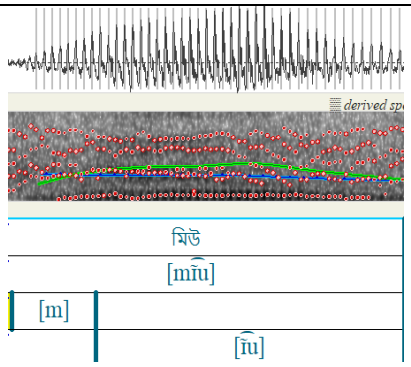
Figure 177 (a): Oscillogram of বাহ, [bɐɦ] It shows a PRAAT illustration of the word বাহ which is displayed in the Interval Tier 01: Bangla Text Word 'বাহ', and its transcription is in Interval Tier 02: IPA: [bɐɦ]. Point Tier 01: Consonants [b], [ɦ] and Point Tier 02: Vowel: [ɐ], 23c focuses on the sound [ɦ], which appears at the end of the word. It is a pulmonic egressive, glottal, voiceless sound which is of 0.13 seconds, 64 dB, 265 Hz.	Figure 177 (b): Oscillogram of বাহ, [bɐ̃ɦ] Here, [ɦ] appears at the end of the word. It's 0.2 seconds. It shows a typical sound. The atypical IPA is [bɐ̃ɦ]. Other features include: nasalization of [ɐ̃]. Note: e [ɦ] = typical

Data Display 24 (a)

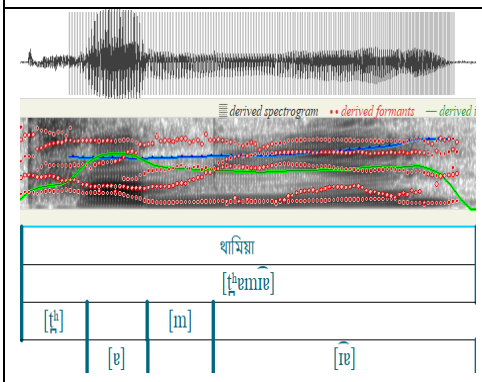
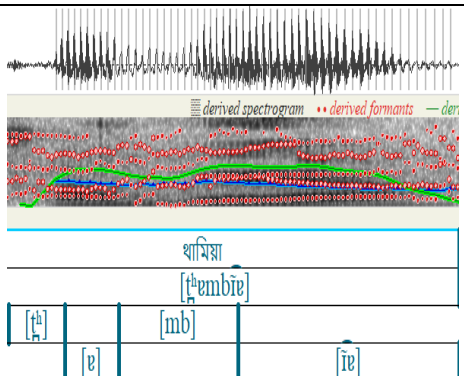
Typical Speech	*Atypical Speech*
	
Figure 178 (a): Oscillogram of ম্যাও, [mæ͡o] It shows a PRAAT illustration of the word ম্যাও which is displayed in the Interval Tier 01: Bangla Text Word 'ম্যাও', and its transcription is in Interval Tier 02: IPA: [mæ͡o]. Point Tier 01: Consonants [m] and	Figure 178 (b): Oscillogram of ম্যাও, [mæ̯͡oˠ] Here, [m] appears at the beginning of the word. It's 0.3 seconds, 56 dB, 201 Hz. It shows a typical sound. The atypical IPA is [mæ̯͡oˠ]. Other features include: velarized creaky voiced [æ̯͡oˠ].

Point Tier 02: Vowel: [æo͡], 24a focuses on [m], which appears at the beginning. It is a pulmonic egressive, bilabial, voiced sound which is of 0.13 seconds, 73 dB, 236 Hz.	Note: b [m] = typical

Data Display 24 (b)

Typical Speech	*Atypical Speech*
	
Figure 179 (a): Oscillogram of মিউ, [mɪu͡] It shows a PRAAT illustration of the word মিউ which is displayed in the Interval Tier 01: Bangla Text Word 'মিউ', and its transcription is in Interval Tier 02: IPA: [mɪu͡]. Point Tier 01: Consonants [m] and Point Tier 02: Vowel: [ɪu͡], 24b focuses on the sound [m], which appears at the beginning of the word. It is a pulmonic egressive, bilabial, voiced sound which is of 0.12 seconds, 70 dB, 237 Hz.	Figure 179 (b): Oscillogram of মিউ, [mɪ̃u͡] Here, [m] appears at the beginning of the word. It's 0.12 seconds, 68 dB, 205 Hz. It shows a typical sound. The atypical IPA is [mɪ̃u͡]. Other features include: nasalization of [ɪ̃u͡]. Note: b [m] = typical

Data Display 24 (c)

Typical Speech	*Atypical Speech*
	
Figure 180 (a): Oscillogram of থামিয়া, [t̪ʰɐmɪɐ͡]	Figure 180 (b): Oscillogram of থামিয়া, [t̪ʰɐmbĩɐ͡]
It shows a PRAAT illustration of the word থামিয়া which is displayed in the Interval Tier 01: Bangla Text Word 'থামিয়া', and its transcription is in Interval Tier 02: IPA: [t̪ʰɐmɪɐ͡]. Point Tier 01: Consonants [t̪ʰ], [m] and Point Tier 02: Vowel: [ɐ], [ɪɐ͡], 24c focuses on the sound [m], which appears in the middle of the word. It is a pulmonic egressive, bilabial, voiced sound of 0.1 seconds, 72 dB, 239 Hz.	Here, [m] appears in the middle of the word. It's 0.08 seconds, 62 dB, 198 Hz. It has was associated with a [b], as in, an addition happened. The atypical IPA is [t̪ʰɐmbĩɐ͡]. Other features include: nasalization with [ĩɐ͡]. Note: m [m] = atypical, addition (associated with a [b])

Data Display 24 (d)

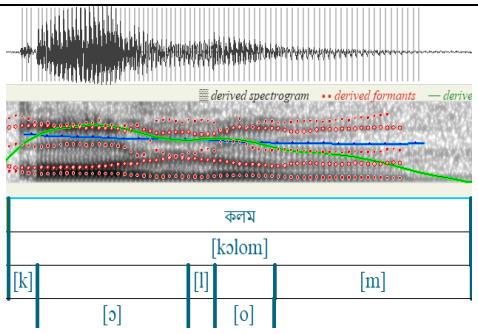
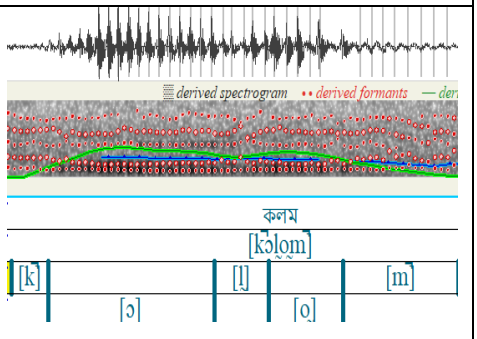
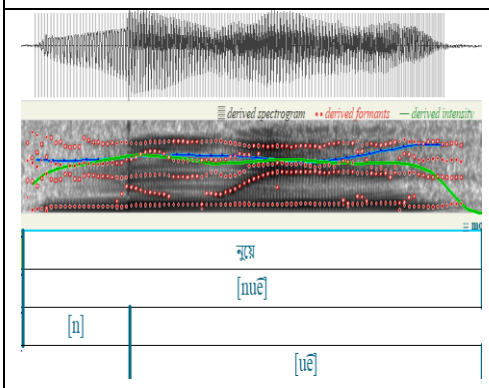
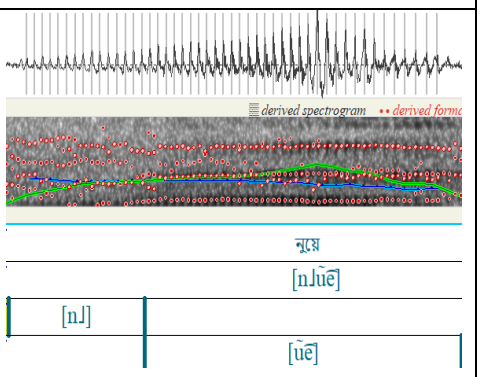
Typical Speech	*Atypical Speech*
	

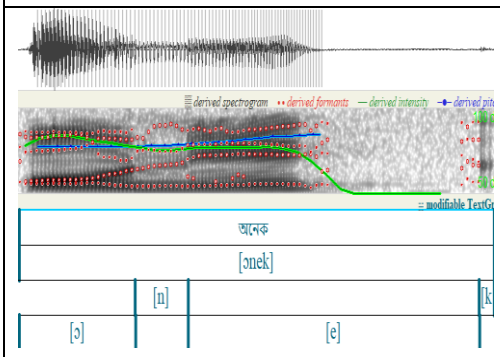
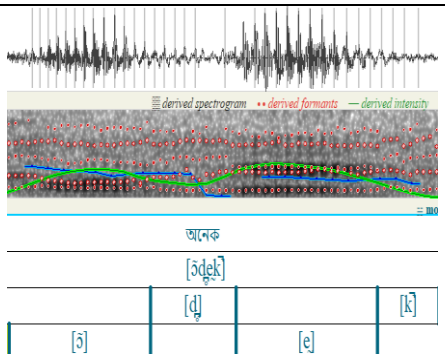
Figure 181 (a): Oscillogram of কলম, [kɔlom] It shows a PRAAT illustration of the word কলম which is displayed in the Interval Tier 01: Bangla Text Word 'কলম', and its transcription is in Interval Tier 02: IPA: [kɔlom]. Point Tier 01: Consonants [k], [l], [m] and Point Tier 02: Vowel: [ɔ], [o], 24d focuses on the sound [m], which appears at the end of the word. It is a pulmonic egressive, bilabial, voiced sound which is of 0.2 seconds, 66 dB, 187 Hz.	Figure 181 (b): Oscillogram of কলম, [k̄ɔl̪o̪m̄] Here, [m] appears at the end of the word. It's 0.3 seconds, 64 dB, 186 Hz. It has no audible release. The atypical IPA is [k̄ɔl̪o̪m̄]. Other features include: no audible release of [k̄], creaky voice of [l̪], and [o̪]. Note: e [m] = atypical, omission (no audible release)

Data Display 25 (a)

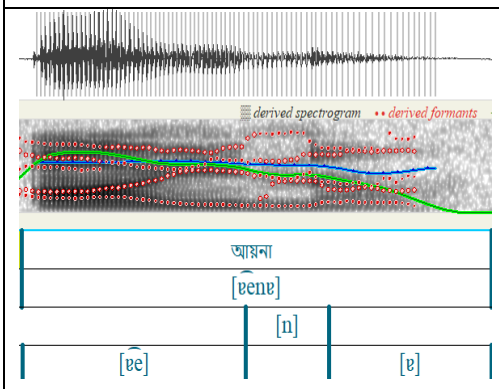
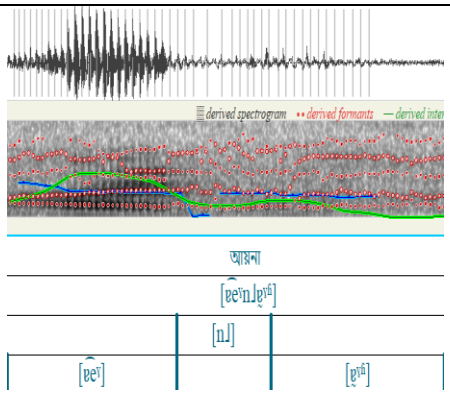
Typical Speech	*Atypical Speech*
	
Figure 182 (a): Oscillogram of নুয়ে, [nu͡e] It shows a PRAAT illustration of the word নুয়ে which is displayed in the Interval Tier 01: Bangla Text Word 'নুয়ে', and its transcription is in Interval Tier 02: IPA: [nu͡e]. Point Tier 01: Consonants /n/ and	Figure 182 (b): Oscillogram of নুয়ে, [nɹ̃u͡e] Here, [n] appears at the beginning of the word. It's 0.2 seconds, 60 dB, 198 Hz. It shows extra low tone. The atypical IPA is [n̥u͡e˩]. Other features include: nasalization of [ũe].

Point Tier 02: Vowel: [u͡e], 25a focuses on the sound [n], which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.14 seconds, 76 dB, 238 Hz.	Note: b [n] = atypical, distortion (extra low tone)

Data Display 25 (b)

Typical Speech	*Atypical Speech*
	
Figure 183 (a): Oscillogram of অনেক, [ɔnek]	Figure 183 (b): Oscillogram of অনেক, [ɔ̃d̪e̯k̚]
It shows a PRAAT illustration of the word অনেক which is displayed in the Interval Tier 01: Bangla Text Word 'অনেক', and its transcription is in Interval Tier 02: IPA: [ɔnek]. Point Tier 01: Consonants [n], [k] and Point Tier 02: Vowel: [ɔ], [e], 25b focuses on [n], which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.06 seconds, 75 dB, 235 Hz.	Here, [n] appears in the middle of the word. It's 0.1 seconds, 64 dB, 203 Hz. It shows substitution with voicelessness. The atypical IPA is [ɔ̃d̪e̯k̚]. Other features include: nasalization of [ɔ̃], creaky voice with [e̯], no audible release of [k̚]. Note: m [n] = atypical, substitution (with voicelessness)

Data Display 25 (c)

Typical Speech	*Atypical Speech*
	
Figure 184 (a): Oscillogram of আয়না, [ʊ͡ɛnʊ]	Figure 184 (b): Oscillogram of আয়না, [ʊ͡ɛʸnɻɻ̊ʸʱ]
It shows a PRAAT illustration of the word আয়না which is displayed in the Interval Tier 01: Bangla Text Word 'আয়না', and its transcription is in Interval Tier 02: IPA: [ʊ͡ɛnʊ]. Point Tier 01: Consonants [n], and Point Tier 02: Vowel: [ʊ], [ʊ͡ɛ], 25c focuses on the sound [n], which appears at the end of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.06 seconds, 75 dB, 235 Hz.	Here, [n] appears at the end of the word. It's 0.1 seconds, 64 dB, 203 Hz. It shows low tone. The atypical IPA is [ʊ͡ɛʸnɻɻ̊ʸʱ]. Other features include: velarization with [ʊ͡ɛʸ], velarized, creaky and breathy voiced, aspirated [ɻ̊ʸʱ]. Note: e [n] = atypical, distortion (low tone)

Data Display 25 (d)

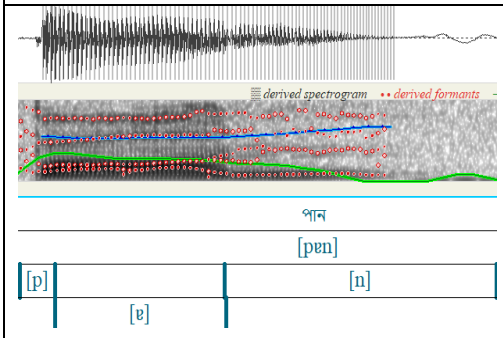
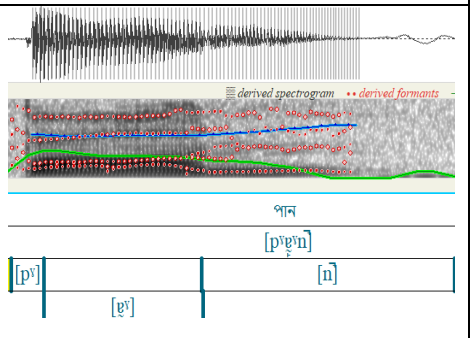
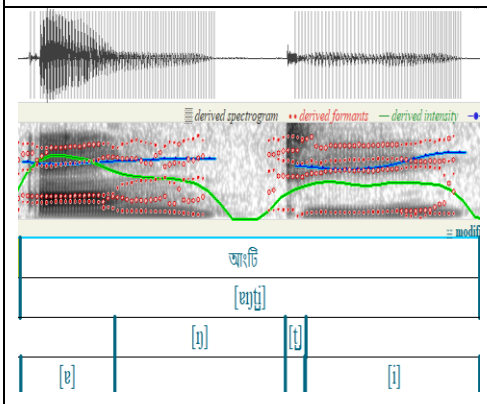
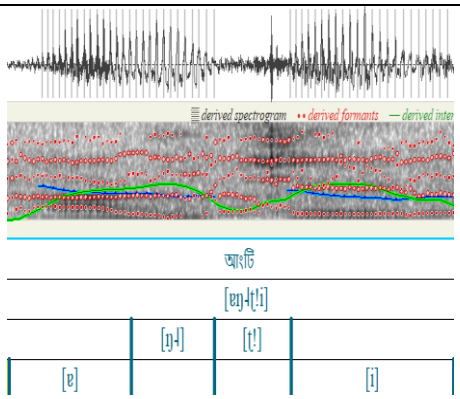
Typical Speech	*Atypical Speech*
	

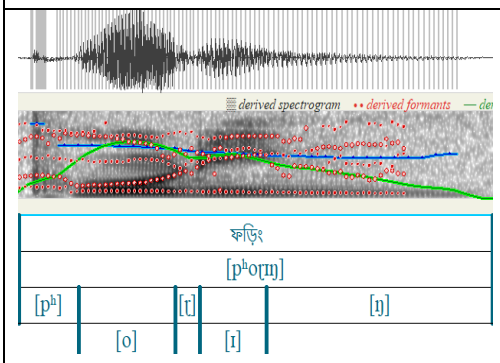
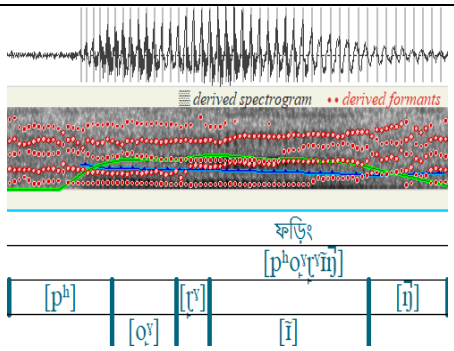
Figure 185 (a): Oscillogram of পান, [pɐn] It shows a PRAAT illustration of the word পান which is displayed in the Interval Tier 01: Bangla Text Word 'পান', and its transcription is in Interval Tier 02: IPA: [pɐn]. Point Tier 01: Consonants [p], [n], and Point Tier 02: Vowel: [ɐ], 25d focuses on the sound [n], which appears at the end of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.06 seconds, 75 dB, 235 Hz.	Figure 185 (b): Oscillogram of পান, [pˠɐ̰ˠn̴] Here, [n] appears at the end of the word. It's 0.1 seconds, 64 dB, 203 Hz. It has no audible release. The atypical IPA is [pˠɐ̰ˠn̴]. Other features include: velarization [pˠ], retracted tongue root position, creaky voice and velarization with [ɐ̰ˠ]. Note: e [n] = atypical, omission (no audible release)

Data Display 26 (a)

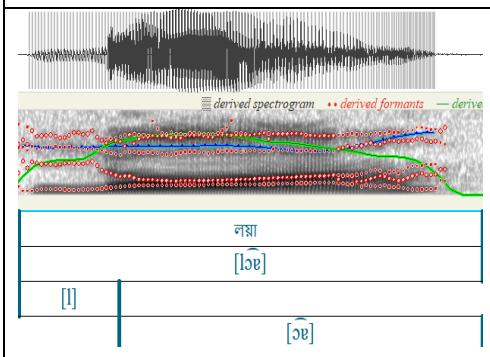
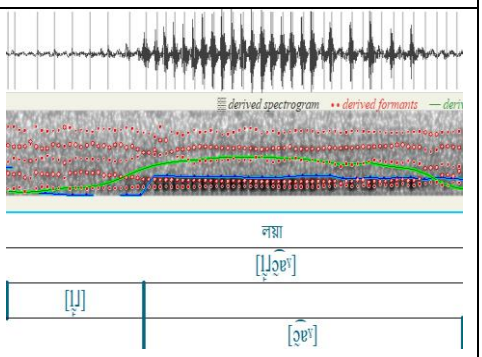
Typical Speech	*Atypical Speech*
	
Figure 186 (a): Oscillogram of আংটি, [ɐŋʈi] It shows a PRAAT illustration of the word আংটি which is displayed in the Interval Tier 01: Bangla Text Word 'আংটি', and its transcription is in Interval Tier 02: IPA: [ɐŋʈi]. Point Tier 01: Consonants [ŋ], [ʈ]	Figure 186 (b): Oscillogram of আংটি, [ɐŋǂʈ!i] Here, [ŋ] appears in the middle of the word. It's 0.4 seconds, 61 dB, 209 Hz. It has low tone. The atypical IPA is [ɐŋǂʈ!i]. Other features include: post-alveolar click [ʈ!].

and Point Tier 02: Vowel: [ɐ], [i] 26a focuses on the sound [ŋ], which appears in the middle of the word. It is a pulmonic egressive, velar, voiced sound which is of 0.23 seconds, 68 dB, 283 Hz.	Note: m [ŋ] = atypical, distortion (low tone)

Data Display 26 (b)

Typical Speech	*Atypical Speech*
	
Figure 187 (a): Oscillogram of ফড়িং, [pʰoɽɪŋ] It shows a PRAAT illustration of the word ফড়িং which is displayed in the Interval Tier 01: Bangla Text Word 'ফড়িং', and its transcription is in Interval Tier 02: IPA: [pʰoɽɪŋ]. Point Tier 01: Consonants [pʰ], [ɽ], [ŋ] and Point Tier 02: Vowel: [o], [ɪ] 26b focuses on the sound [ŋ], which appears at the end of the word. It is a pulmonic egressive, velar, voiced sound which is of 0.25 seconds, 62 dB, 179 Hz.	Figure 187 (b): Oscillogram of ফড়িং, [pʰo̤ʏɽ̤ʏĩŋ̃] Here, [ŋ] appears at the end of the word. It's 0.3 seconds, 50 dB, 171 Hz. It has no audible release. The atypical IPA is [pʰo̤ʏɽ̤ʏĩŋ̃]. Other features include: retracted tongue root position and velarization for [o̤ʏ] and [ɽ̤ʏ], and nasalization with [ĩ]. Note: e [ŋ] = atypical, omission (no audible release)

Data Display 27 (a)

Typical Speech	*Atypical Speech*
	
Figure 188 (a): Oscillogram of লয়া, [lɔ͡ɐ]	Figure 188 (b): Oscillogram of লয়া, [l̪ɹɔ̝͡ɐˠ]
It shows a PRAAT illustration of the word লয়া which is displayed in the Interval Tier 01: Bangla Text Word 'লয়া', and its transcription is in Interval Tier 02: IPA: [lɔ͡ɐ]. Point Tier 01: Consonants [l] and Point Tier 02: Vowel: [ɔ͡ɐ], 27a focuses on the sound [l], which appears at the beginning of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.13 seconds, 76 dB, 232 Hz.	Here, [l] appears at the beginning of the word. It's 0.2 seconds, 72 dB, 206 Hz. It has creaky voice and retracted tongue root position, also extra low tone. The atypical IPA is [l̪ɹɔ̝͡ɐˠ]. Other features include: velarization and creaky voice for [ɔ̝͡ɐˠ]. Note: b [l] = atypical, distortion (creaky voice and retracted tongue root position, also extra low tone)

Data Display 27 (b)

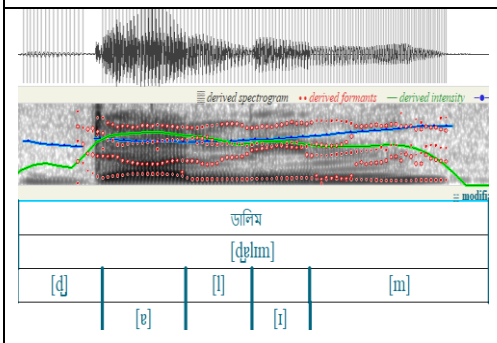
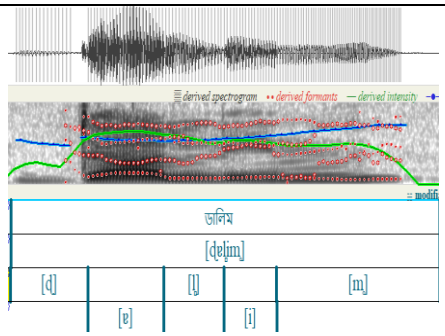
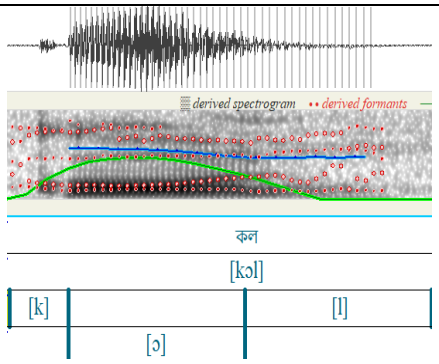
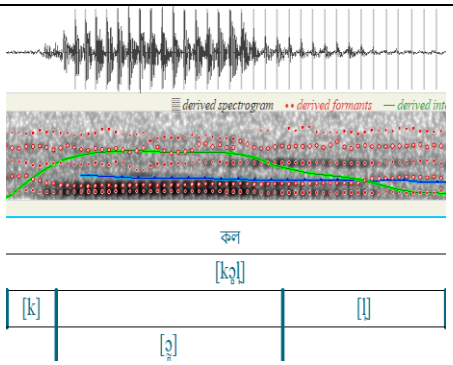
Typical Speech	*Atypical Speech*
	

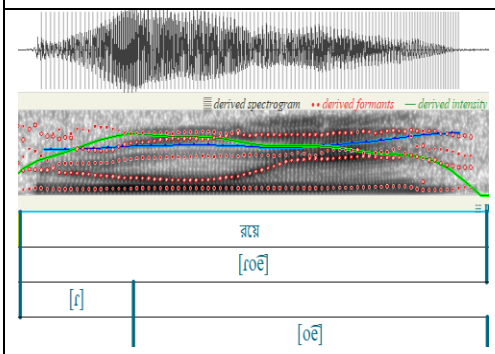
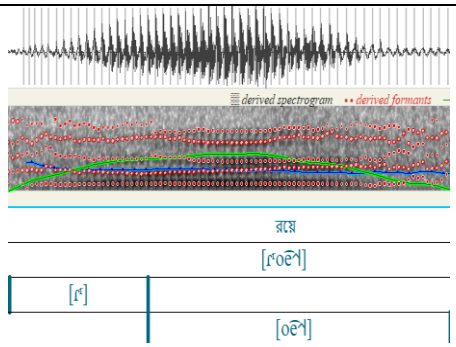
Figure 189 (a): Oscillogram of ডালিম, [ɖɐlɪm] It shows a PRAAT illustration of the word ডালিম which is displayed in the Interval Tier 01: Bangla Text Word 'ডালিম', and its transcription is in Interval Tier 02: IPA: [ɖɐlɪm]. Point Tier 01: Consonants [ɖ], [l], [m] and Point Tier 02: Vowel: [ɐ], [ɪ], 27b focuses on the sound [l], which appears in the middle of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.08 seconds, 77 dB, 222 Hz.	Figure 189 (b): Oscillogram of ডালিম, [ɖɐl̪iṃ] Here, [l] appears in the middle of the word. It's 0.12 seconds, 66 dB, 228 Hz. It shows laminal [l̪]. The atypical IPA is [ɖɐl̪iṃ]. Other features include: and voiceless [ṃ]. Note: m [l] = atypical, distortion (laminal)

Data Display 27 (c)

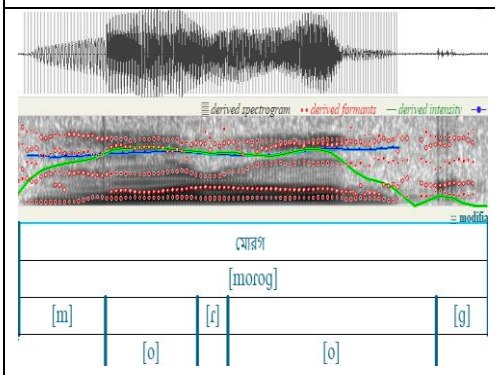
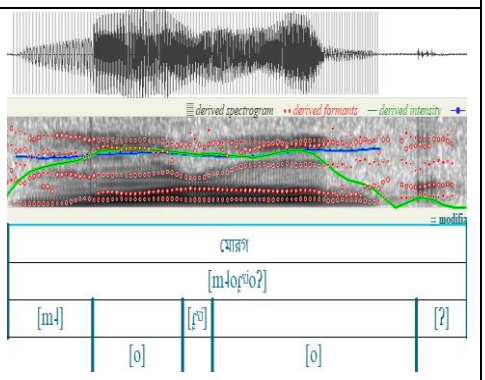
Typical Speech	*Atypical Speech*
	
Figure 190 (a): Oscillogram of কল, [kɔl] It shows a PRAAT illustration of the word কল which is displayed in the Interval Tier 01: Bangla Text Word 'কল', and its transcription is in Interval Tier 02: IPA: [kɔl]. Point Tier 01: Consonants [k], [l] and	Figure 190 (b): Oscillogram of কল, [kɔ̰l̪] Here, [l] appears at the end of the word. It's 0.12 seconds, 63 dB, 187 Hz. It has retracted tongue root position. The atypical IPA is [kɔ̰l̪]. Other features include: creaky voiced, laminal [ɔ̰]. Note: e [l] = atypical, distortion

Point Tier 02: Vowel: [ɔ], 27c focuses on [l], which appears at the end of the word. It is a pulmonic egressive, alveolar, voiced sound which is of 0.08 seconds, 77 dB, 222 Hz.	(retracted tongue root position)

Data Display 28 (a)

Typical Speech	*Atypical Speech*
	
Figure 191 (a): Oscillogram of রয়ে, [ɾo͡e]	Figure 191 (b): Oscillogram of রয়ে, [ɾʳo͡e̞ˠ]
It shows a PRAAT illustration of the word রয়ে which is displayed in the Interval Tier 01: Bangla Text Word 'রয়ে', and its transcription is in Interval Tier 02: IPA: [ɾo͡e]. Point Tier 01: Consonants [ɾ] and Point Tier 02: Vowel: [o͡e], 28a focuses on the sound [ɾ], which appears at the beginning of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiced sound which is of 0.12 seconds, 77 dB, 225 Hz.	Here, [ɾ] appears at the beginning of the word. It's 0.3 seconds, 65 dB, 191 Hz. It has rhotic release. The atypical IPA is [ɾo͡e̞ˠ]. Other features include: rising-falling for [o͡e̞ˠ]. Note: b [ɾ] = atypical, distortion, also could be noted for addition (rhotic release)

Data Display 28 (b)

Typical Speech	*Atypical Speech*
	
Figure 192 (a): Oscillogram of মোরগ, [morog]	Figure 192 (b): Oscillogram of মোরগ, [mɬoɾʸʲoʔ]
It shows a PRAAT illustration of the word মোরগ which is displayed in the Interval Tier 01: Bangla Text Word 'মোরগ', and its transcription is in Interval Tier 02: IPA: [morog], Point Tier 01: Consonants [m], [ɾ], [g] and Point Tier 02: Vowel: [o], 28b focuses on [ɾ], which appears in the middle of the word. It is a pulmonic egressive, post-alveolar or palato-alveolar, voiced sound which is of 0.04 seconds, 78 dB, 245 Hz.	Here, [ɾ] appears in the middle of the word. It's 0.3 seconds. It shows velarization and retracted tongue root position with [ɾʸ]. The atypical IPA is [mɬoɾʸʲoʔ]. Other features include: low tone with [mɬ], pre-palatalization with [ʲo], and a substitution with a glottal stop. Note: m [ɾ] = atypical, distortion (velarization and retracted tongue root position)

Data Display 28 (c)

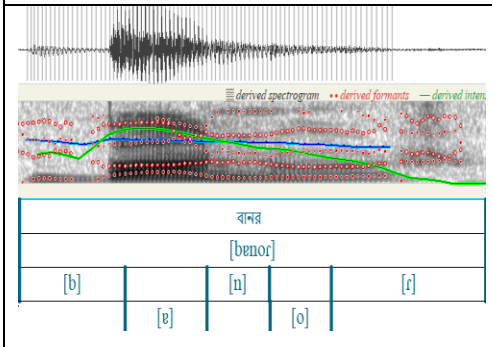
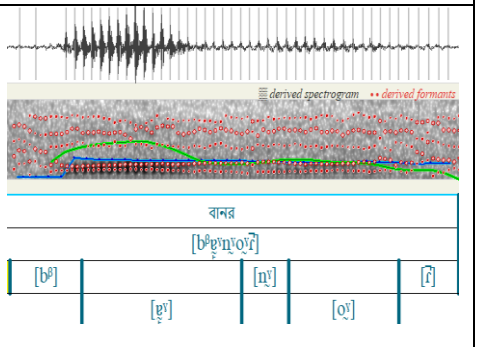
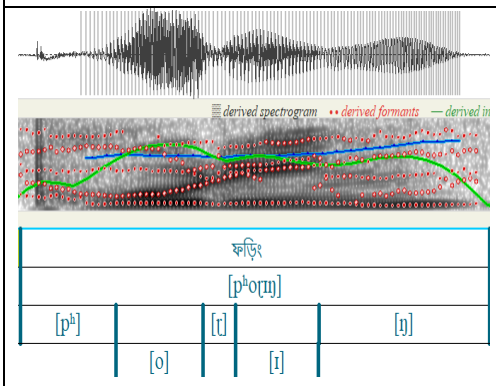
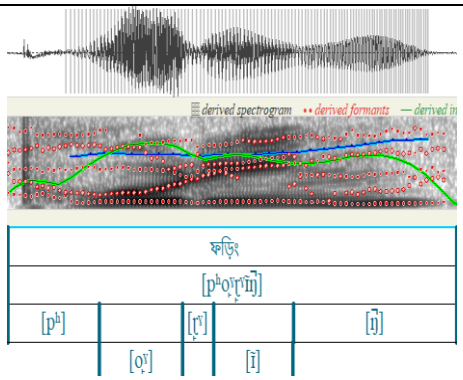
Typical Speech	*Atypical Speech*
	

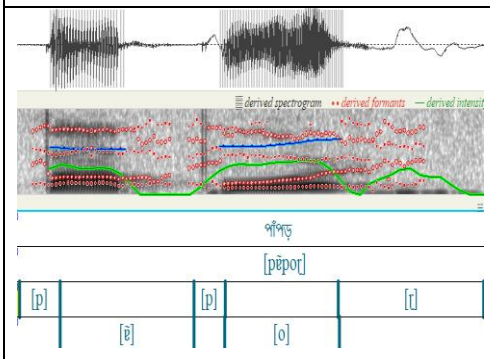
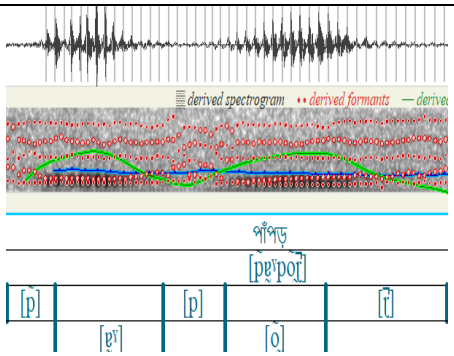
Figure 193 (a): Oscillogram of বানর, [bɐnoɾ]	Figure 193 (b): Oscillogram of বানর, [bᵝβ̞̈ʸn̪ʸo̞ʸɾ̃]
It shows a PRAAT illustration of the word বানর which is displayed in the Interval Tier 01: Bangla Text Word 'বানর', and its transcription is in Interval Tier 02: IPA: [bɐnoɾ], Point Tier 01: Consonants [b], [n], [ɾ] and Point Tier 02: Vowel: [ɐ], [o], 28c focuses on [ɾ], which appears at the end. It is pulmonic egressive, post-alveolar or palato-alveolar, voiced, 0.18 seconds, 60 dB, 167 Hz.	Here, [ɾ] appears at the end of the word. It's 0.2 seconds. It has no audible release. The atypical IPA is [bᵝβ̞̈ʸn̪ʸo̞ʸɾ̃]. Other features include: lip compression of [bᵝ], velarization, retracted togue root position, and creaky voice for [β̞̈ʸ], velarization for [n̪ʸ] and [o̞ʸ]. Note: e [ɾ] = atypical, omission (no audible release)

Data Display 29 (a)

Typical Speech	*Atypical Speech*
	
Figure 194 (a): Oscillogram of ফড়িং, [pʰoɽɪŋ]	Figure 194 (b): Oscillogram of ফড়িং, [pʰo̞ʸɽ̞ʸĩŋ̃]
It shows a PRAAT illustration of the word ফড়িং which is displayed in the Interval Tier 01: Bangla Text Word 'ফড়িং', and its transcription is in Interval Tier 02: IPA: [pʰoɽɪŋ]. Point Tier 01: Consonants [pʰ], [ɽ],	Here, [ɽ] appears in the middle of the word. It's 0.3 seconds, 50 dB, 171 Hz. It has retracted tongue root position and velarization. The atypical IPA is [pʰo̞ʸɽ̞ʸĩŋ̃]. Other features include: retracted tongue

[ŋ] and Point Tier 02: Vowel: [o], [ɪ] 29a focuses on [ɽ], appears in the middle, pulmonic egressive, velar, voiced, 0.03 seconds, 77 dB, 244 Hz.	root position and velarization for [ọˠ] and [ɽˠ], and nasalization with [ĩ], and no audible release for [n̄]. Note: m [ɽ] = atypical, distortion (retracted tongue root position and velarization)

Data Display 29 (b)

Typical Speech	*Atypical Speech*
	
Figure 195 (a): Oscillogram of পাঁপড়, [pɛ̃poɽ] It shows a PRAAT illustration of the word পাঁপড় which is displayed in the Interval Tier 01: Bangla Text Word 'পাঁপড়', and its transcription is in Interval Tier 02: IPA: [pɛ̃poɽ]. Point Tier 01: Consonants [p], [p], [ɽ] and Point Tier 02: Vowel: [ɛ̃], [o] 29b focuses on [ɽ], appears at the end, pulmonic egressive, velar, voiced, 0.03 seconds, 77 dB, 244 Hz.	Figure 195 (b): Oscillogram of পাঁপড়, [p̃ɐ̃ˠpo̰ɽ̃] Here, [ɽ] appears at the end of the word. It's 0.08 seconds. It has no audible release. The atypical IPA is [p̃ɐ̃ˠpo̰ɽ̃]. Other features include: nasalization of [p̃], creaky voice, velarization of [ɐ̃ˠ], nasalization and creaky voice for [o̰]. Note: e [ɽ] = atypical, omission (no audible release)

4.2. Sample Patient Reports

The following summarizes the patient's medical diagnoses relevant to the speech analysis only. The V Scale (0-5) from Glasgow Coma Scale (1974) are V5

(Oriented: fluent speech, comprehension and production are intact), V4 (Confused Conversation: speech is connected but disoriented), V3 (Inappropriate Words: random or irrelevant words, affected comprehension), V2 (Incomprehensible Sounds: moans, no real words, severe speech/language breakdown), V1 (None/Coma: no verbal output).

Suggestive Typical versus Atypical Ratio Assessment Color-Flag Chart (original work) Green 🟢 is Normal Range (0–25 %), Yellow 🟡 is Elevated Atypical (26-50%), Orange 🟠 (51-75%) is Markedly Atypical, Red 🔴 is Highly Atypical (76-100%). For error types similar measures were taken identify the levels. Detailed information has been omitted to maintain medical confidentiality.

SL No. 03

General Information and Diagnosis	***Name:*** *Jannatul Ferdous*	***Age:*** *24*	***Sex:*** *Female*
History: *2012-2023*	In 2012, experienced headache, vomiting, double vision, diagnosed as a post fossa SOL and operated by posterior midline approach to remove the SOL and VP shunt followed by removal of the tumor in the right sub-occipital approach and was diagnosed as hemangioblastoma in the year of 2014. In 2023, she again got admitted with headaches, vomiting, and dimness of vision and diagnosed as recurrence of post fossa SOL and operated through right sub-occipital approach and removal of tumor took place. Histopathology came out to be Hemangioblastoma, WHO grade 1.		
Present Day: *2025 Recurring*	Now, in 2025, for the last 6 months, her symptoms are, headaches aggravated during coughing and sneezing, gradual decrease of vision and tendency to fall towards left.		

	On Nervous System Examination (received info) Higher Psychic Function Intact, GCS 15, Right handed Speech-Scanning, Gait-Ataxic, Lobe Sign: Absent No signs of meningeal irritation
Speech-Language Screening Report	***Error Types:*** T1 (Distortion)= 69.41%, T2 (Omission) = 22.35%, T3 (Substitution)= 8.24%, T4 (Addition/Insertion)= 20% ***Organs Involved*** b (beginning) = 34.31%; upper lip, lower lip, upper teeth, lower teeth, Alveolar Ridge, tip and blade/front of the tongue m (middle) = 26.47% ; hard palate, center of the tongue e (ending) = 39.22% ; soft palate/Velum, back and the root of the tongue, Uvula ***Types, Features, Placements (Details)*** A. Distortion 1. weak articulation e [p] 2. low tone e [t̪], e [m], e [n] 3. lip compression e [b], m [m] 4. labialized m [bʱ] 5. laminal b [t̻], m [t̻] 6. breathy-voiced e [bʱ], e [d̪], b [ɦ] 7. creaky-voiced b [ɟʱ], b [gʱ], b [ɦ], e [l] 8. rising-falling tone b [t̻], m [ɖ̻ʱ], m [c], b [ɦ] 9. rising tone b [m] 10. velarization m [t̪ʰ], e [t̻], e [t̻ʰ], m [ɖ̻ʱ], b [cʰ], b [ɟ], m [ɟ], e [ɟ], b [ɟʱ], e [k], e [kʰ], m [g], b [gʱ], b [ɦ], b [l], e [l], m [ɾ̪]

	11. nasalization m [d̪], e [d̪], b [g], b [m], b [n] 12. retracted tongue-root position e [tˤ], b [cʰ], b [ɟ], m [ɟ], e [ɟ], b [ɟˤ], e [k], b [kʰ], e [kʰ], b [ŋ], e [ŋ], b [l], e [l], b [ɾ], m [ɽ] 13. more roundedness b [n] *A. Omission* 1. no audible release e [t̪ʰ], e [ɖ], e [c], e [k], e [g], b [s], e [ɦ], e [ɾ], e [ɽ] 2. unaspirated b [bˤ] 3. partial devoicing m [d̪], e [d̪] 4. voiceless b [dˤ], e [ɟ], e [ɟˤ], e [gˤ], m [l], m [ɖ], m [d̪ˤ] *B. Substitution* 1. sound substitution b [d̪ˤ], m [d̪ˤ], b [dˤ], e [dˤ], b [g], m [gˤ], m [ɾ] *C. Addition/Insertion* 1. double articulation m [m], m [n], e [n] 2. aspirated e [bˤ], e [d̪], b [kʰ], m [gˤ], b [ʃ] 3. pre-aspirated m [t̪], m [cˤ], e [ʃ] 4. post-alveolar click e [t̪] 5. voiced e [t], b [tˤ], m [tˤ], b [ɖ], m [ɦ] ***Typical versus Atypical Ratio:*** 24.71% : 77.65% = 🔴 Highly Atypical Typical (21 out of 85) = 24.71% Atypical (66 out of 85) = 77.65% ***Suggestive:*** ***GCS (V5):*** patient is oriented, as in, fluent speech, comprehension and production are intact ***Error Type:*** T1 (Distortion) = 🟠 69.41% ***Atypical:*** 🔴 Highly Atypical (77.65%) ***Affected Organs:*** tongue, lower lip, soft palate/Velum are moderately affected

Figure 196: Speech-Language Screening Report of Patient 03

SL No. 01

General Information and Diagnosis	***Name:*** *Kamal Uddin*	***Age:*** *55*	***Sex:*** *Male*
Present Day: *2025* *Spasmodic*	Patient experienced gradual progression of headache on the right side aggravated during coughing, vomiting, eye pain, vertigo and has been diagnosed with glioblastoma at right temporo-parieto-occipital lobe ICSOL, perilesional edema, mass effect with midline displacement. ***On Nervous System Examination*** (received info) GCS (E4V5M6) The V (verbal response) score: patient is oriented, able to speak on command and coherently, content is intact Cranial Nerves V, VII, IX, X, XII are crucial for speech, voice, swallowing: no swallowing difficulties, voice and speech are on command (speech data to be analyzed). Motor System (UL, LL, Reflexes, Plantar, Clonus): reflects motor pathways, UMN lesions can also involve corticobulbar tracts leading to slurred speech or even Aphasia if lesion is cortical and left-sided (speech data to be analyzed)		
Speech-Language Screening Report	***Error Types:*** T1 (Distortion)= 44.71%, T2 (Omission) = 18.82%, T3 (Substitution)= 12.94%, T4 (Addition/Insertion)= 9.41% ***Organs Involved*** b (beginning) = 16.09% ; upper lip, lower lip, upper teeth, lower teeth, Alveolar Ridge, tip and blade/front of the tongue		

m (middle) 🟡

= 26.44% ; hard palate, center of the tongue

e (ending) 🟠

= 57.47% ; soft palate/Velum, back and the root of the tongue, Uvula

Types, Features, Placements (Details)

A. Distortion

1. laminal m [d̻], m [l]
2. velarization m [dˠ], m [g], m [ɾ], m [ɽ]
3. fricative release m [c], e [c], e [cʰ]
4. rhotic release b [ɾ]
5. weak articulation m [pʰ], e [pʰ], e [t̪ʰ], m [ɟ]
6. nasalization e [b], b [ɟ], m [kʰ]
7. low tone e [b], b [t̪], e [ɟʱ], e [n], m [ŋ]
8. extra low tone e [t̪ʰ], e [kʰ], b [n], b [l]
9. rising-falling m [dˠ]
10. breathy voice e [t̪], e [t̪ʰ], e [ɟʱ]
11. creaky voice e [d̪], b [ɦ], b [l]
12. retracted tongue root position b [ʃ], b [l], e [l], m [ɾ], m [ɽ]

B. Omission

1. no audible release e [p], e [t̪], e [gʱ], e [n], e [ŋ], e [ɾ], e [ɽ]
2. unaspirated b [bʱ], m [bʱ], e [bʱ], b [ɟʱ], b [gʱ]
3. partial devoicing e [d̪]
4. devoicing m [d̪ʱ], b [dˠʱ], m [n]

C. Substitution

5. substitution b [d̪ʱ], m [d̪ʱ], e [d̪ʱ], b [dˠʱ], m [c], e [ɟ], e [ɟʱ], e [k], e [g], b [gʱ], m [n]

	D. Addition/Insertion 1. addition m [m] 2. glottal stop e [ɡ] 3. post-alveolar click b [ʈʱ], e [ɖ̪] 4. aspiration e [d̪] 5. voiced e [bʱ], m [bʱ], m [k] ***Typical versus Atypical Ratio:*** 16.47% : 85.88% = 🔴 Highly Atypical Typical (14 out of 85) = 16.47% Atypical (73 out of 85) = 85.88% ***Suggestive:*** ***GCS (V5):*** patient is oriented, as in, fluent speech, comprehension and production are intact ***Error Type:*** T1 (Distortion) = 🟡 44.71%, ***Atypical:*** 🔴 Highly Atypical (85.88%) ***Affected Organs:*** soft palate/Velum, back and root of the tongue are mostly affected, center of the tongue is moderately affected

Figure 197: Speech-Language Screening Report of Patient 01

4.3. Ratio Analysis of Atypical Speech Features

In this section, the data ratio have been represented. The occurrences of the phonological errors of 10 patients have been represented in percentage.

Distortion comprises of nasal release/nasalized 5.13%, labialized 4.19%, lip compression 3.51%, laminal 4.06%, velarized 6.3%, dental expression 1.37%, fricative release 2.39%, rhotic release 1.45%, strong/weak articulation 2.39%, inconsistent /h/ 2.35%, low tone 3.81%, extra-low tone 3.93%, rising-falling tone 5.64%, rising tone 1.5%, breathy-voiced 2.86%, creaky-voiced 5.7%, sliding articulation 1.45%, retracted tongue-root position 5.6%, more roundedness 0.98%.

Hence, Distortion is 64.61%. Addition/Insertion includes pre-palatalization 1.45%, post-alveolar click 1.54%, aspirated 2.39%, pre-aspirated 2.39%, double articulation 2.65%, sound addition 1.45%, glottal stop addition 1.41%, post-alveolar click addition 1.37%, voiced 2.48%.

Addition/Insertion is 17.13%. Omission is 13.47%, which are unaspirated 2.31%, no audible release 5.6%, voiceless 4.19%, partial devoicing 1.37%. Substitution is sound substitution 4.79%, and substitution with unintelligible speech 0.98%, which is 4.79%.

Given next are the individual ratio analyses of these features.

The ratio of nasal release or nasalization as opposed to other atypical features is 5.13: 94.87 which is shown on the right hand side.

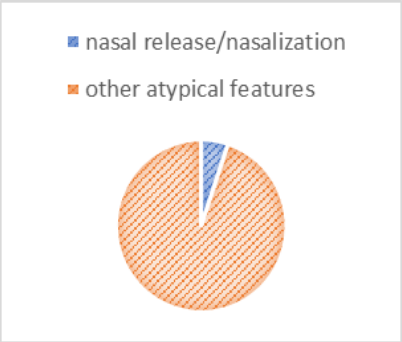


Figure 198: Nasal Release/Nasalization Ratio

The ratio of labialization as opposed to other atypical features is 4.19: 95.81 which is shown on the right hand side.

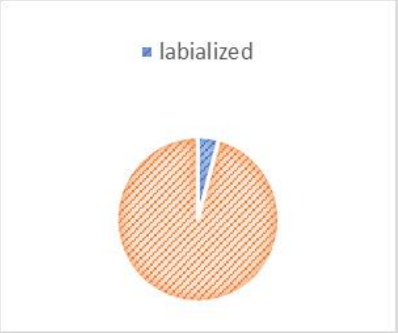


Figure 199: Labialization Ratio

The ratio of lip compression as opposed to other atypical features is 3.51: 96.49 which is shown on the right hand side.

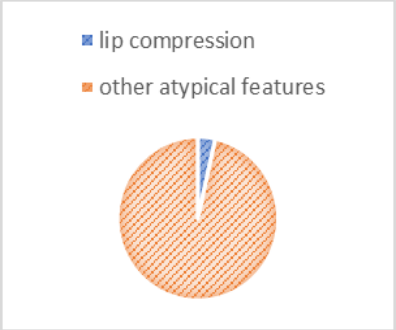


Figure 200: Lip Compression Ratio

The ratio of velarized sounds as opposed to other atypical features is 6.3: 93.7 which is shown on the right hand side.

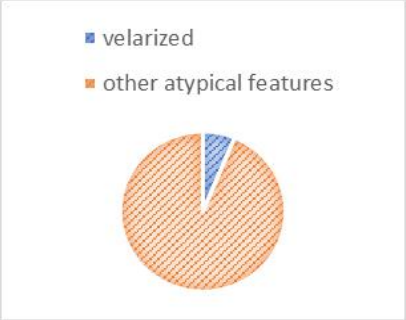


Figure 201: Velarization Ratio

The ratio of laminal sounds as opposed to other atypical features is 4.06: 95.94 which is shown on the right hand side.

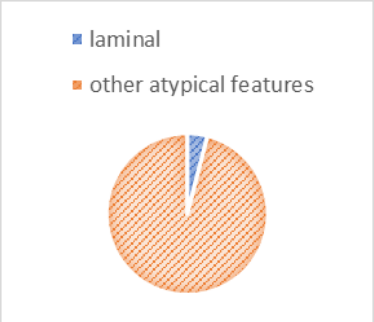


Figure 202: Laminal Ratio

The ratio of pre-palatalized sounds as opposed to other atypical features is 1.45: 98.55 which is shown on the right hand side.

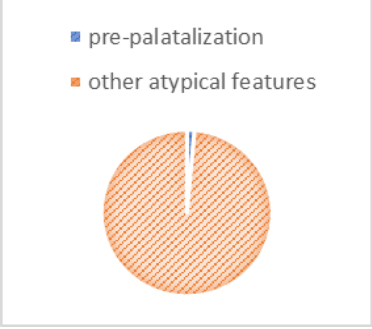


Figure 203: Pre-Palatalization Ratio

The ratio of post-alveolar click sounds as opposed to other atypical features is 1.54: 98.46 which is shown on the right hand side.

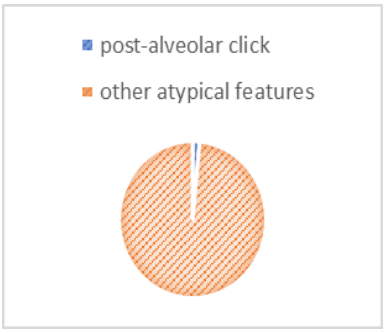


Figure 204: Post-Alveolar Click Ratio

The ratio of sounds with dental expression as opposed to other atypical features is 1.37: 98.63 which is shown on the right hand side.

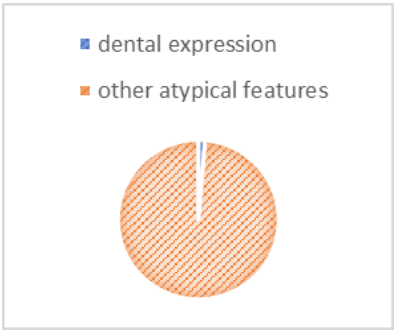


Figure 205: Dental Expression Ratio

The ratio of sounds with fricative release as opposed to other atypical features is 1.37: 98.63 which is shown on the right hand side.

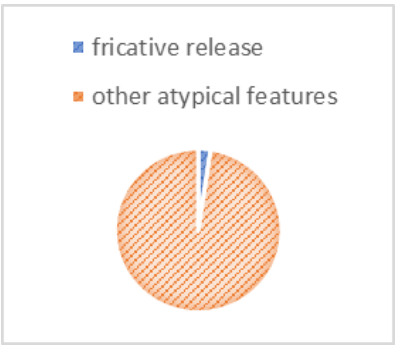


Figure 206: Fricative Release Ratio

The ratio of sounds with rhotic release as opposed to other atypical features is 1.37: 98.63 which is shown on the right hand side.

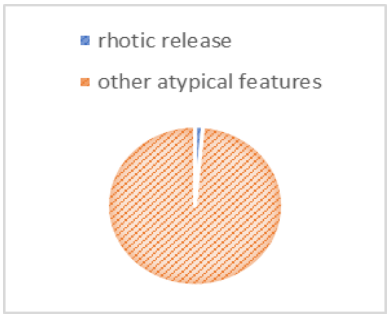


Figure 207: Rhotic Relesae Ratio

The ratio of voiced sounds as opposed to other atypical features is 2.48: 97.52 which is shown on the right hand side.

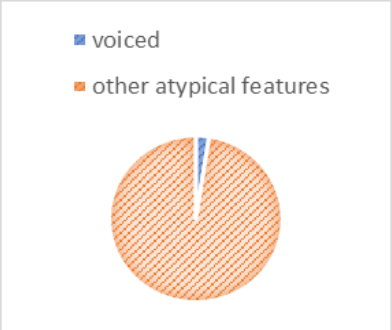


Figure 208: Voiced Ratio

The ratio of voiceless sounds as opposed to other atypical features is 4.19: 95.81 which is shown on the right hand side.

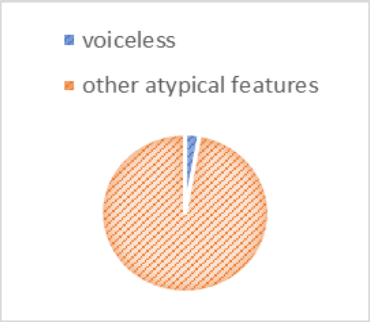


Figure 209: Voiceless Ratio

The ratio of partial devoiced sounds as opposed to other atypical features is 1.37: 98.63 which is shown on the right hand side.

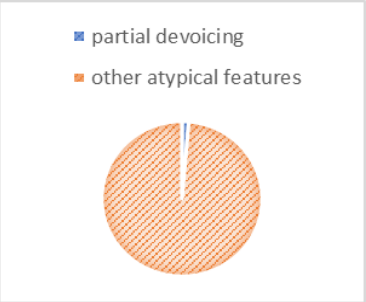


Figure 210: Partial Devoiced Ratio

The ratio of strong/weak articulation sounds as opposed to other atypical features is 2.39: 97.61 which is shown on the right hand side.

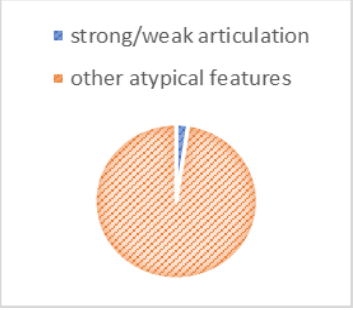


Figure 211: Strong/Weak Articulation Ratio

The ratio of sounds with inconsistent [ɦ] as opposed to other atypical features is 2.35: 97.65 which is shown on the right hand side.

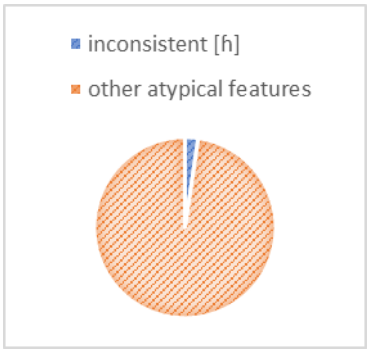


Figure 212: Inconsistent [ɦ] Ratio

The ratio of sounds with aspiration as opposed to other atypical features is 2.39: 97.61 which is shown on the right hand side.

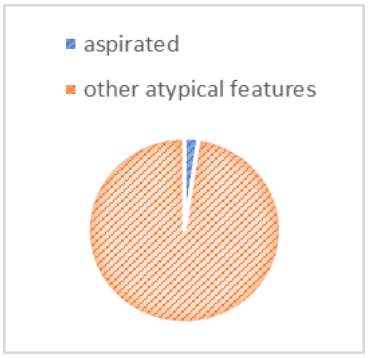


Figure 213: Aspiration Ratio

The ratio of unaspirated sounds as opposed to other atypical features is 2.31:97.69 which is shown on the right hand side.

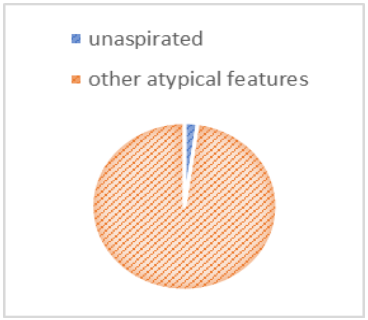


Figure 214: Unaspirated Ratio

The ratio of pre-unaspirated sounds as opposed to other atypical features is 2.39: 97.61 which is shown on the right hand side.

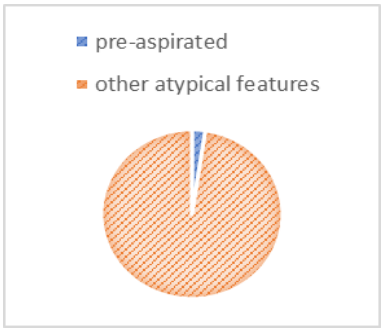


Figure 215: Pre-Unaspirated Ratio

The ratio of sounds with low-tone as opposed to other atypical features is 3.81: 96.19 which is shown on the right hand side.

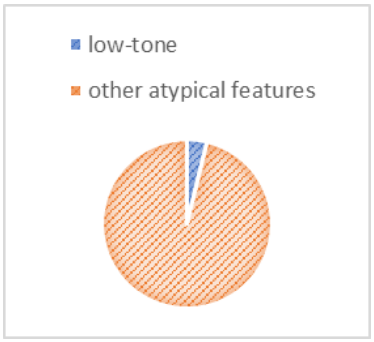


Figure 216: Low-Tone Ratio

The ratio of sounds with extra low-tone as opposed to other atypical features is 3.93: 96.07 which is shown on the right hand side.

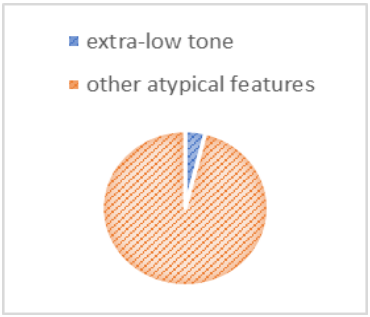


Figure 217: Extra Low-Tone Ratio

The ratio of sounds with rising-falling tone as opposed to other atypical features is 5.64: 94.36 which is shown on the right hand side.

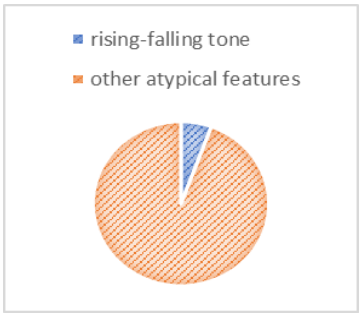


Figure 218: Rising-Falling Tone Ratio

The ratio of sounds with rising tone as opposed to other atypical features is 1.5: 98.5 which is shown on the right hand side.

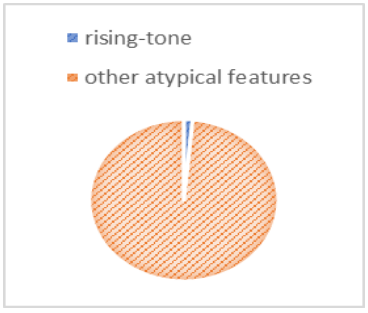


Figure 219: Rising Tone Ratio

The ratio of sounds with breathy-voice as opposed to other atypical features is 2.86: 97.14 which is shown on the right hand side.

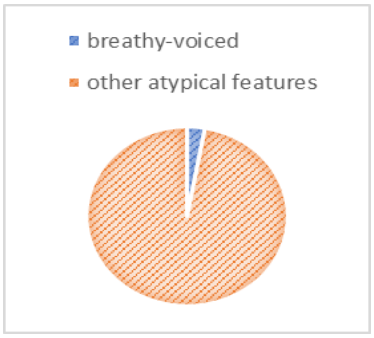


Figure 220: Breathy-Voice Ratio

The ratio of sounds with creaky voice as opposed to other atypical features is 5.7: 94.3 which is shown on the right hand side.

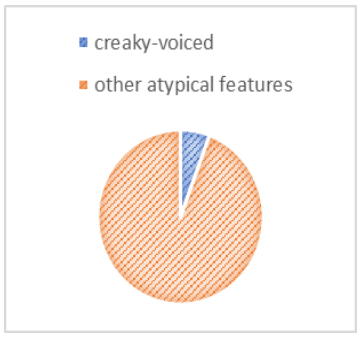


Figure 221: Creaky Voice Ratio

The ratio of sounds with sliding articulation as opposed to other atypical features is 1.45: 98.55 which is shown on the right hand side.

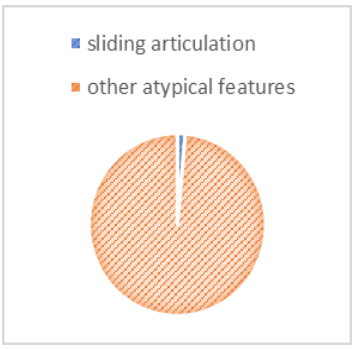


Figure 222: Sliding Articulation Ratio

The ratio of sounds with retracted tongue-root position as opposed to other atypical features is 5.6: 94.4 which is shown on the right hand side.

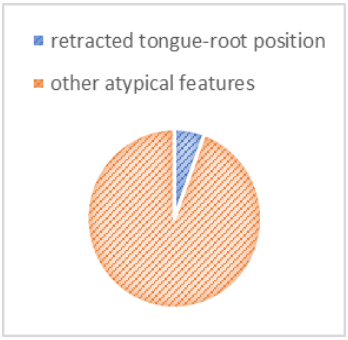


Figure 223: Retracted Tongue-Root Position Ratio

The ratio of sounds with more roundedness as opposed to other atypical features is 0.98: 99.02 which is shown on the right hand side.

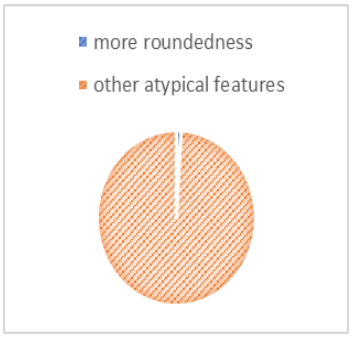


Figure 224: More Roundedness Ratio

The ratio of sounds with no audible release as opposed to other atypical features is 5.6: 94.4 which is shown on the right hand side.

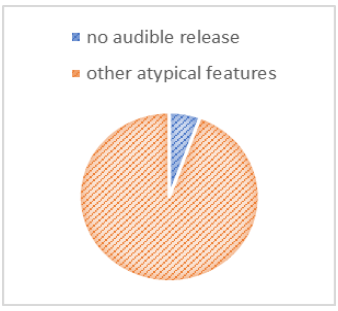


Figure 225: No Audible Release Ratio

The ratio of sound substitution as opposed to other atypical features is 3.81: 96.19 which is shown on the right hand side.

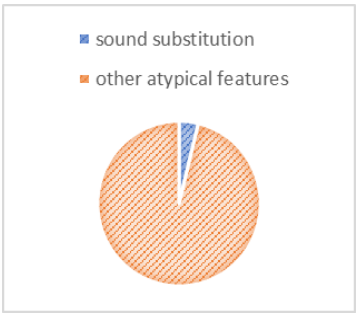


Figure 226: Sound Substitution Ratio

The ratio of substitution with unintelligible speech as opposed to other atypical features is 0.98:99.02 which is shown on the right hand side.

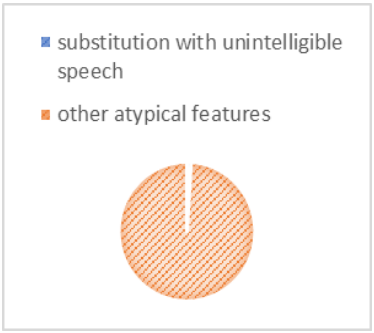


Figure 227: Substitution with Unintelligible Speech Ratio

The ratio of substitution with double articulation as opposed to other atypical features is 2.65: 97.35 which is shown on the right hand side.

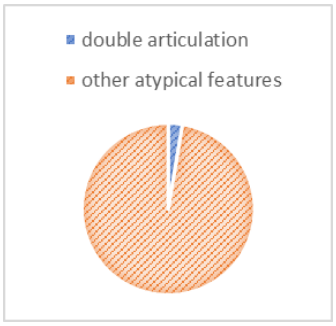


Figure 228: Substitution with Double Articulation ratio

The ratio of sound addition as opposed to other atypical features is 1.45: 98.55 which is shown on the right hand side.

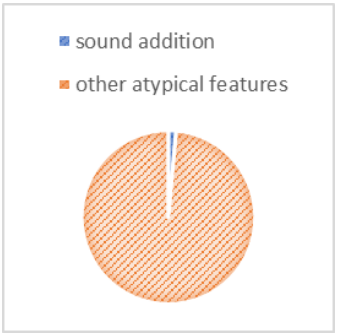


Figure 229: Sound Addition Ratio

The ratio of glottal stop addition as opposed to other atypical features is 1.41: 98.59 which is shown on the right hand side.

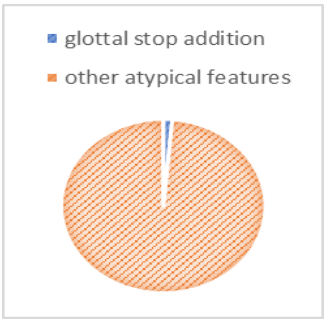


Figure 230: Glottal Stop Addition Ratio

The ratio of post-alveolar click addition as opposed to other atypical features is 1.37:98.63 which is shown on the right hand side.

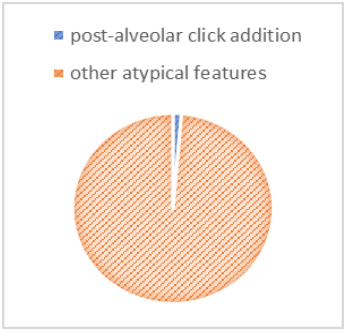


Figure 231: Post-Alveolar Click Addition Ratio

Given next is the bar diagram representing all the percentages which shows that the highest form of atypical speech occurs due to velarization and nasal release/nasalization which is a phonological matter and it can be considered under

distortion. Other significant errors happen due to retracted tongue-root position, creaky-voice, rising-falling tone, nasal release/nasalization and no audible release. Creaky-voice and rising-falling tone can be considered as suprasegmental features, and retracted tongue-root position can cause phonological or acoustic errors which all leads to distortion. No audible release, on the other hand, can lead to omission.

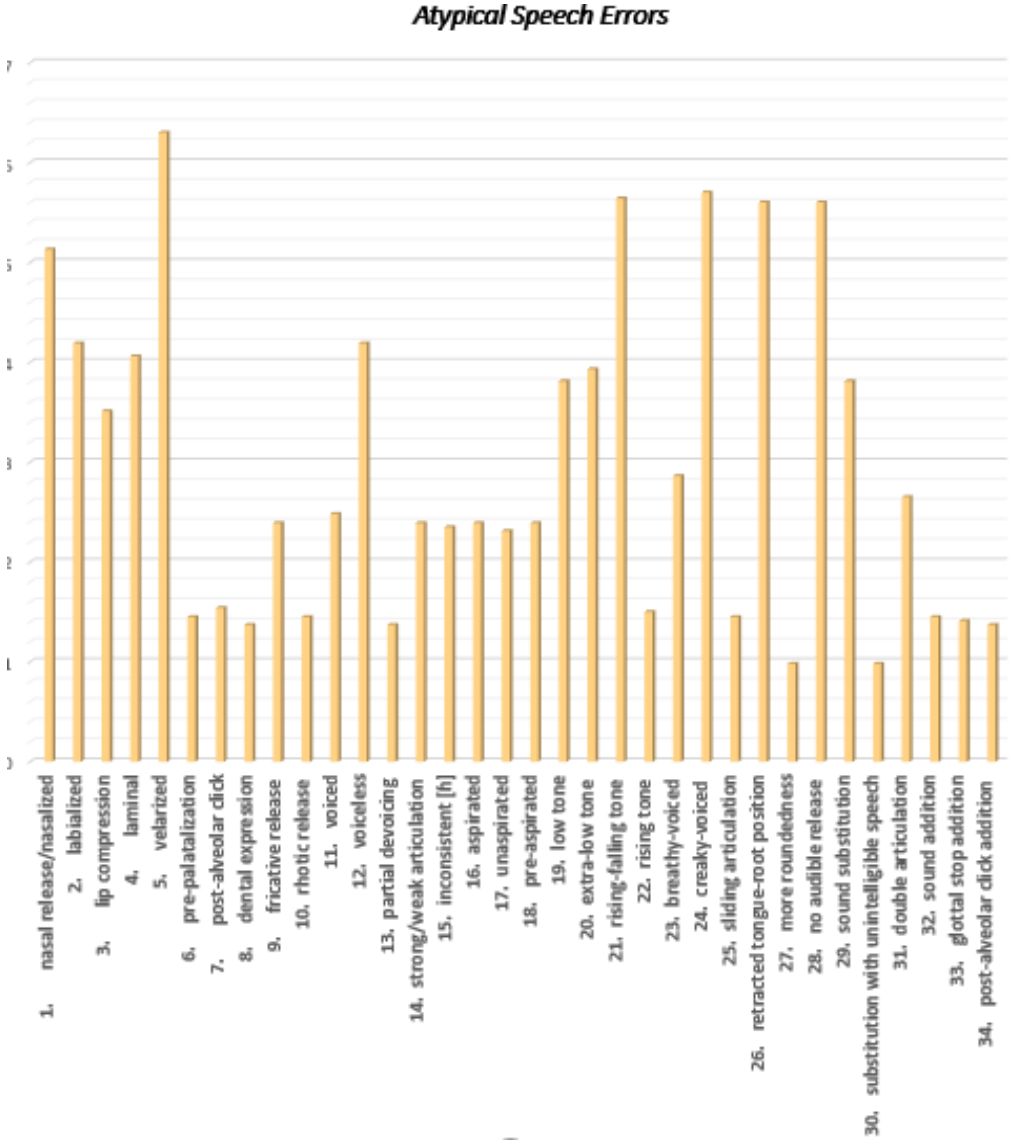


Figure 232: Atypical Speech Errors

The bar diagram below represents the summary of 10 patient's Phonological Error Types; T1: Distortion 64.61%, T2: Omission 13.47%, T3: Substitution 4.79%, T4: Insertion/Addition 17.13%. Given next is the ratio of the four major types of atypical speech features.

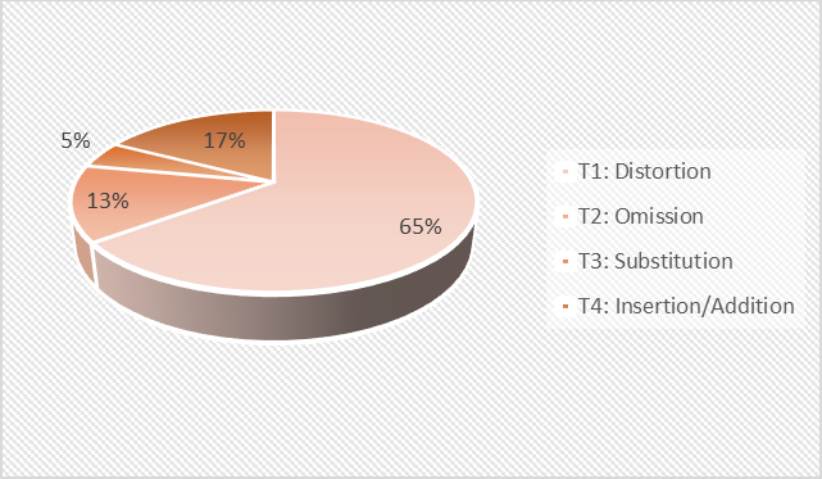


Figure 233: Atypical Speech Error Types

4.4. Feature Matrix Analyses

Given next is the phonological and articulatory matrix analysis of the atypical speech of patient 03. For patient 03, in the word পাপ, [pɐˤp̚], [p̚] represents rising-falling onset addition, for segmental features it shows [+consonantal], [+labial], [+anterior]. Here, there is no secondary articulation, however it displays weak articulation. It's an end sound and the articulatory organs include upper and lower lips. The place of articulation is bilabial, manner is plosive, and it is a voiceless sound. It is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. There is weak Articulation (̚) as it shows lower intensity and blurred formants.

In the word লেবু, [l̪ebᵝũ], [bᵝ] doesn't show any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+labial], [+anterior]. Here, there is no secondary articulation, however it displays lips compression. It's a near-end sound and the articulatory organs include upper and lower lips. The place of articulation is bilabial, manner is plosive, and it is a voiced sound. It is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. Clear formant structure without aperiodic noise identifies sonorants. Here, [bᵝ] is a consonant because it is produced with a bilabial closure. Since there is a stop-closure, it doesn't display any vowel-like formants.

However, the flat F2 confirms that [bᵝ] behaves as a consonant rather than a vowel in this sequence.

In the word ভাল, [bʱɐ͡lo˩], [bʱ] doesn't show any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+labial], [+anterior]. Here, there is no secondary articulation, however it displays unaspiration. It's a beginning sound and the articulatory organs include upper and lower lips. The place of articulation is bilabial, manner is plosive, and it is a voiced sound. It is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It shows unaspiration /◌ʱ/ as shows that voicing begins quickly after stop release. Clear formant structure without aperiodic noise identifies sonorants. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word অভাব, [ɔˠbʱʷɐb̪], [bʱʷ] doesn't show any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+labial], [+labialization], [+anterior], [+rounded]. Here, there is a secondary articulation, which is labialization. It's a beginning sound and the articulatory organs include upper and lower lips. The place of articulation is bilabial, manner is plosive, and it is a voiced sound. It is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. It is rounded as there is a lowering of F2, a cue for lip rounding. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. Clear formant structure without aperiodic noise identifies sonorants. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বিক্ষোভ, [b̪ɪkˤkˠobʱ], [bʱ] doesn't show any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+labial], [+anterior]. Here, there is no secondary articulation, however it displays breathy-voice. It's an end sound and the articulatory organs include upper and lower lips. The place of articulation is bilabial, manner is plosive, and it is a voiced sound. It is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. It is

anterior as have concentrated energy in the higher frequency region, indicating front articulations. It shows labialization /◌ʷ/ as it shows lowered F2. Clear formant structure without aperiodic noise identifies sonorants. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word দ্বিতীয়, [d̪ʱʲiˀʱt̪i̯õ], [ʱt̪] represents rising-falling as onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation, however it displays pre-aspiration. It's a near-end sound and the articulatory organs include blade of the tongue and upper teeth. The place of articulation is dental, manner is plosive, and it is a voiceless sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows dental /◌̪/ energy shifted lower. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word হাত, [ɦɐt̪!˩], [t̪!˩] doesn't display any onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation, however it displays a click sound and a low tone. It's an end sound and the articulatory organs include blade of the tongue, alveolar ridge and upper teeth. The place of articulation is alveo-dental due to the click, manner is plosive, and it is a voiceless sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows dental /◌̪/ energy shifted lower. It shows low Tone (˩) showing close to/lower F0 contour in pitch. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word কোথাও, [kʊt̪ʰʸɐo̯], [t̪ʰʸ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+velarization], [+high], [+back]. Here, there is a secondary articulation, which is velarization. It's a near-

end sound and the articulatory organs include blade of the tongue, back of the tongue and upper teeth. The place of articulation is dento-velar due to velarization, manner is plosive, and it is a voiceless sound. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word পথ, [p̪ɔˈt̪], [t̪] represents rising-falling as onset addition, and it's an end sound. The segmental features, secondary articulation, articulatory organs, place, manner and voicing are not relevant as there is no audible release.

In the word ইঁদুর, [ĩˈ(d̪̃)uʲɾ], [(d̪̃)] represents rising-falling as onset addition, for segmental features it shows [+consonantal], [+/-sonorant], [+/-voice], [+coronal], [+nasal], [+nasalization], [+anterior], [+high]. Here, there is a secondary articulation, which is nasalization. It's a starting-mid sound and the articulatory organs include blade of the tongue, upper teeth and nasal cavity. The place of articulation is dental assisted with nasalization, manner is plosive, and it is a partially devoiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows nasalization /◌̃/as it shows (~250–300 Hz), higher formants. It shows dental /◌̪/ energy shifted lower. Clear formant structure without aperiodic noise identifies sonorants. It shows nasal as there is voicing with low-frequency energy and nasal murmur around. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word চাঁদ, [ʧɛ̃ˈ(d̪̃ʱ)], [(d̪̃ʱ)] doesn't display any onset addition, for segmental features it shows [+consonantal], [+/-sonorant], [+/-voice], [+coronal], [+nasal], [+nasalization], [+anterior], [+high]. Here, there is no secondary articulation, however it displays breathy-voice. It's an end sound and the articulatory organs

include blade of the tongue, upper teeth and nasal cavity. The place of articulation is dental assisted with nasalization, manner is plosive, and it is a partially devoiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows nasalization /◌̃/as it shows (~250–300 Hz), higher formants. It shows dental /◌̪/ energy shifted lower. Clear formant structure without aperiodic noise identifies sonorants, however, it is not very clear here. It shows nasal as there is voicing with low-frequency energy and nasal murmur around. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ধোঁয়া, [d̪o͡ɐ̃ʲˠ], [d̪] is a substitution, it doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation, however it displays substitution. It's a beginning sound and the articulatory organs include blade of the tongue and upper teeth. The place of articulation is dental, manner is plosive, and it is a voiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows dental /◌̪/ energy shifted lower. Clear formant structure without aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word অর্ধেক, [ɔᵛˠɾd̪̥dekˠᵛ], [d̪̥] doesn't display any onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation, however it displays voicelessness. It's a mid-sound and the articulatory organs include blade of the tongue and upper teeth. The place of articulation is dental, manner is plosive, and it is a voiceless sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low

F1, indicating a high tongue position. It shows dental /◌̪/ energy shifted lower. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word টমেটো, [ʈ̪ˠɔˠmᵝɐ̯ʈ̪o̯], [ʈ̪] doesn't display any onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+laminal], [+high]. Here, there is no secondary articulation, however it displays laminal feature and rising-falling. It's a beginning sound and the articulatory organs include blade of the tongue and alveolar ridge. The place of articulation is alveolar, manner is plosive, and it is a voiceless sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows laminal as /◌̻/ it shows broader spectral shape due to flat tongue. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আটক, [ɐˠʈ̪oˠkˠ], [ʈ̪] doesn't display any onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+laminal], [+high]. Here, there is no secondary articulation, however it displays laminal feature and rising-falling. It's a first-mid sound and the articulatory organs include blade of the tongue and alveolar ridge. The place of articulation is alveolar, manner is plosive, and it is a voiceless sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows laminal as /◌̻/ it shows broader spectral shape due to flat tongue. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word খাট, [kʰʏɐˠʈ̪ʳ], [ʈ̪ʳ] represents rising-falling as onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+coronal], [+anterior], [+high]. Here, there is a secondary articulation, which is a rhotic

release. It's an end sound and the articulatory organs include blade of the tongue, alveolar ridge and hard palate. The place of articulation is alveolar which is assisted with post-alveolar, manner is plosive assisted with approximant, and it is a voiceless sound, however, appears as voiced, that means there is a vibration in the vocal cord. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ঠিকানা, [t̪ʰikɐˠnɻɐɻ], [t̪ʰ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation, however it displays voiced feature. It's a beginning sound and the articulatory organs include blade of the tongue, and alveolar ridge. The place of articulation is alveolar, manner is plosive, and it appears as voiced, that means there is a vibration in the vocal cord. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word কাঁঠাল, [kɐt̪ʰɐˠl̪ɻ], [t̪ʰ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation, however it displays voiced feature. It's a mid-sound and the articulatory organs include blade of the tongue, and alveolar ridge. The place of articulation is alveolar, manner is plosive, and it appears as voiced, that means there is a vibration in the vocal cord. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low

F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word কাঠ, [k̚ˠɐˀt̚], [t̚] represents rising-falling as onset addition, and it's an end sound. The segmental features, secondary articulation, articulatory organs, place, manner and voicing are not relevant as there is no audible release.

In the word ডালিম, [d̪ˠɾˠlim], [d̪] doesn't display any onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation, however it displays voicelessness. It's a beginning sound and the articulatory organs include blade of the tongue, and alveolar ridge. The place of articulation is alveolar, manner is plosive, and it appears as voiceless, that means there is no vibration in the vocal cord. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আড্ডা, [ɐˀd̪d̪ɐˀ], [d̪] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation, however it displays voicelessness. It's a second-mid sound and the articulatory organs include blade of the tongue, and alveolar ridge. The place of articulation is alveolar, manner is plosive, and it appears as voiceless, that means there is no vibration in the vocal cord. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word রড, [ɾʸɔˠɖ̚], [ɖ̚] represents rising-falling as onset addition, and it is an end sound. The segmental features, secondary articulation, articulatory organs, place, manner and voicing are not relevant as there is no audible release.

In the word ঢেঁড়স, [ɖ̥ɐ̯̞ʱʸˠɭʷoʃɬ], [ɖ̥] is a substitution. It doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation, however it displays voicelessness. It's a beginning sound and the articulatory organs include blade of the tongue, and alveolar ridge. The place of articulation is alveolar, manner is plosive, and it appears as voiceless, that means there is no vibration in the vocal cord. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বেঢপ, [bɐ̯̞ɖʱʸˠɔp̚], [ɖʱʸˠ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+velarization], [+voice], [+coronal], [+anterior], [+high]. Here, there is a secondary articulation, which is velarization. It's a mid-sound and the articulatory organs include blade of the tongue, and alveolar ridge. The place of articulation is alveolar, manner is plosive, and it is a voiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic noise identifies sonorants. However, the lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ঢৈচৈ, [ɖo͡iˠɖo͡iˠ], [ɖ] is a substitution and it represents rising-falling as onset addition, for segmental features it shows [+consonantal], [+sonorant],

[+voice], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation. It's a second-mid sound and the articulatory organs include blade of the tongue, and alveolar ridge. The place of articulation is alveolar, manner is plosive, and it is a voiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আচার, [ɐʏˀɔˀɐɾ̄], [ɔˀ] represents rising-falling as onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+delayed release], [+strident], [+high]. Here, there is no secondary articulation. It's a first-mid sound and the articulatory organs include center of the tongue, and hard palate. The place of articulation is post-alveolar, manner is affricate, and it is a voiceless sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It is strident as it shows intense high-frequency noise. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ছাগল, [ʧʰʏɐˀgʏoˀlɨ], [ʧʰʏ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+velarization], [+delayed release], [+strident], [+high]. Here, there is a secondary articulation, which is velarization, assisted with creaky voice and retracted tongue-root position. It's a beginning sound and the articulatory organs include center of the tongue, and hard palate. The place of articulation is post-alveolar, manner is affricate, and it is a voiceless sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. It shows velarization /◌ʏ/ as it

shows lowered F2, reflects tongue body retracted toward velum. It is strident as it shows intense high-frequency noise. However, lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বছর, [bɔˠˤʰcʰo̞ʲˠɾˠ], [ʰcʰ] represents pre-aspiration as onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+delayed release], [+strident], [+high]. Here, there is no secondary articulation. It's an end sound and the articulatory organs include center of the tongue, and hard palate. The place of articulation is post-alveolar, manner is affricate, and it is a voiceless sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It is strident as it shows intense high-frequency noise. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word যেও, [ɟ̟ˠe͡oˤ], [ɟ̟ˠ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+coronal], [+velarization], [+anterior], [+delayed release], [+strident], [+high]. Here, there is a secondary articulation, which is velarization, assisted with creaky voice and retracted tongue-root position. It's a beginning sound and the articulatory organs include center of the tongue, and hard palate. The place of articulation is post-alveolar, manner is affricate, and it is a voiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic noise identifies sonorants. It is strident as it shows intense high-frequency noise. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word গাজর, [gˠɐjɟˠoˈɾ], [ɟˠ] doesn’t display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+velarization], [+coronal], [+anterior], [+delayed release], [+strident], [+high]. Here, there is a secondary articulation, which is velarization, assisted with creaky voice and retracted tongue-root position. It’s a mid-sound and the articulatory organs include center of the tongue, and hard palate. The place of articulation is post-alveolar, manner is affricate, and it is a voiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic noise identifies sonorants. It is strident as it shows intense high-frequency noise. However, lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word জাহাজ, [ɟˠɐɦˠɐhˠɐˀɟˠ], [ɟˠ] doesn’t display any onset addition, for segmental features it shows [+consonantal], [+coronal], [+velarization], [+anterior], [+delayed release], [+strident], [+high]. Here, there is a secondary articulation, which is velarization, assisted with voicelessness and retracted tongue-root position. It’s an end sound and the articulatory organs include center of the tongue, and hard palate. The place of articulation is post-alveolar, manner is affricate, and it is a voiceless sound as there is no significant vibration in the vocal cord. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. It is strident as it shows intense high-frequency noise. However, lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ঝাউবন, [ʝ̟ʱˠʲʊ̯̟ˠt̪̟ɔɦn̪̟], [ʝ̟ʱˠ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+velarization], [+voice], [+coronal], [+anterior], [+delayed release], [+strident], [+high]. Here, there is a secondary articulation, which is velarization, assisted with creaky voice and retracted tongue-root position. It's a beginning sound and the articulatory organs include center of the tongue, and hard palate. The place of articulation is post-alveolar, manner is affricate, and it is a voiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic noise identifies sonorants. It is strident as it shows intense high-frequency noise. However, lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ঝাঁঝ, [ʝ̟̃ʱˠˀʝ̟̰], [ʝ̟̰] represents rising-falling as onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+delayed release], [+strident], [+high]. Here, there is no secondary articulation. It's an end sound and the articulatory organs include center of the tongue, and hard palate. The place of articulation is post-alveolar, manner is affricate, and it is a voiceless sound as there is no significant vibration in the vocal cord. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It is strident as it shows intense high-frequency noise. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word নাক, [nˠˀʱˠk̚], [k̚] doesn't display any onset addition, and it is an end sound. The segmental features, secondary articulation, articulatory organs, place, manner and voicing are not relevant as there is no audible release.

In the word খেয়া, [k̟ʰẽ̞ɐˠˤ], [k̟ʰ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+constricted glottis], [+high], [+back]. Here, there is no secondary articulation, however there is unaspiration, creaky voice and retracted tongue-root position. It's a beginning sound and the articulatory organs include back of the tongue, soft palate, and uvula. The place of articulation is velar, manner is plosive, and it is a voiceless sound. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. It shows unaspiration /◌ʰ/ as shows that voicing begins quickly after stop release. Irregular or creaky voicing indicates constricted glottis. However, the lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আখ, [ɐˤk̟ʰˠ], [k̟ʰˠ] represents rising-falling as onset addition, for segmental features it shows [+consonantal], [+constricted glottis], [+velarization], [+high], [+back]. Here, there is a secondary articulation, which is velarization, assisted with creaky voice and retracted tongue-root position. It's an end sound and the articulatory organs include back of the tongue, soft palate, and uvula. The place of articulation is velar, manner is plosive, and it is a voiceless sound. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. Irregular or creaky voicing indicates constricted glottis. However, the lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word গয়না, [k̃o̞i̯ˠn̪ɐˤ], [k̃] is a substitution, it doesn't display any onset addition, for segmental features it shows [+consonantal], [+constricted glottis], [+nasalization], [+high], [+back]. Here, there is a secondary articulation, which is nasalization. It's a beginning sound and the articulatory organs include back of the tongue, soft palate, and uvula. The place of articulation is velar, manner is plosive, and it is a voiceless sound. It is high as it shows low F1 and F2, indicating a high tongue position. It shows nasalization /◌̃/as it shows (~250–300 Hz), higher formants. Irregular or creaky voicing indicates constricted glottis. However, the

low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আগামী, [ɐˤɐgˠɐm̪ɪ̄], [gˠ] represents rising-falling as onset addition, for segmental features it shows [+consonantal], [+sonorant], [+velarization], [+voice], [+constricted glottis], [+high], [+back]. Here, there is a secondary articulation, which is velarization. It's a first-mid sound and the articulatory organs include back of the tongue, soft palate, and uvula. The place of articulation is velar, manner is plosive, and it is a voiced sound. It is high as it shows low F1, indicating a high tongue position. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic noise identifies sonorants. However, the lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word মোরগ, [m̃ᵝõˠɾõg̃], [g̃] doesn't display any onset addition, and it is an end sound. The segmental features, secondary articulation, articulatory organs, place, manner and voicing are not relevant as there is no audible release. Irregular or creaky voicing indicates constricted glottis.

In the word ঘেউঘেউ, [g̰ʱˠe̯͡uˠg̰ʱˠe̯͡uʷˠ], [g̰ʱˠ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+velarization], [+voice], [+constricted glottis], [+high], [+back]. Here, there is a secondary articulation, which is velarization, assisted with creaky voice. It's a beginning sound and the articulatory organs include back of the tongue, soft palate, and uvula. The place of articulation is velar, manner is plosive, and it is a voiced sound. It is high as it shows low F1, indicating a high tongue position. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic noise identifies sonorants. Irregular or creaky voicing indicates constricted glottis. However, the lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আঘাত, [ɐ̈ˠɐdʱɐlɬ], [dʱ] is a substitution, it represents rising-falling as onset addition, for segmental features it shows [+consonantal], [+sonorant],

[+voice], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation. It's a first-mid sound and the articulatory organs include blade of the tongue, and alveolar ridge. The place of articulation is alveolar, manner is plosive, and it is a voiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বাঘ, [b̪ᵝɐʸˤgʱ̚], [gʱ̚] represents rising-falling as onset addition, for segmental features it shows [+consonantal], [+constricted glottis], [+high], [+back]. Here, there is no secondary articulation, however it displays voicelessness. It's an end sound and the articulatory organs include back of the tongue, soft palate, and uvula. The place of articulation is velar, manner is plosive, and it is a voiceless sound as there is no significant vibration in the vocal cord. It is high as it shows low F1 and F2, indicating a high tongue position. Irregular or creaky voicing indicates constricted glottis. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word সূফী, [s̄u̪ʷpiʷˤ], [s̄] doesn't display any onset addition, and it is a beginning sound. The segmental features, secondary articulation, articulatory organs, place, manner and voicing are not relevant as there is no audible release.

In the word সেদিকেই, [ʃʰed̪ɪˤgeɪ̄], [ʃʰ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+spread glottis], [+distributed]. Here, there is no secondary articulation, however there is aspiration. It's a beginning sound and the articulatory organs include center of the tongue, and hard palate. The place of articulation is post-alveolar, manner is fricative, and it is a voiceless sound. It is distributed as it shows broader spectral energy. However, low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word শ্বাস, [ʃ̃ʰʄʲʰʃ], [ʰʃ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+spread glottis], [+distributed]. Here, there is no secondary articulation, however there is pre-aspiration. It's an end sound and the articulatory organs include center of the tongue, and hard palate. The place of articulation is post-alveolar, manner is fricative, and it is a voiceless sound. It is distributed as it shows broader spectral energy. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word হও, [ɦ̞ʷʌ͡ɔ˥], [ɦ̞ʷʌ] is a substitution, it doesn't display any onset addition, for segmental features it shows [+syllabic], [+velarization], [+rounded], [+low]. Here, there is a secondary articulation, which is velarization, assisted with rising marker, creaky voice, and breathy voice. It's a beginning sound and the articulatory organs include upper lip, lower lip, and velum. The place of articulation, manner, and voicing are not relevant, however, due to velarization, velum is involved. It shows low position as it shows high F1, reflecting a low tongue position, shows low F2, signaling tongue retraction. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বহুত, [bʷõ˧ɦ̰ũˠ˧t̪̄], [ɦ̰] represents rising-falling as onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+continuant]. Here, there is no secondary articulation, however it displays voiced feature. It's a mid-sound. Here the articulatory organs are not relevant, the place of articulation is glottal, and manner is fricative. Clear formant structure without aperiodic noise identifies sonorants. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বাহ, [bʷɦ̃˧h̄], [h̄] represents rising-falling as onset addition, and it is an end sound. The segmental features, secondary articulation, articulatory organs, place, manner and voicing are not relevant as there is no audible release.

In the word ম্যাও, [m̃lɛ̝͡oʲˠˤ], [m̃l] doesn’t display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+nasal], [+nasalization], [+labial], [+anterior]. Here, there is a secondary articulation, which is nasalization, assisted with rising marker. It’s a beginning sound and the articulatory organs include upper lip, lower lip, and nasal cavity. The place of articulation is bilabial, manner is nasal, and it is a voiced sound. It is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It shows nasalization /◌̃/as it shows (~250–300 Hz), higher formants. Clear formant structure without aperiodic noise identifies sonorants. It shows nasal as there is voicing with low-frequency energy and nasal murmur around. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word মিউ, [mlɪu̯ʲˠˤ], [ml] doesn’t display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+nasal], [+labial], [+anterior]. Here, there is no secondary articulation, however there is rising marker. It’s a beginning sound and the articulatory organs include upper lip, lower lip, and nasal cavity. The place of articulation is bilabial, manner is nasal, and it is a voiced sound. It is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. Clear formant structure without aperiodic noise identifies sonorants. It shows nasal as there is voicing with low-frequency energy and nasal murmur around. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word থামিয়া, [t̪ʰɐmm͡ʲβɪe̞ˈɻ], [mm͡ʲβ] doesn’t display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+nasal], [+labial], [+anterior]. Here, there is a secondary articulation, which is double articulation, assisted with lip compression. It’s a mid-sound and the articulatory organs include upper lip, lower lip, and nasal cavity. The place of articulation is bilabial, manner is nasal, and it is a voiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations.

It shows double articulation /◌͡◌/ as it shows overlapping energy patterns. Clear formant structure without aperiodic noise identifies sonorants. It shows nasal as there is voicing with low-frequency energy and nasal murmur around. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word কলম, [kˌʏɔˌjɪʏˀlɔˀmɻ], [mɻ] represents rising-falling as onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+nasal], [+labial], [+anterior]. Here, there is no secondary articulation, however it is assisted with low tone. It's an end sound and the articulatory organs include upper lip, lower lip, and nasal cavity. The place of articulation is bilabial, manner is nasal, and it is a voiced sound. It is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It shows low Tone (ɻ) showing close to/lower F0 contour in pitch. Clear formant structure without aperiodic noise identifies sonorants. It shows nasal as there is voicing with low-frequency energy and nasal murmur around. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word নুয়ে, [n̪͡ueˀ], [n̪] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+nasal], [+nasalized], [+rounded], [+high], [+anterior]. Here, there is a secondary articulation, which is nasalization, assisted with roundedness. It's a beginning sound and the articulatory organs include alveolar ridge, blade of the tongue, and nasal cavity. The place of articulation is alveolar, manner is nasal, and it is a voiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It is high as it shows low F1 and F2, indicating a high tongue position. It shows nasalization /◌̃/as it shows (~250–300 Hz), higher formants. Clear formant structure without aperiodic noise identifies sonorants. It shows nasal as there is voicing with low-frequency energy and nasal murmur around. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word অনেক, [ɔ̃n͡n̪e̪gʸ], [n͡n] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+nasal], [+high], [+anterior]. Here, there is a secondary articulation, which is double articulation. It's a first-mid sound and the articulatory organs include alveolar ridge, blade of the tongue, and nasal cavity. The place of articulation is alveolar, manner is nasal, and it is a voiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It is high as it shows low F1 and F2, indicating a high tongue position. It shows double articulation /◌͡◌/ as it shows overlapping energy patterns. Clear formant structure without aperiodic noise identifies sonorants. It shows nasal as there is voicing with low-frequency energy and nasal murmur around. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আয়না, [ɐ͡e̯ʸn͡n˩ɐʲᵑ˧], [n͡n˩] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+nasal], [+high], [+anterior]. Here, there is a secondary articulation, which is double articulation, assisted with low tone. It's a second-mid sound and the articulatory organs include alveolar ridge, blade of the tongue, and nasal cavity. The place of articulation is alveolar, manner is nasal, and it is a voiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It is high as it shows low F1 and F2, indicating a high tongue position. It shows double articulation /◌͡◌/ as it shows overlapping energy patterns. It shows low Tone (˩) showing close to/lower F0 contour in pitch. Clear formant structure without aperiodic noise identifies sonorants. It shows nasal as there is voicing with low-frequency energy and nasal murmur around. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আংটি [ɐ̃ʸŋ̰ʈiˀ˧], [ŋ̰] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+constricted glottis], [+nasal], [+high], [+back]. Here, there is no secondary articulation, however there is retracted tongue-root position. It's a first-mid sound and the articulatory organs include back of the tongue, velum, uvula, and nasal cavity. The place of articulation is velar, manner is nasal, and it is a voiced sound. It is high as it shows

low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. Clear formant structure without aperiodic noise identifies sonorants. Irregular or creaky voicing indicates constricted glottis. It shows nasal as there is voicing with low-frequency energy and nasal murmur around. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ফড়িং, [pʰo̰ʸɾ̰ʸɪŋ̰], [ŋ̰] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+constricted glottis], [+nasal], [+high], [+back]. Here, there is no secondary articulation, however there is retracted tongue-root position. It's an end sound and the articulatory organs include back of the tongue, velum, uvula, and nasal cavity. The place of articulation is velar, manner is nasal, and it is a voiced sound. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. Clear formant structure without aperiodic noise identifies sonorants. Irregular or creaky voicing indicates constricted glottis. It shows nasal as there is voicing with low-frequency energy and nasal murmur around. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word লয়া, [l̪ʸɔ͡ɐʏ], [l̪ʸ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+lateral], [+velarization], [+high], [+anterior]. Here, there is a secondary articulation, which is velarization, assisted with retracted tongue-root position. It's a beginning sound and the articulatory organs include alveolar ridge, and blade of the tongue. The place of articulation is alveolar, manner is approximant, and it is a voiced sound. There is voiced segments with a drop in F2 and dark zones due to side-channel airflow marking a lateral sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. It shows velarization /◌ʸ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic noise identifies sonorants. It is lateral as there is voiced segments with a drop in F2 and dark zones due to side-channel airflow. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ডালিম, [d̪ɦˠˤɭ̪im], [l̪] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+lateral], [+high], [+anterior]. Here, there is no secondary articulation, however there is voicelessness. It's a mid-sound and the articulatory organs include alveolar ridge, and blade of the tongue. The place of articulation is alveolar, manner is approximant, and it is a voiceless sound. There is a drop in F2 and dark zones due to side-channel airflow marking a lateral sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. It is lateral as there is voiced segments with a drop in F2 and dark zones due to side-channel airflow. However, the drop in F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word কল, [k̪ˠɔˠˤl̪], [l̪] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+lateral], [+high], [+anterior]. Here, there is no secondary articulation, however it is assisted with retracted tongue-root position. It's an end sound and the articulatory organs include alveolar ridge, and blade of the tongue. The place of articulation is alveolar, manner is approximant, and it is a voiced sound. There is voiced segments with a drop in F2 and dark zones due to side-channel airflow marking a lateral sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. Clear formant structure without aperiodic noise identifies sonorants. It is lateral as there is voiced segments with a drop in F2 and dark zones due to side-channel airflow. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word রয়ে, [ɾo͡eˠˤ], [ɾ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+high]. Here, there is no secondary articulation, however it is assisted with retracted tongue-root position. It's a beginning sound and the articulatory organs include hard palate, and center of the tongue. The place of articulation is post-alveolar, manner is approximant, and it is a voiced sound. It is high as it shows low F1, indicating a high tongue

position. It shows low F2, indicating back tongue placement. Clear formant structure without aperiodic noise identifies sonorants. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word মোরগ, [m̃ᵝõʸɽõg̃], [ɽ] is a substitution, it doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+high]. Here, there is no secondary articulation. It's a mid-sound and the articulatory organs include hard palate, and center and back of the tongue. The place of articulation is post-alveolar, manner is approximant, and it is a voiced sound. It is high as it shows low F1 and F2, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বানর, [bɛ̃n̪o̞ɾ̃], [ɾ̃] doesn't display any onset addition, and it is an end sound. The segmental features, secondary articulation, articulatory organs, place, manner and voicing are not relevant as there is no audible release.

In the word ফড়িং, [pʰõ̞ʸɽ̞ʸɪŋ̟], [ɽ̞ʸ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+high]. Here, there is a secondary articulation, which is velarization, assisted with retracted tongue-root position. It's a mid-sound and the articulatory organs include hard palate, and center and back of the tongue. The place of articulation is post-alveolar, manner is approximant, and it is a voiced sound. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. It shows velarization /◌ʸ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic noise identifies sonorants. However, the lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word পাঁপড়, [p̃ɛ̟̃ˤpo̞ɽ̞̃], [ɽ̞̃] doesn't display any onset addition, and it is an end sound. The segmental features, secondary articulation, articulatory organs, place, manner and voicing are not relevant as there is no audible release.

For Patient 01, in the word পাপ, [ɐpp̚p̄], [p̄] doesn't display any onset addition, and it's an end sound. The segmental features, secondary articulation, articulatory organs, place, manner and voicing are not relevant as there is no audible release.

In the word লাফানো, [lɐp̪ʰɐno], [p̪ʰ] doesn't show any onset addition, for segmental features it shows [+consonantal], [+labial], [+anterior]. Here, there is no secondary articulation, however it displays weak articulation. It's first-mid sound and the articulatory organs include upper and lower lips. The place of articulation is bilabial, manner is plosive, and it is a voiceless sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. There is weak Articulation (̩) as it shows lower intensity and blurred formants. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বরফ, [bɔ̪ˠɾop̪ʰ], [p̪ʰ] doesn't show any onset addition, for segmental features it shows [+consonantal], [+labial], [+anterior]. Here, there is no secondary articulation, however it displays weak articulation. It's an end sound and the articulatory organs include upper and lower lips. The place of articulation is bilabial, manner is plosive, and it is a voiceless sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. There is weak Articulation (̩) as it shows lower intensity and blurred formants. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word লেবু, [leb̃ɻu], [b̃ɻ] doesn't show any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+labial], [+anterior]. Here, there is a secondary articulation, which is nasalization, assisted with low tone. It's a near-end sound and the articulatory organs include upper and lower lips. The place of articulation is bilabial, manner is plosive, and it is a voiced sound. It is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It shows nasalization /̃/as it shows

(~250–300 Hz), higher formants. It shows low Tone (˩) showing close to/lower F0 contour in pitch. Clear formant structure without aperiodic noise identifies sonorants. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ভাল, [bʱˈɐlʸo˩], [bʱ] doesn't show any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+labial], [+anterior]. Here, there is no secondary articulation, however it displays unaspiration. It's a beginning sound and the articulatory organs include upper and lower lips. The place of articulation is bilabial, manner is plosive, and it is a voiced sound. It is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It shows unaspiration /◌ʱ/ as shows that voicing begins quickly after stop release. Clear formant structure without aperiodic noise identifies sonorants. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word অভাব, [ɔõʸ˧˩˨bʱɐʸbᵝ], [bʱ] represents rising-falling as onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+labial], [+anterior]. Here, there is no secondary articulation, however there is voicing and unaspiration. It's a mid-sound and the articulatory organs include upper and lower lips. The place of articulation is bilabial, manner is plosive, and it is a voiced sound. It is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It shows unaspiration /◌ʱ/ as shows that voicing begins quickly after stop release. Clear formant structure without aperiodic noise identifies sonorants. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বিক্ষোভ, [bɪkkʰo˧˩˨bʱ], [bʱ] represents rising-falling as onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+labial], [+anterior]. Here, there is no secondary articulation, however there is voicing and unaspiration. It's an end sound and the articulatory organs include upper and lower

lips. The place of articulation is bilabial, manner is plosive, and it is a voiced sound. It is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It shows unaspiration /◌̄/ as shows that voicing begins quickly after stop release. Clear formant structure without aperiodic noise identifies sonorants. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word তবুও, [t̪˩˨o˨˩b˩˨u͡o˩], [t̪˩] doesn't display any onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation, however it displays low tone. It's a beginning sound and the articulatory organs include blade of the tongue and upper teeth. The place of articulation is dental, manner is plosive, and it is a voiceless sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows dental /◌̪/ energy shifted lower. It shows low Tone (˩) showing close to/lower F0 contour in pitch. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word হাত, [h̄ɐ̯˧t̪ʰ], [t̪ʰ] is a substitution, it represents rising-falling as onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation. It's an end sound and the articulatory organs include blade of the tongue, and upper teeth. The place of articulation is dental, manner is plosive, and it is a voiceless sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows dental /◌̪/ energy shifted lower. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word পথ, [pʷɔˀt̪ʰ̚], [t̪ʰ̚] represents rising-falling as onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation, however there is extra-low tone and weak articulation. It's an end sound and the articulatory organs include blade of the tongue, and upper teeth. The place of articulation is dental, manner is plosive, and it is a voiceless sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows dental /◌̪/ energy shifted lower. It shows low Tone (˩) showing close to/lower F0 contour in pitch. There is weak Articulation (̩) as it shows lower intensity and blurred formants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word চাঁদ, [cɐʸ(d̪ʱ̰)], [(d̪ʱ̰)] doesn't display any onset addition, for segmental features it shows [+consonantal], [+/-sonorant], [+/-voice], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation, however there is creaky-voice. It's an end sound and the articulatory organs include blade of the tongue, and upper teeth. The place of articulation is dental, manner is plosive, and it is a partially devoiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows dental /◌̪/ energy shifted lower. Clear formant structure without aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ধোঁয়া, [d̪o͡ɐˀ], [d̪] is a substitution, it doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation, however it displays substitution. It's a beginning sound and the articulatory organs include blade of the tongue and upper teeth. The place of articulation is dental, manner is plosive, and it is a voiced sound. It is anterior as have concentrated energy in the higher frequency

region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows dental /̪/ energy shifted lower. Clear formant structure without aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word অর্ধেক, [ɔ̃ʳʸɾʸd̪e৭k̄ǂ], [d̪] doesn't display any onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation, however it displays voicelessness. It's a mid-sound and the articulatory organs include blade of the tongue and upper teeth. The place of articulation is dental, manner is plosive, and it is a voiceless sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows dental /̪/ energy shifted lower. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ঔষধ, [o͡uʲˈʃɔ̃ʲt̪̚], [t̪̚] is a substitution, it doesn't display any onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation. It's an end sound and the articulatory organs include blade of the tongue and upper teeth. The place of articulation is dental, manner is plosive, and it is a voiceless sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows dental /̪/ energy shifted lower. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

খাট, [kʰ̄ɛ̃ʸʳt̪̄ʰɟ̊ʰˢ], [t̪̄ʰɟ̊ʰˢ] has no audible release, however it shows addition. It doesn't display any onset addition, and it's an end sound. The segmental features,

secondary articulation, articulatory organs, place, manner and voicing are not relevant as there is no audible release.

In the word ঠিকানা, [!ʈʰi̪ˠgʲɸʲn̪ɬɸˠʳ], [!ʈʰ] doesn't display any onset addition, however there is a click sound, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation, however it displays click sound. It's a beginning sound and the articulatory organs include blade of the tongue, and alveolar ridge. The place of articulation is alveolar, manner is plosive, and it is a voiceless sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আড্ডা, [ɸˠd̪ˠd̪ɸˠɭ], [d̪] doesn't display any onset addition, for segmental features it shows [+consonantal], [+coronal], [+velarization], [+anterior], [+high]. Here, there is a secondary articulation, which is velarization. It's a first-mid sound and the articulatory organs include blade of the tongue, and alveolar ridge. The place of articulation is alveolar, manner is plosive, and it appears as voiceless, that means there is no vibration in the vocal cord. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. However, the lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word রূড, [ɾʳɔˠɭɖ!], [ɖ!] represents rising-falling as onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation, however it displays a click sound. It's an end sound and the articulatory organs include blade of the tongue, and alveolar ridge. The place of articulation is alveolar, manner is plosive,

and it is a voiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ঢেঁড়স, [d̪ˌæˈɽ̞ˠo̪ʳʏʃ], [d̪ˌ] is a substitution and it doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation, however it displays voicelessness. It's a beginning sound and the articulatory organs include blade of the tongue, and alveolar ridge. The place of articulation is alveolar, manner is plosive, and it appears as voiceless, that means there is no vibration in the vocal cord. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বেচপ, [be̪ˌd̪ʱʏˈɔp̚], [d̪ʱʏˈ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+velarization], [+voice], [+coronal], [+anterior], [+high]. Here, there is a secondary articulation, which is velarization. It's a mid-sound and the articulatory organs include blade of the tongue, and alveolar ridge. The place of articulation is alveolar, manner is plosive, and it is a voiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows velarization /◌ʏ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic noise identifies sonorants.

However, the lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আচার, [ɐʰcʰˢɐˤɾɻ], [cʰˢ] doesn’t display any onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+fricative release], [+delayed release], [+strident], [+high]. Here, there is a secondary articulation, which is a fricative release. It’s a first-mid sound and the articulatory organs include center of the tongue, and hard palate. The place of articulation is post-alveolar, manner is affricate, and it is a voiceless sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It is strident as it shows intense high-frequency noise. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word চামচ, [cʰˢʊ̟ˠm̪ˠõcˢ], [cˢ] doesn’t display any onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+fricative release], [+delayed release], [+strident], [+high]. Here, there is a secondary articulation, which is a fricative release. It’s an end sound and the articulatory organs include center of the tongue, and hard palate. The place of articulation is post-alveolar, manner is affricate, and it is a voiceless sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It is strident as it shows intense high-frequency noise. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word মাছ, [m̪ᵝˠʊ̟ˠcʰˢ], [cʰˢ] doesn’t display any onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+fricative release], [+delayed release], [+strident], [+high]. Here, there is a secondary articulation, which is a fricative release. It’s an end sound and the articulatory organs include

center of the tongue, and hard palate. The place of articulation is post-alveolar, manner is affricate, and it is a voiceless sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It is strident as it shows intense high-frequency noise. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word যেও, [ʒ̃e͡oˠ], [ʒ̃] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+coronal], [+nasalization], [+anterior], [+delayed release], [+strident], [+high]. Here, there is a secondary articulation, which is nasalization. It's a beginning sound and the articulatory organs include center of the tongue, and hard palate. The place of articulation is post-alveolar, manner is affricate, and it is a voiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows nasalization /ঁ/as it shows (~250–300 Hz), higher formants. Clear formant structure without aperiodic noise identifies sonorants. It is strident as it shows intense high-frequency noise. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word গাজর, [ɡˠɐ̯ʒˠɹ̪o̯ɾˠ], [ɹ̪] represents rising-falling as onset addition, however there is weak articulation, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+coronal], [+anterior], [+delayed release], [+strident], [+high]. Here, there is no secondary articulation, however it displays weak articulation. It's a mid-sound and the articulatory organs include center of the tongue, and hard palate. The place of articulation is post-alveolar, manner is affricate, and it is a voiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-

frequency range. It is high as it shows low F1, indicating a high tongue position. There is weak Articulation (̩) as it shows lower intensity and blurred formants. Clear formant structure without aperiodic noise identifies sonorants. It is strident as it shows intense high-frequency noise. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word জাহাজ, [ʤˢɐhʱ˩s], [s] is a substitution and it represents low tone as onset addition, for segmental features it shows [+consonantal], [+spread glottis], [+distributed]. Here, there is no secondary articulation, however it is a substitution. It's an end sound and the articulatory organs include alveolar ridge. The place of articulation is alveolar, manner is fricative, and it is a voiceless sound. It is distributed as it shows broader spectral energy. It shows low Tone (˩) showing close to/lower F0 contour in pitch. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ঝাউবন, [ʤ⁼ʲɐ͡ubʷɔʷʸn˩], [ʤ⁼] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+coronal], [+anterior], [+delayed release], [+strident], [+high]. Here, there is no secondary articulation, however it is unaspirated. It's a beginning sound and the articulatory organs include center of the tongue, and hard palate. The place of articulation is post-alveolar, manner is affricate, and it is a voiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows unaspirated sound /◌⁼/ as it shows that voicing begins quickly after stop release. Clear formant structure without aperiodic noise identifies sonorants. It is strident as it shows intense high-frequency noise. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ঝাঁঝ, [ʤ⁼ʲɐˤkʱ˩], [kʱ˩] is a substitution and it represents rising-falling as onset addition, for segmental features it shows [+consonantal], [+constricted glottis], [+high], [+back]. Here, there is no secondary articulation, however there is

a low tone. It's an end sound and the articulatory organs include back of the tongue, soft palate, and uvula. The place of articulation is velar, manner is plosive, and it is a voiceless sound. It is high as it shows low F1 and F2, indicating a high tongue position. It shows low Tone (˩) showing close to/lower F0 contour in pitch. Irregular or creaky voicing indicates constricted glottis. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word দোকান, [d̪ʲo˩k̚ɣ̃ʏn̪], [k̚] represents rising-falling as onset addition, for segmental features it shows [+consonantal], [+constricted glottis], [+high], [+back]. Here, there is no secondary articulation, however it is voiced. It's a mid-sound and the articulatory organs include back of the tongue, soft palate, and uvula. The place of articulation is velar, manner is plosive, and it is a voiced sound due to vibration in the vocal cord. It is high as it shows low F1 and F2, indicating a high tongue position. Irregular or creaky voicing indicates constricted glottis. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word নৌকা, [ʰño͡ugɣ̃ʏ], [g] is a substitution and doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+constricted glottis], [+high], [+back]. Here, there is no secondary articulation. It's a second-mid sound and the articulatory organs include back of the tongue, soft palate, and uvula. The place of articulation is velar, manner is plosive, and it is a voiced sound. It is high as it shows low F1 and F2, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. Irregular or creaky voicing indicates constricted glottis. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word নাক, [ñɣ̃ʏk̄], [k̄] doesn't display any onset addition, and it is an end sound. The segmental features, secondary articulation, articulatory organs, place, manner and voicing are not relevant as there is no audible release.

In the word আখ, [ɣ̃ʏʳkʰ˩], [kʰ˩] doesn't display any onset addition, for segmental features it shows [+consonantal], [+constricted glottis], [+high], [+back]. Here,

there is no secondary articulation, however it shows low tone. It's an end sound and the articulatory organs include back of the tongue, soft palate, and uvula. The place of articulation is velar, manner is plosive, and it is a voiceless sound. It is high as it shows low F1 and F2, indicating a high tongue position. It shows low Tone (˩) showing close to/lower F0 contour in pitch. Irregular or creaky voicing indicates constricted glottis. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আগামী, [ɐ̆gˠɐ̯ˠm˩iɻ], [gˠ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+velarization], [+voice], [+constricted glottis], [+high], [+back]. Here, there is a secondary articulation, which is velarization. It's a first-mid sound and the articulatory organs include back of the tongue, soft palate, and uvula. The place of articulation is velar, manner is plosive, and it is a voiced sound. It is high as it shows low F1, indicating a high tongue position. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. Irregular or creaky voicing indicates constricted glottis. However, the lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word মোরগ, [m˩oɾʲʲoʔ], [ʔ] is a substitution and doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+constricted glottis], [+back]. Here, there is no secondary articulation. It's an end sound and the articulatory organs include back of the tongue, soft palate, and uvula. The place of articulation is velar, manner is plosive, and it is a voiced sound. Clear formant structure without aperiodic noise identifies sonorants. Irregular or creaky voicing indicates constricted glottis. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ঘেউঘেউ, [gʱe͡u˩gʱe͡u˩], [gʱ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+constricted glottis], [+high], [+back]. Here, there is no secondary articulation, however there is unaspiration. It's a beginning sound and the articulatory organs include back of the tongue, soft palate, and uvula. The place of articulation is velar, manner is plosive,

and it is a voiced sound. It is high as it shows low F1 and F2, indicating a high tongue position. It shows unaspiration /◌ʰ/ as shows that voicing begins quickly after stop release. Clear formant structure without aperiodic noise identifies sonorants. Irregular or creaky voicing indicates constricted glottis. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বাঘ, [bᵝɐ̯ᵛg̅ʱ], [g̅ʱ] doesn't display any onset addition, and it is an end sound. The segmental features, secondary articulation, articulatory organs, place, manner and voicing are not relevant as there is no audible release.

In the word সেদিকেই, [ʃe̤d̪ɪge̤ɪ̄], [ʃ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+spread glottis], [+distributed]. Here, there is no secondary articulation, however there is retracted tongue-root position. It's a beginning sound and the articulatory organs include center of the tongue, and hard palate. The place of articulation is post-alveolar, manner is fricative, and it is a voiceless sound. It is distributed as it shows broader spectral energy. It shows low F2, indicating back tongue placement. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word হও, [ɦ̰ɔ̰o̰ɻ], [ɦ̰] doesn't display any onset addition, for segmental features it shows [+consonantal], [+continuant]. Here, there is no secondary articulation, however it displays creaky-voice. It's a beginning sound. Here the articulatory organs are not relevant, the place of articulation is glottal, and manner is fricative. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word থামিয়া, [t̪ʰɐmbi̯ɐ], [b] is an addition to [m], [b] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+labial], [+anterior]. Here, there is no secondary articulation, however it displays addition with [b]. It's a mid-sound and the articulatory organs include upper and lower lips. The place of articulation is bilabial, manner is plosive, and it is a voiced sound. It is labial as it displays weak formant transitions, especially flat F2, and

shows a lower burst. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. Clear formant structure without aperiodic noise identifies sonorants. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word কলম, [k̄ɔl̪o m̄], [m̄] doesn't display any onset addition, and it is an end sound. The segmental features, secondary articulation, articulatory organs, place, manner and voicing are not relevant as there is no audible release.

In the word নুয়ে, [nɹu͡ē], [nɹ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+nasal], [+high], [+anterior]. Here, there is no secondary articulation, however it displays extra-low tone. It's a beginning sound and the articulatory organs include alveolar ridge, blade of the tongue, and nasal cavity. The place of articulation is alveolar, manner is nasal, and it is a voiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It is high as it shows low F1 and F2, indicating a high tongue position. It shows low Tone (˩) showing close to/lower F0 contour in pitch. Clear formant structure without aperiodic noise identifies sonorants. It shows nasal as there is voicing with low-frequency energy and nasal murmur around. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word অনেক, [ɔ̃d̪e k̄], [d̪̊] is a substitution, it doesn't display any onset addition, for segmental features it shows [+consonantal], [+coronal], [+anterior], [+high]. Here, there is no secondary articulation, however it displays voicelessness. It's a first-mid sound and the articulatory organs include blade of the tongue, and alveolar ridge. The place of articulation is alveolar, manner is plosive, and it appears as voiceless, that means there is no vibration in the vocal cord. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আয়না, [ɐe˧nɻɐ˧˥], [nɻ] doesn’t display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+nasal], [+high], [+anterior]. Here, there is no secondary articulation, however it displays extra-low tone. It’s an end sound and the articulatory organs include alveolar ridge, blade of the tongue, and nasal cavity. The place of articulation is alveolar, manner is nasal, and it is a voiced sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It is high as it shows low F1 and F2, indicating a high tongue position. It shows low Tone (˩) showing close to/lower F0 contour in pitch. Clear formant structure without aperiodic noise identifies sonorants. It shows nasal as there is voicing with low-frequency energy and nasal murmur around. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word পান, [p˧ɐ̯˧n̄], [n̄] doesn’t display any onset addition, and it’s an end sound. The segmental features, secondary articulation, articulatory organs, place, manner and voicing are not relevant as there is no audible release.

In the word আংটি, [ɐŋ˩t!i], [ŋ˩] doesn’t display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+constricted glottis], [+nasal], [+high], [+back]. Here, there is no secondary articulation, however there is low tone. It’s a first-mid sound and the articulatory organs include back of the tongue, velum, uvula, and nasal cavity. The place of articulation is velar, manner is nasal, and it is a voiced sound. It is high as it shows low F1 and F2, indicating a high tongue position. It shows low Tone (˩) showing close to/lower F0 contour in pitch. Clear formant structure without aperiodic noise identifies sonorants. Irregular or creaky voicing indicates constricted glottis. It shows nasal as there is voicing with low-frequency energy and nasal murmur around. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ফড়িং, [pʰo˧ɽ˧ĩŋ̄], [ŋ̄] doesn’t display any onset addition, and it’s an end sound. The segmental features, secondary articulation, articulatory organs, place, manner and voicing are not relevant as there is no audible release.

In the word লয়া, [l̪ɹ̪ɔ̃ɐ̯ˠ], [l̪] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+lateral], [+high], [+anterior]. Here, there is no secondary articulation, however it is assisted with creaky-voice, and retracted tongue-root position. It's a beginning sound and the articulatory organs include alveolar ridge, and blade of the tongue. The place of articulation is alveolar, manner is approximant, and it is a voiced sound. There is voiced segments with a drop in F2 and dark zones due to side-channel airflow marking a lateral sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. Clear formant structure without aperiodic noise identifies sonorants. It is lateral as there is voiced segments with a drop in F2 and dark zones due to side-channel airflow. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ডালিম, [ɖɐ̪l̪im̪̚], [l̪] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+lateral], [+laminal], [+high], [+anterior]. Here, there is a secondary articulation, which is a laminal feature. It's a mid-sound and the articulatory organs include alveolar ridge, and blade of the tongue. The place of articulation is alveolar, manner is approximant, and it is a voiced sound. There is voiced segments with a drop in F2 and dark zones due to side-channel airflow marking a lateral sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows laminal as /̪/ it shows broader spectral shape due to flat tongue. Clear formant structure without aperiodic noise identifies sonorants. It is lateral as there is voiced segments with a drop in F2 and dark zones due to side-channel airflow. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word কল, [kɔ̪l̪], [l̪] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+lateral], [+high], [+anterior].

Here, there is no secondary articulation, however it is assisted with retracted tongue-root position. It's an end sound and the articulatory organs include alveolar ridge, and blade of the tongue. The place of articulation is alveolar, manner is approximant, and it is a voiced sound. There is voiced segments with a drop in F2 and dark zones due to side-channel airflow marking a lateral sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. Clear formant structure without aperiodic noise identifies sonorants. It is lateral as there is voiced segments with a drop in F2 and dark zones due to side-channel airflow. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word রয়ে, [ɾʳo͡eˠ], [ɾʳ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+rhotic release], [+high]. Here, there is a secondary articulation, which is rhotic release. It's a beginning sound and the articulatory organs include hard palate, and center of the tongue. The place of articulation is post-alveolar, manner is approximant, and it is a voiced sound. It is high as it shows low F1 and F2, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word মোরগ, [mɻoɻʷʲoʔ], [ɻʷ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+velarization], [+high]. Here, there is a secondary articulation, which is velarization. It's a mid-sound and the articulatory organs include hard palate, and center of the tongue. The place of articulation is post-alveolar, manner is approximant, and it is a voiced sound. It is high as it shows low F1, indicating a high tongue position. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic noise identifies sonorants. However, the lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বানর, [bᵝɐ̯ˠn̪ˠɐˠɾ̄], [ɾ̄] doesn't display any onset addition, and it is an end sound. The segmental features, secondary articulation, articulatory organs, place, manner and voicing are not relevant as there is no audible release.

In the word ফড়িং, [pʰɒˠɻˠĩŋ̄], [ɻˠ] doesn't display any onset addition, for segmental features it shows [+consonantal], [+sonorant], [+voice], [+high]. Here, there is a secondary articulation, which is velarization, assisted with retracted tongue-root position. It's a mid-sound and the articulatory organs include hard palate, and center and back of the tongue. The place of articulation is post-alveolar, manner is approximant, and it is a voiced sound. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic noise identifies sonorants.

In the word পাঁপড়, [p̃ɐˠpɔ̃ɽ̄], [ɽ̄] doesn't display any onset addition, and it is an end sound. The segmental features, secondary articulation, articulatory organs, place, manner and voicing are not relevant as there is no audible release. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

4.5. Formant Analyses

In phonetics, formants analyses includes description of the resonant frequencies of the vocal tracts (F1, F2, F3, etc.) and how they appear in spectrogram. Given next is the phonological and articulatory format analysis of the atypical speech of patient 03. For patient 03, in the word পাপ, [pɐˠp̪], [p̪] is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. There is weak Articulation (̪) as it shows lower intensity and blurred formants.

In the word লেবু, [l̪ebᵝũ], [bᵝ] is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. Clear formant structure without aperiodic noise identifies sonorants. Here, /bᵝ/ is a consonant because it is produced with a bilabial closure. Since there is a stop-closure, it doesn't display

any vowel-like formants. However, the flat F2 confirms that /bᵝ/ behaves as a consonant rather than a vowel in this sequence.

In the word ভাল, [bˉɐ͡llo˩], [bˉ] labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. Clear formant structure without aperiodic noise identifies sonorants. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word অভাব, [ɔʸbʱʷɐb̰], [bʱʷ] is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. It is rounded as there is a lowering of F2, a cue for lip rounding. Clear formant structure without aperiodic noise identifies sonorants. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বিক্ষোভ, [b̪ɪkˢkʸobʱ], [bʱ] is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. It shows labialization /◌ʷ/ as it shows lowered F2. Clear formant structure without aperiodic noise identifies sonorants. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word দ্বিতীয়, [d̪ʱʸiˠʰt̪ɪ͡õ], [ʰt̪] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word হাত, [ɦɐt̪!˩], [t̪!˩] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position It shows low Tone (˩) showing close to/lower F0 contour in pitch. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word কোথাও, [kʊt̪ʰʏ͡ɐo̯], [t̪ʰʏ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word পথ, [p̪ɔˤt̪], for [t̪] formats are not relevant as there is no audible release.

In the word ইঁদুর, [ĩˤ(d̪̃)ʊɹ], [(d̪̃)] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows nasalization /◌̃/as it shows (~250–300 Hz), higher formants. Clear formant structure without aperiodic noise identifies sonorants. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word চাঁদ, [ʧ̃ɐ̃ʲ(d̪̃ʱ)], [(d̪̃ʱ)] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows nasalization /◌̃/as it shows (~250–300 Hz), higher formants. Clear formant structure without aperiodic noise identifies sonorants, however, it is not very clear here. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ধোঁয়া, [d̪o͡ɐˤˤ], [d̪] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word অর্ধেক, [ɔˠˤɹd̪ekˠ], [d̪] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word টমেটো, [t̪ˠɔˠmᵝe̪t̪o̪], [t̪] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আটক, [ɐˠt̪oˠk̟], [t̪] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word খাট, [kʰʏɐˠt̪ʳ], [t̪ʳ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ঠিকানা, [t̪ʰik̟ɐˠnɻɐɻ], [t̪ʰ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word কাঁঠাল, [kɐt̪ʰɐˠl̪ɻ], [t̪ʰ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word কাঠ, [k̟ˠɐˠt̪̚], [t̪̚] does not show formants as there is no audible release.

In the word ডালিম, [d̪ˠɾˠlim], [d̪] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আড্ডা, [ɐˠɖd̪ɐˠ], [d̪] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word রড, [ɾˠɔˠɖ̚], [ɖ̚] does not represent any formants as there is no audible release.

In the word ঢেঁড়স, [d̪æ̃ʰˠɾʷoʃɨ], [d̪] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বেঢপ, [beɖʰˠɔp̚], [ɖʰˠ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic noise identifies sonorants. However, the lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ঢৈঢৈ, [ɖo͡iˠɖo͡iˠ], [ɖ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without

aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আচার, [ɐˠˤcˤɐɹ̠̊˗], [cˤ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ছাগল, [ɕ̟ʰˠɐ̟ˤgˠoˤlɻ], [ɕ̟ʰˠ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. However, lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বছর, [bɔˠˤʰcʰo̟jˠɾ̟ˠ], [ʰcʰ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word যেও, [ɟ̟ˠe͡oˤ], [ɟ̟ˠ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic noise identifies sonorants. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word গাজর, [gˠɐjɟ̟ˠoɻ̟], [ɟ̟ˠ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic

noise identifies sonorants. The lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word জাহাজ, [ɟˠɐˠʲɐˠhˠɐˠɟˠ], [ɟˠ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. The lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ঝাউবন, [ɟʱˠɐ͡uˠbɔˠn̪], [ɟʱˠ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic noise identifies sonorants. The lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ঝাঁঝ, [ɟʱ̃ɐ̃ˠɐˠɟ], [ɟ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word নাক, [nˠɐ̃ˠk̚], [k̚] doesn’t display any formants; it is not relevant as there is no audible release.

In the word খেয়া, [kʰ̞ˠe͡ɐˠˠ], [kʰ̞ˠ] shows low F2, indicating back tongue placement. It shows unaspiration /◌ʰ̞/ as shows that voicing begins quickly after stop release. The lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আখ, [ɐˤkʲ̟ʰʸ], [kʲ̟ʰʸ] is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. It shows velarization /◌ʸ/ as it shows lowered F2, reflects tongue body retracted toward velum. The lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word গয়না, [k̃ɔi̯ʸn̪ɐˤ], [k̃] is high as it shows low F1 and F2, indicating a high tongue position. It shows nasalization /◌̃/as it shows (~250–300 Hz), higher formants. The low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আগামী, [ɐˤgʸɐm̩ɪ̃], [gʸ] is high as it shows low F1, indicating a high tongue position. It shows velarization /◌ʸ/ as it shows lowered F2, reflects tongue body retracted toward velum. The lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word মোরগ, [m̃ᵝõʸɾõg̃], [g̃] doesn’t display any formants as there is no audible release.

In the word ঘেউঘেউ, [g̠ʱʸe͡uʸg̠ˠʷʸe͡uʷʸ], [g̠ʱʸ] is high as it shows low F1, indicating a high tongue position. It shows velarization /◌ʸ/ as it shows lowered F2, reflects tongue body retracted toward velum. The lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আঘাত, [ɐ̟ʸˤdʱɐˤlɬ], [dʱ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বাঘ, [bˠʱɐˠˤgʱ], [gʱ] is high as it shows low F1 and F2, indicating a high tongue position. The low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word সূফী, [s̪ˠuˠpiʷˤ], [s̪] doesn't display any formants as there is no audible release.

In the word সেদিকেই, [ʃʰeˠd̪ɪˠgeˠi̯], in [ʃʰ], low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word শ্বাস, [ɕʰɐˠʲʃ], in [ʰʃ] the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word হও, /ɦˠɔ͡oˤ/, /ɦˠ/ shows low position as it shows high F1, reflecting a low tongue position, shows low F2, signaling tongue retraction. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বহুত, [bʷõˤɦˠũˠˤt̪], in [ɦ], clear formant structure without aperiodic noise identifies sonorants. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বাহ, [bʷɐˠhˠ], [hˠ] does not show any formants as there is no audible release.

In the word ম্যাও, [mˠɐ͡ɔˠʲˤ], [mˠ] is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. It shows nasalization /◌̃/as it shows (~250–300 Hz), higher formants. Clear formant structure without aperiodic noise identifies sonorants. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word মিউ, [mˀi̯u̯ˠˀ], [mˀ] is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. Clear formant structure without aperiodic noise identifies sonorants. The flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word থামিয়া, [t̪ʰɐmmᵝɪe̯ʲ˩], in [mmᵝ], clear formant structure without aperiodic noise identifies sonorants. The low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word কলম, [k̟ˠɔʲˠloˠm˩], [m˩] is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. It shows low Tone (˩) showing close to/lower F0 contour in pitch. Clear formant structure without aperiodic noise identifies sonorants. The flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word নুয়ে, [ñ̤ue̯ˠ], [ñ̤] is high as it shows low F1 and F2, indicating a high tongue position. It shows nasalization /◌̃/as it shows (~250–300 Hz), higher formants. Clear formant structure without aperiodic noise identifies sonorants. The low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word অনেক, [ɔ̤nn̪e̯gˠ], [nn] is high as it shows low F1 and F2, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. The low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আয়না, [ɐe̯ˠnn˩ɐʲˠ], [nn˩] is high as it shows low F1 and F2, indicating a high tongue position. It shows low Tone (˩) showing close to/lower F0 contour in pitch. Clear formant structure without aperiodic noise identifies sonorants. The low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আংটি [ɐ̃ˠŋʈiˤ], [ŋ̍] is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. Clear formant structure without aperiodic noise identifies sonorants. The low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ফড়িং, [pʰõˠɽˠɪŋ̍], [ŋ̍] is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. Clear formant structure without aperiodic noise identifies sonorants. The low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word লয়া, [l̪ˠɔ͡ɐˤ], in [l̪ˠ], there is voiced segments with a drop in F2 and dark zones due to side-channel airflow marking a lateral sound. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic noise identifies sonorants. It is lateral as there is voiced segments with a drop in F2 and dark zones due to side-channel airflow. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ডালিম, [d̪ɐʳˤl̪̊im], in [l̪̊], there is a drop in F2 and dark zones due to side-channel airflow marking a lateral sound. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. It is lateral as there is voiced segments with a drop in F2 and dark zones due to side-channel airflow. However, the drop in F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word কল, [k̟ˠɔˠl̪], [l̪] there is voiced segments with a drop in F2 and dark zones due to side-channel airflow marking a lateral sound. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. Clear formant structure without aperiodic noise identifies sonorants. It is lateral as there is voiced segments with a drop in F2 and dark zones due to side-channel airflow. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word রয়ে, [ɾo͡eˤ], [ɾ] is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. Clear formant structure without aperiodic noise identifies sonorants. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word মোরগ, [m̃ᵝõˠɾõg̃], [ɾ] is high as it shows low F1 and F2, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বানর, [bɛ̃n̪o̞ɾ̃], [ɾ̃] doesn't display any formants as there is no audible release.

In the word ফড়িং, [pʰõˠɾˠɪŋ̟], [ɾˠ] is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic noise identifies sonorants. However, the lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word পাঁপড়, [p̃ɛ̃ˤpo̞ɾ̃], [ɾ̃] doesn't display any formants as there is no audible release.

For Patient 01, in the word পাপ, [ɐpɐp̃], [p̃] doesn't display any formants as there is no audible release.

In the word লাফানো, [lɐp̪ʰɐno], in [p̪ʰ], there is weak Articulation (̪) as it shows lower intensity and blurred formants. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বরফ, [bɔˠɾopʰ], in [p̪ʰ], there is weak Articulation (̪) as it shows lower intensity and blurred formants. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word লেবু, [leb̃˩u], [b̃˩] is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. It shows nasalization /̃/as it shows (~250–300 Hz), higher formants. It shows low Tone (˩) showing close to/lower F0 contour in pitch. Clear formant structure without aperiodic noise identifies sonorants. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ভাল, [bˉɐlˠo˩], [bˉ] is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. Clear formant structure without aperiodic noise identifies sonorants. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word অভাব, [ɔõˠˤb̚ˉɐˠbᵝ], [b̚ˉ] is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. Clear formant structure without aperiodic noise identifies sonorants. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বিক্ষোভ, [bɪkkʰoˤb̚ˉ], [b̚ˉ] is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. Clear formant structure without aperiodic noise identifies sonorants. However, the flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word তবুও, [t̪˩o˩b˩u͡o˩], [t̪˩] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows low Tone (˩) showing close to/lower F0 contour in pitch. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word হাত, [ɦ̄ɐˠɻt̪ʰ], [t̪ʰ] is a substitution, it shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word পথ, [pʷɔˠɻt̪ʰ̩˕], [t̪ʰ̩˕] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows low Tone (˕) showing close to/lower F0 contour in pitch. There is weak Articulation (̩) as it shows lower intensity and blurred formants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word চাঁদ, [cɐˠ(d̪̊ʰ)], [(d̪̊ʰ)] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ধোঁয়া, [d̪o͡ɐˠɻ], [d̪] is a substitution, it shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word অর্ধেক, [ɔ̝ʳʸɾˠd̪̊eˠɻk̄ʲ], [d̪̊] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ঔষধ, [o͡uʲˈʃɔ̝ʲt̪], [t̪] is a substitution, it shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It

is high as it shows low F1, indicating a high tongue position. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

খাট, [kʰɡ̫ʏrʈ̚ʰɟ̚ʰʰs], [ʈ̚ʰɟ̚ʰʰs] has no audible release, hence no formants.

In the word ঠিকানা, [!ʈʰi̯ʏgʲɡ̫ʲn̪ɬɡ̫ʏr], [!ʈʰ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আড্ডা, [ɡ̫ʏɖ̚ʏɖ̪ɡ̫ɻ], [ɖ̪] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows velarization /◌ʏ/ as it shows lowered F2, reflects tongue body retracted toward velum. However, the lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word রড, [ɾʳɔ̚ʏɻɖ!], [ɖ!] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ঢেঁড়স, [ɖ̚æɻʈ̚ʏo̞ʳʏʃ], [ɖ̚] is a substitution and it shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বেচপ, [bɛ̪ɖʱʏˠɔp̚], [ɖʱʏˠ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows velarization /◌ʏ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic noise identifies sonorants. However, the lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আচার, [ɐʰcʰˢɐˠɾɻ], [cʰˢ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word চামচ, [cʰˢɟ̪ʏm̪ʏõcˢ], [cˢ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word মাছ, [m̪ᵝʏɟ̪ʏcʰˢ], [cʰˢ] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word যেও, [ʄ̃e̞o̯ʏ], [ʄ̃] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. It shows nasalization /◌̃/as it shows (~250–300 Hz), higher formants. Clear formant structure without aperiodic noise identifies sonorants. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word গাজর, [g̪ʏɟ̪ˠɻo̞ɾ̪ʏ], [ɻ̪] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it

shows low F1, indicating a high tongue position. There is weak Articulation (̞) as it shows lower intensity and blurred formants. Clear formant structure without aperiodic noise identifies sonorants. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word জাহাজ, [ɟˢɐhʊ̯˩s], [s] is a substitution and it shows low Tone (˩) showing close to/lower F0 contour in pitch. The low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ঝাউবন, [ɟ⁼ʲɐ͡ubʷɔʷʸn˩], [ɟ⁼] shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ঝাঁঝ, [ɟ⁼ʲɐˤkʱ˩], [kʱ˩] is a substitution and it is high as it shows low F1 and F2, indicating a high tongue position. It shows low Tone (˩) showing close to/lower F0 contour in pitch. Irregular or creaky voicing indicates constricted glottis. The low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word দোকান, [d̪ʲoˤkʊ̯ɐʸn̪], [k̯] is high as it shows low F1 and F2, indicating a high tongue position. The low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word নৌকা, [ʰño͡ugʊ̯ʸ], [g] is a substitution and it is high as it shows low F1 and F2, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. The low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word নাক, [ñʊ̯ʸk̚], [k̚] doesn’t display any formants as there is no audible release.

In the word আখ, [ɐ̟ʸʳkʰ˩], [kʰ˩] is high as it shows low F1 and F2, indicating a high tongue position. It shows low Tone (˩) showing close to/lower F0 contour in pitch. The low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আগামী, [ɐ̆gʸɐ̟ʸm˩i˩], [gʸ] is high as it shows low F1, indicating a high tongue position. It shows velarization /◌ʸ/ as it shows lowered F2, reflects tongue body retracted toward velum. The lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word মোরগ, [m˩oɾˠʲoʔ], [ʔ] is a substitution. Clear formant structure without aperiodic noise identifies sonorants. The low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ঘেউঘেউ, [gʱe͡u˩gʱe͡u˩], [gʱ] is high as it shows low F1 and F2, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. The low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বাঘ, [bᵝɐ̟ʸg̈ʱ], [g̈ʱ] doesn’t display any formants as there is no audible release.

In the word সেদিকেই, [ʃ̻̟e̞̟d̻̟ɪge͡ɪ̈], [ʃ̻̟] is shows low F2, indicating back tongue placement. The low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word হও, [ɦɔ͡o˩], for [ɦ], the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word থামিয়া, [t̪ʰɐmbi͡ɐ], [b] is an addition to [m], [b] is labial as it displays weak formant transitions, especially flat F2, and shows a lower burst. Clear

formant structure without aperiodic noise identifies sonorants. The flat F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word কলম, [k̄ɔl̪o m̄], [m̄] doesn't display any formants as there is no audible release.

In the word নুয়ে, [nɹu̯e̯], [nɹ] is high as it shows low F1 and F2, indicating a high tongue position. It shows low Tone (˩) showing close to/lower F0 contour in pitch. Clear formant structure without aperiodic noise identifies sonorants. The low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word অনেক, [ɔ̃n̪e k̄], [n̪] is a substitution, it shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. The F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word আয়না, [ɐe̯ʸnɹɐ̯ʸʰ], [nɹ] is high as it shows low F1 and F2, indicating a high tongue position. It shows low Tone (˩) showing close to/lower F0 contour in pitch. Clear formant structure without aperiodic noise identifies sonorants. It shows nasal as there is voicing with low-frequency energy and nasal murmur around. The low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word পান, [pʸɐ̯ʸn̄], [n̄] doesn't display any formants as there is no audible release.

In the word আংটি, [ɐŋ˩t!i], [ŋ˩] is high as it shows low F1 and F2, indicating a high tongue position. It shows low Tone (˩) showing close to/lower F0 contour in pitch. Clear formant structure without aperiodic noise identifies sonorants. It shows nasal as there is voicing with low-frequency energy and nasal murmur around. The low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ফড়িং, [pʰɔ̯ɾ̆ɪ̃ŋ̃], [ŋ̃] doesn't display any formants as there is no audible release.

In the word লয়া, [l̪ɹ̆ɔ͡ɐˠ], in [l̪], there is voiced segments with a drop in F2 and dark zones due to side-channel airflow marking a lateral sound. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. Clear formant structure without aperiodic noise identifies sonorants. It is lateral as there is voiced segments with a drop in F2 and dark zones due to side-channel airflow. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word ডালিম, [ɖɐl̪iṃ], in [l̪], there is voiced segments with a drop in F2 and dark zones due to side-channel airflow marking a lateral sound. It is anterior as have concentrated energy in the higher frequency region, indicating front articulations. It also shows coronal as there is a higher F2 transitions, bursts may appear more concentrated in the mid-frequency range. It is high as it shows low F1, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. It is lateral as there is voiced segments with a drop in F2 and dark zones due to side-channel airflow. However, the F2 transition confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word কল, [kɔ̰l̪], in [l̪], there is voiced segments with a drop in F2 and dark zones due to side-channel airflow marking a lateral sound. It is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. Clear formant structure without aperiodic noise identifies sonorants. It is lateral as there is voiced segments with a drop in F2 and dark zones due to side-channel airflow. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word রয়ে, [ɾʳo͡eˠˤ], [ɾʳ] is high as it shows low F1 and F2, indicating a high tongue position. Clear formant structure without aperiodic noise identifies sonorants. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word মোরগ, [mɬoɾˠʲoʔ], [ɾˠ] is high as it shows low F1, indicating a high tongue position. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic noise identifies sonorants. However, the lowered F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

In the word বানর, [bᵝɸˠn̪ˠo̪ˠr̪̚], [r̪̚] doesn't display any formants as there is no audible release.

In the word ফড়িং, [pʰo̞ˠɾˠĩŋ̊], [ɾˠ] is high as it shows low F1, indicating a high tongue position. It shows low F2, indicating back tongue placement. It shows velarization /◌ˠ/ as it shows lowered F2, reflects tongue body retracted toward velum. Clear formant structure without aperiodic noise identifies sonorants.

In the word পাঁপড়, [p̃ɸ̃ˠpõ̰ʈ̚], [ʈ̚] doesn't display any formants as there is no audible release. However, the low F2 confirms that it behaves as a consonant rather than a vowel in this sequence.

The vowel sounds have more duration and tonal features for atypical speech. The rising-falling tone often happens due to various dialects which is not an atypical feature. Other dialect features include: Controlled Nasalization where the nasal formant around ~250 Hz (e.g. পুঁইশাক) as opposed to Hypernasality which indicates presence of higher F2/F3, the Absence of /ɦ/ which is missing aspiration (e.g. in বাঘ) as opposed to attempted aspiration but not keeping up showing drops in F2.

Formant positions also distinguished the atypical speech from the dialects. The vowel formants merges, or shifts, often shows fronting or backing in a predictable manner showing consistency. Consonant cues displays F2 or F3 transition patterns or positions ratio, such a 1:2, 2:1, 3:2, 4:3 and such. For atypical speech, by contrast, there were irregular, unstable, physiologically constrained formants. This appeared as excessive variability between tokens of typical and atypical speech, and also formant transitions that do not match the regular patterns.

In dialect variation, F1-F2 relationships shift in predictable and consistent ways. For example, a dialect may show lower or flat F1 or an F2 transition while maintaining F1 and F2 spacing. The ratio remains structed and well-paced. The overall geometry is coherent and rule-governed. As opposed to atypical speech, often disrupts this geometry. It shows inconsistent F2 transitions and the spacing is larger or shorter. In dialect, F1-F2 ratios shift in a systematic pace, for example, F1:F2 shows 1:2, or 1:3, as opposed to for atypical it shows 1:5 or 1:4. It disrupts the normal formant geometry.

4.6. Voice Onset Timing Analyses

Voice Onset Timing (VOT) analysis is the time between the release of a stop consonant and the onset of voicing. It distinguishes between voiced and voiceless stop consonants. VOT is used to denote dialect-specific voicing/aspiration timing (e.g., shorter VOT in [pʱ]) as opposed to inconsistent or abnormal VOT or excessive delay and Jitter Report normal range < 1.0% denotes that is is dialect feature unlike > 2.0% which might denote atypical stage. VOT is shown in the boundary level in PRAAT, if it is a negative value then the voicing starts before the burst. 0-20 milliseconds can be considered as minimal delay, 20-80 milliseconds are moderate and 80-120 milliseconds are significant delay, beyond 120 milliseconds are excessive delay.

In the word লেবু, [l̪ebᵝũ], [bᵝ] shows a VOT of 0.068. It means that after the release [bᵝ] sound the vocal cords start vibrating 68 milliseconds later. It is not typical and it suggests delayed voicing.

In the word ভাল, [bʱɐl̪o˩], [bʱ] shows a VOT of 0.0106. It means that after the release [bʱ] sound the vocal cords start vibrating 10.6 milliseconds later. It is not typical and it suggests very little delay between release and voicing.

In the word অভাব, [ɔʸbʱʷɐb̪], [bʱʷ] shows VOT of 0.156. It means that after the release [bʱʷ] sound the vocal cords start vibrating 156 milliseconds later. It is not typical and it suggests significant delay between release and voicing.

In the word বিক্ষোভ, [b̪ɪkˢkᵛobʱ], [bʱ] shows 0.081. It means that after the release [bʱ] sound the vocal cords start vibrating 81 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word দ্বিতীয়, [d̪ʱᵛiˠʰt̪ɪ͡õ], [ʰt̪] shows 0.156. It means that after the release of the sound the vocal cords start vibrating 156 milliseconds later. It is not typical and it suggests significant delay between release and voicing.

In the word হাত, [ɦɐt̪!ɬ], [t̪!ɬ] shows 0.168. It means that after the release of the sound the vocal cords start vibrating 168 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word কোথাও, [kʊt̪ʰʲɐ͡o̯], [t̪ʰʲ] shows 0.207. It means that after the release of the sound the vocal cords start vibrating 207 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word পথ, [p̪ɔˠt̄], for [t̄] formats are not relevant as there is no audible release.

In the word ইঁদুর, [ĩˠ(d̪̃)uʲɾ], [(d̪̃)] shows 0.103. It means that after the release of the sound the vocal cords start vibrating 103 milliseconds later. It is not typical and it suggests significant delay between release and voicing.

In the word চাঁদ, [c̪̃ɐ̃ʲ(d̪̃ʱ)], [(d̪̃ʱ)] shows 0.144. It means that after the release of the sound the vocal cords start vibrating 144 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word ধোঁয়া, [d̪o͡ɐˠˠ], [d̪] shows 0.068. It means that after the release of the sound the vocal cords start vibrating 68 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word অর্ধেক, [ɔˠˤɾd̪̊ekɣ̊ˠ], [d̪̊] shows 0.111. It means that after the release of the sound the vocal cords start vibrating 111 milliseconds later. It is not typical and it suggests long delay between release and voicing.

In the word টমেটো, [ʈ̊ˤɔˤmᵝɐʈ̊o], [ʈ̊] shows 0.086. It means that after the release of the sound the vocal cords start vibrating 86 milliseconds later. It is not typical and it suggests significant delay between release and voicing.

In the word আটক, [ɐˤʈ̊oˤkɣ̊], [ʈ̊] shows 0.132. It means that after the release of the sound the vocal cords start vibrating 132 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word খাট, [kʰˠɐˤʈ̊ʳ], [ʈ̊ʳ] shows 0.177. It means that after the release of the sound the vocal cords start vibrating 177 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word ঠিকানা, [ʈ̊ʰikɣ̊ɐˤnɬɐɬ], [ʈ̊ʰ] shows 0.03. It means that after the release of the sound the vocal cords start vibrating 30 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word কাঁঠাল, [kɐʈ̊ʰɐˤlˌɬ], [ʈ̊ʰ] shows 0.173. It means that after the release of the sound the vocal cords start vibrating 173 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word কাঠ, [k̚ˠɐˤʈ̚], [ʈ̚] does not show formants as there is no audible release.

In the word ডালিম, [d̪̊ɐːʳˤlim], [d̪̊] shows 0.04. It means that after the release of the sound the vocal cords start vibrating 40 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word আড্ডা, [ɐˤɖd̥ɖ̥ɐˤ], [d̥] shows 0.1. It means that after the release of the sound the vocal cords start vibrating 100 milliseconds later. It is not typical and it suggests long delay between release and voicing.

In the word রড, [ɾʸɔˤɖ̚], [ɖ̚] does not represent any formants as there is no audible release.

In the word ঢেঁড়স, [ɖ̥ɐ̟̰ʰʸˤɭʷoʃɬ], [ɖ̥] shows 0.06. It means that after the release of the sound the vocal cords start vibrating 60 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word বেঢপ, [bɐ̯ɖʰʸˤɔp̚], [ɖʰʸˤ] shows 0.19. It means that after the release of the sound the vocal cords start vibrating 190 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word ঢৈঢৈ, [ɖo͡iˤɖo͡iˤ], [ɖ] shows 0.06. It means that after the release of the sound the vocal cords start vibrating 60 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word আচার, [ɐʸˤcˤɐɻr̃], [cˤ] shows 0.149. It means that after the release of the sound the vocal cords start vibrating 149 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word ছাগল, [ɕ̟ʰʸɐ̟ˤgɤ̝oˤlɻ], [ɕ̟ʰʸ] shows 0.06. It means that after the release of the sound the vocal cords start vibrating 60 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word বছর, [bɔʸˤʰcʰo̟ʲʸɾʸ], [ʰcʰ] shows 0.182. It means that after the release of the sound the vocal cords start vibrating 182 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word যেও, [ɟ̥ʸe͡oˤ], [ɟ̥ʸ] shows 0.171. It means that after the release of the sound the vocal cords start vibrating 171 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word গাজর, [gʸɐʲɟ̥ʸoʲɾ], [ɟ̥ʸ] shows 0.141. It means that after the release of the sound the vocal cords start vibrating 141 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word জাহাজ, [ɟ̥ʸɐʲʸˤhʸɐˤɟ̥ʸ], [ɟ̥ʸ] shows 0.222. It means that after the release of the sound the vocal cords start vibrating 222 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word ঝাউবন, [ɟ̥ʱʸɡ͡u̟ʸbɔˠn̪], [ɟ̥ʱʸ] shows 0.135. It means that after the release of the sound the vocal cords start vibrating 135 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word ঝাঁঝ, [ɟ̥ʱ̃ɐ̃ʸˤɟ̥], [ɟ̥] shows 0.08. It means that after the release of the sound the vocal cords start vibrating 80 milliseconds later. It is not typical and it suggests significant delay between release and voicing.

In the word নাক, [nˤɐ̃ʸk̚], [k̚] doesn’t display any formants; it is not relevant as there is no audible release.

In the word খেয়া, [k̟̚ʷe͡ɐʸˤ], [k̟̚ʷ] shows 0.03. It means that after the release of the sound the vocal cords start vibrating 30 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word আখ, [ɐˤk̟̚ʰʸ], [k̟̚ʰʸ] shows 0.23. It means that after the release of the sound the vocal cords start vibrating 230 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word গয়না, [k̃ɔ̝̈ʸn̪ɐˤ], [k̃] shows 0.06. It means that after the release of the sound the vocal cords start vibrating 60 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word আগামী, [ɐ̪ˤgʸɐm̥ĩ], [gʸ] shows 0.143. It means that after the release of the sound the vocal cords start vibrating 143 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word মোরগ, [m̃ᵝõʸɾõg̃], [g̃] doesn’t display any formants as there is no audible release.

In the word ঘেউঘেউ, [g̊ʱʸe̞͡uʸg̊⁼ʸe̞͡uʷʸ], [g̊ʱʸ] shows 0.113. It means that after the release of the sound the vocal cords start vibrating 113 milliseconds later. It is not typical and it suggests long delay between release and voicing.

In the word আঘাত, [ɐ̈ʸˤdʰɐˤlɻ], [dʰ] shows 0.142. It means that after the release of the sound the vocal cords start vibrating 142 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word বাঘ, [b̪ᵝɐ̃ʸˤg̊ʱ], [g̊ʱ] shows 0.128. It means that after the release of the sound the vocal cords start vibrating 128 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word সূফী, [s̃u̪ʷpiʷˤ], [s̃] doesn’t display any formants as there is no audible release.

In the word সেদিকেই, [ʃʰed̪ɪɻgeʲĩ], in [ʃʰ], shows 0.193. It means that after the release of the sound the vocal cords start vibrating 193 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word শ্বাস, [ɕ̰ʰʱ̰ʲʰʃ], in [ʰʃ] shows 0.171. It means that after the release of the sound the vocal cords start vibrating 171 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word হও, [ɦ̰ʸɦ̰ɔ̰ʷ], [ɦ̰ʸɦ̰] shows 0.3. It means that after the release of the sound the vocal cords start vibrating 300 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word বহুত, [bʷo̰ʷɦ̰ʊ̰ʸʷt̪̰], in [ɦ̰], shows 0.114. It means that after the release of the sound the vocal cords start vibrating 114 milliseconds later. It is not typical and it suggests long delay between release and voicing.

In the word বাহ, [bʷɐ̰ʷɦ̰], [ɦ̰] does not show any formants as there is no audible release.

In the word ম্যাও, [m̰ɐ̰æ̰ʲʸʷ], [m̰ɐ̰] shows 0.06. It means that after the release of the sound the vocal cords start vibrating 60 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word মিউ, [m̰ɪ̰ʊ̰ʸʷ], [m̰ɪ̰] shows 0.07. It means that after the release of the sound the vocal cords start vibrating 70 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word থামিয়া, [t̪̰ʰɐm̰m̰ᵝɪ̰ʲɻ̰], in [m̰m̰ᵝ], shows 0.19. It means that after the release of the sound the vocal cords start vibrating 190 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word কলম, [kʸɔ̰ʲʸʷlo̰ʷm̰ɻ̰], [m̰ɻ̰] shows 0.26. It means that after the release of the sound the vocal cords start vibrating 260 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word নুয়ে, [n̪͡uᵉˀ], [n̪] shows 0.22. It means that after the release of the sound the vocal cords start vibrating 220 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word অনেক, [ɔ̹͡nn̪ᵉgᵸ], [n͡n] shows 0.128. It means that after the release of the sound the vocal cords start vibrating 128 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word আয়না, [ɐ̪͡eᵸn͡nɬɐʲˀ], [n͡nɬ] shows 0.126. It means that after the release of the sound the vocal cords start vibrating 126 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word আংটি [ɐ̃ᵸn̪̩tiˀ], [n̪̩] shows 0.163. It means that after the release of the sound the vocal cords start vibrating 163 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word ফড়িং, [pʰõ̞ᵸɾ̞ᵸɪŋ̩], [ŋ̩] shows 0.09. It means that after the release of the sound the vocal cords start vibrating 90 milliseconds later. It is not typical and it suggests significant delay between release and voicing.

In the word লয়া, [l̪ᵸɔ͡ɐˀ], in [l̪ᵸ], shows 0.08. It means that after the release of the sound the vocal cords start vibrating 80 milliseconds later. It is not typical and it suggests significant delay between release and voicing.

In the word ডালিম, [d̪̊ɐʳˀl̪̊im], in [l̪̊], shows 0.03. It means that after the release of the sound the vocal cords start vibrating 30 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word কল, [k̪̚ᵸɔ̹ᵸl̪̚], [l̪̚] shows 0.08. It means that after the release of the sound the vocal cords start vibrating 80 milliseconds later. It is not typical and it suggests significant delay between release and voicing.

In the word রয়ে, [ɾo͡eˠ], [ɾ] shows 0.03. It means that after the release of the sound the vocal cords start vibrating 30 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word মোরগ, [m̃ᵝõʸɽõg̃], [ɽ] shows 0.09. It means that after the release of the sound the vocal cords start vibrating 90 milliseconds later. It is not typical and it suggests significant delay between release and voicing.

In the word বানর, [bɛ̃n̪o̞ɹ̃], [ɾ̃] doesn't display any formants as there is no audible release.

In the word ফড়িং, [pʰõ̞ʸɽ̞ʸɪŋ̟], [ɽ̞ʸ] shows 0.09. It means that after the release of the sound the vocal cords start vibrating 90 milliseconds later. It is not typical and it suggests significant delay between release and voicing.

In the word পাঁপড়, [p̃ɛ̃ˠpo̞ɽ̃], [ɽ̃] doesn't display any formants as there is no audible release.

For Patient 01, in the word পাপ, [ɐpɐp̄], [p̄] doesn't display any formants as there is no audible release.

In the word লাফানো, [lɐp̪ʰɐno], in [p̪ʰ], is 0.03. It means that after the release of the sound the vocal cords start vibrating 30 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word বরফ, [bɔ̞ʸɾop̪ʰ], in [p̪ʰ], is 0.121. It means that after the release of the sound the vocal cords start vibrating 121 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word লেবু, [leb̃ɬu], [b̃ɬ] is 0.10. It means that after the release of the sound the vocal cords start vibrating 100 milliseconds later. It is not typical and it suggests long delay between release and voicing.

In the word ভাল, [bˉɐlᵛoˌ], [bˉ] is 0.05. It means that after the release of the sound the vocal cords start vibrating 50 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word অভাব, [ɔõᵛˤbˉɐᵛbᵝ], [bˉ] is 0.05. It means that after the release of the sound the vocal cords start vibrating 50 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word বিক্ষোভ, [bɪkkʰoˤbˉ], [bˉ] is 0.03. It means that after the release of the sound the vocal cords start vibrating 30 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word তবুও, [t̪ˌoɹbˌu͡oˌ], [t̪ˌ] is 0.05. It means that after the release of the sound the vocal cords start vibrating 50 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word হাত, [ɦ̄ɐˤt̪ʰ], [t̪ʰ] is a substitution, it is 0.07. It means that after the release of the sound the vocal cords start vibrating 70 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word পথ, [pʷɔˤt̪ʰˌɹ], [t̪ʰˌɹ] is 0.107. It means that after the release of the sound the vocal cords start vibrating 107 milliseconds later. It is not typical and it suggests long delay between release and voicing.

In the word চাঁদ, [cɐᵛ(d̪̊ʱ)], [(d̪̊ʱ)] is 0.199. It means that after the release of the sound the vocal cords start vibrating 199 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word ধোঁয়া, [d̪͡oɐˤ], [d̪] is a substitution, it is 0.127. It means that after the release of the sound the vocal cords start vibrating 127 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word অর্ধেক, [ɔ̹ʳʸɾʸd̪eˤk̟̄ǂ], [d̪] 0.122. It means that after the release of the sound the vocal cords start vibrating 122 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word ঔষধ, [o͡uʲˈʃɔ̹ʲt̪̚], [t̪̚] is a substitution, it is 0.171. It means that after the release of the sound the vocal cords start vibrating 171 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

খাট, [kʰ̄ɐ̹ʸrt̪ʰ̄ɟ̊ʰˢ], [t̪ʰ̄ɟ̊ʰˢ] has no audible release, hence no formants.

In the word ঠিকানা, [!t̪ʰi̹ʸgʲɐ̹ʲnɻɐ̹ʸr], [!t̪ʰ] is 0.1. It means that after the release of the sound the vocal cords start vibrating 100 milliseconds later. It is not typical and it suggests long delay between release and voicing.

In the word আড্ডা, [ɐ̹ʸd̪ʸd̪ɐ̹ˤ], [d̪] is 0.09. It means that after the release of the sound the vocal cords start vibrating 90 milliseconds later. It is not typical and it suggests significant delay between release and voicing.

In the word রড, [ɾˠɔ̹ʸˤɖ!], [ɖ!] is 0.171. It means that after the release of the sound the vocal cords start vibrating 171 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word ঢেঁড়স, [ɖæˤʈ̪̃ʸo̹ʳʸʃ], [ɖ] is a substitution and it is 0.182. It means that after the release of the sound the vocal cords start vibrating 182 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word বেঢপ, [bɐ̹ɖʱʸˤɔp̚], [ɖʱʸˤ] is 0.97. It means that after the release of the sound the vocal cords start vibrating 970 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word আচার, [ɐʰcʰˢɐˤɾɬ], [cʰˢ] is 0.117. It means that after the release of the sound the vocal cords start vibrating 117 milliseconds later. It is not typical and it suggests long delay between release and voicing.

In the word চামচ, [cʰˢɐ̪ʏm̪ʏõ̪cˢ], [cˢ] is 0.09. It means that after the release of the sound the vocal cords start vibrating 117 milliseconds later. It is not typical and it suggests significant delay between release and voicing.

In the word মাছ, [m̪ᵝʏɐ̪ʏcʰˢ], [cʰˢ] is 0.176. It means that after the release of the sound the vocal cords start vibrating 176 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word যেও, [j̃e̪o͡ʏ], [j̃] is 0.192. It means that after the release of the sound the vocal cords start vibrating 192 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word গাজর, [g̪ʏɐ̪ʏɟo̪ɟ̪ʏ], [ɟ̪] is 0.05. It means that after the release of the sound the vocal cords start vibrating 50 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word জাহাজ, [ɟˢɐhɐ̪ɬs], [s] is 0.231. It means that after the release of the sound the vocal cords start vibrating 231 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word ঝাউবন, [ɟ̝ʲɐ͡ubʷɔʷʸnɬ], [ɟ̝] is 0.08. It means that after the release of the sound the vocal cords start vibrating 80 milliseconds later. It is not typical and it suggests significant delay between release and voicing.

In the word ঝাঁঝ, [ɟ̝ʲɐˤkʱɬ], [kʱɬ] is 0.08. It means that after the release of the sound the vocal cords start vibrating 80 milliseconds later. It is not typical and it suggests significant delay between release and voicing.

In the word দোকান, [d̪ʲoˠkʲɐˠn̪], [kʲ] is 0.1. It means that after the release of the sound the vocal cords start vibrating 100 milliseconds later. It is not typical and it suggests long delay between release and voicing.

In the word নৌকা, [ʰn̪o͡ugɐˠ], [g] is 0.86. It means that after the release of the sound the vocal cords start vibrating 860 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word নাক, [n̪ɐˠk̚], [k̚] doesn’t display any formants as there is no audible release.

In the word আখ, [ɐˠrkʰɹ], [kʰɹ] is 0.14. It means that after the release of the sound the vocal cords start vibrating 140 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word আগামী, [ɐ̆gˠɐˠmɻiɹ], [gˠ] is 0.08. It means that after the release of the sound the vocal cords start vibrating 80 milliseconds later. It is not typical and it suggests significant delay between release and voicing.

In the word মোরগ, [mɻoɾˠʲoʔ], [ʔ] is 0.09. It means that after the release of the sound the vocal cords start vibrating 90 milliseconds later. It is not typical and it suggests significant delay between release and voicing.

In the word ঘেউঘেউ, [gʱ͡eu̯ɻgʱ͡eu̯ɻ], [gʱ] is 0.07. It means that after the release of the sound the vocal cords start vibrating 70 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word বাঘ, [bᵝɐˠg̚ʱ], [g̚ʱ] doesn’t display any formants as there is no audible release.

In the word সেদিকেই, [ʃ̺e̪d̪ɪgeɪ̃], [ʃ̺] is 0.04. It means that after the release of the sound the vocal cords start vibrating 40 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word হও, [ɦ̪ɔ̃o̞˩], [ɦ̪] is 0.06. It means that after the release of the sound the vocal cords start vibrating 60 milliseconds later. It is not typical and it suggests moderate delay between release and voicing.

In the word থামিয়া, [t̪ʰɐmbĩɐ], [mb] is 0.169. It means that after the release of the sound the vocal cords start vibrating 169 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word কলম, [k̃ɔl̪o̪m̃], [m̃] doesn't display any formants as there is no audible release.

In the word নুয়ে, [nɹũe], [nɹ] is 0.149. It means that after the release of the sound the vocal cords start vibrating 149 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word অনেক, [ɔ̃d̪e̪k̃], [d̪̚] is a substitution, it is 0.08. It means that after the release of the sound the vocal cords start vibrating 80 milliseconds later. It is not typical and it suggests significant delay between release and voicing.

In the word আয়না, [ɐ̃eʸnɹ̪ɐ̃ʷ], [nɹ] is 0.227. It means that after the release of the sound the vocal cords start vibrating 227 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word পান, [pʸɐ̃ʷñ̪], [ñ̪] doesn't display any formants as there is no audible release.

In the word আংটি, [ɐŋˠɬˈi], [ŋˠ] is 0.119. It means that after the release of the sound the vocal cords start vibrating 119 milliseconds later. It is not typical and it suggests long delay between release and voicing.

In the word ফড়িং, [pʰo̯ˠɾ̥ˠĩn̄], [n̄] doesn’t display any formants as there is no audible release.

In the word লয়া, [l̪ɹ̥͡ɐˠ], [l̪] is 0.15. It means that after the release of the sound the vocal cords start vibrating 150 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word ডালিম, [ɖɐl̪im̪], [l̪] is 0.14. It means that after the release of the sound the vocal cords start vibrating 140 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word কল, [kɔl̪], [l̪] is 0.147. It means that after the release of the sound the vocal cords start vibrating 147 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word রয়ে, [ɾʳo̯͡eˤ], [ɾʳ] is 0.182. It means that after the release of the sound the vocal cords start vibrating 182 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word মোরগ, [mɬoɾˠʲoʔ], [ɾˠ] is 0.182. It means that after the release of the sound the vocal cords start vibrating 182 milliseconds later. It is not typical and it suggests extremely long delay between release and voicing.

In the word বানর, [bᵝɐˠn̪ˠo̯ˠɾ̄], [ɾ̄] doesn’t display any formants as there is no audible release.

In the word ফড়িং, [pʰo̯ɾ̯ʲɪ̯ʲɪ̃ŋ̍], [ɾ̯ʲ] is 0.15. It means that after the release of the sound the vocal cords start vibrating 150 milliseconds later. It is not typical and it suggests very long delay between release and voicing.

In the word পাঁপড়, [p̃ɐ̯ʷpõ̯ɾ̯̃], [ɾ̯̃] doesn't display any formants as there is no audible release.

4.7. Additional Analyses

Unaspirated Nasalization /◌̃ˉ/ and Unaspirated Dental Expression /◌̪̃/, Pre-Palatalization /ʲ◌/, Pre-Aspiration /ʰ◌/, perhaps can be newly added for Bangla atypical speech sounds. Low tone (˩), Extra-Low Tone (˩̩), Weak Articulation (◌̩), Retracted Tongue-Root Position (◌̙) are also prominent in most utterances. In a few cases, Post-Alveolar Clicks (◌!) and Palatal Clicks (◌ǂ) were observed. For data management, 'letter b' has been used to identify the beginning of the sound, 'letter m' marks the middle and 'letter e' presents the end sound.

Following the data, it shows that the beginning sounds have 25.5% phonological errors, middle sounds have 35.3%, and the end sounds have 39.2% errors. The upper lip, lower lip, upper teeth, lower teeth, Alveolar Ridge, tip and blade/front of the tongue is involved in producing the beginning sounds, the hard palate, center of the tongue assists in articulating the middle sounds, and soft palate/Velum , back and the root of the tongue, Uvula produce the ending sounds. The Larynx and vocal folds movements needed to produce all the sounds.

Consonants showed abnormal formant trajectories, incomplete or delayed transitions, or patterns indicating misarticulations such as backing, fronting etc. that do not form any systematic, rule-governed sound patterns. In brief, dialects showed patterned, rule-based formant shifts, while atypical speech shows non-systematic, inconsistent, or biomechanically constrained deviations that make the acoustic system internally incoherent.

Mispronunciation occurs due to misunderstanding of the word or habitual use etc. (e.g. মোরগ) as opposed to Tensed/Reiteration with greater effort or repeated bursts and closure,

4.8. Proposed Addition to extIPA

As per Ratio Analyses, the Aphasic patient's speech outputs show various results. Such as, if looked from the number of diacritics, given next is the list. Many of these are included in the standard IPA chart except for, in case of the use of one diacritic, pre-palatalization /ʲ◌/, nasal release /◌ⁿ/, lip compression /◌̫/, fricative release /◌ˣ/ (and /◌ˢ/, /◌ᶠ/ as systematic release markers), strong articulation /◌̪/, weak articulation /◌̬/, inconsistent /O/, unaspirated /◌̹/ (often unmarked), unintelligible speech /◌/. pre-aspirated /ʰ◌/ are used and should be in the extIPA for Aphasic patients who speak Bangla as L1. In case of two, partial devoicing /◌̥/, sliding articulation /◌◌/, double articulation /◌͡◌/, aspirated fricative /◌ʰˢ/ are used. The rest for two and three or more include addition or stacking qualities and are not necessarily new symbols.

1 diacritic	2 diacritics	3/3+ diacritics
1. /◌˩/ – low tone 2. /◌˧/ – lower pitch 3. /◌˥/ – rising tone 4. /◌˦˥/ – contour tone 5. /◌ʱ/ – breathy 6. /◌̥/ – voiceless 7. /◌̰/ – creaky 8. /◌̬/ – voiced 9. /◌̘/ – advanced tongue root 10. /◌ˢ/ – sibilant 11. /◌̪/ –	1. /◌̃˥/ – nasal + rising tone 2. /◌̪˧/ – dental + low tone 3. /◌͡˧/ – tie-bar + low tone 4. /◌̥ʱ/ – voiceless + breathy 5. partial devoicing /◌̥/ 6. /◌̰̘/ – creaky + advanced tongue root 7. /◌̚ʱ/ – unreleased + breathy 8. /◌̰̤/ – creaky + breathy	1. /◌ʰʏ˦˥/ – aspirated + velarized + contour tone 2. /◌ʱʏ˦˥/ – breathy voiced aspirated + velarized + contour tone 3. /◌̰̤ʏ˥/ – creaky + breathy + velarized + rising tone 4. /◌̰ʰʏ/ – creaky +

linguolabial 12. /◌ʷ/ – labialized 13. /◌̪/ – dental 14. /◌̺/ – laminal 15. /◌̃/ – nasalized 16. /◌ⁿ/ - nasal release 17. /◌ˠ/ – velarized 18. /◌ʰ/ – aspirated 19. /◌⁼/ – unaspirated 20. /◌͡/ –tie-bar 21. /◌ʳ/ – trill/tap 22. /◌̄/ – unreleased 23. pre-palatalization /j◌/ 24. pre-aspiration /ʰ◌/ 25. lip compression /◌̼/ 26. strong articulation /◌̪/ 27. weak articulation /◌̩/ 28. inconsistent /O/ 29. unaspirated /◌⁼/ (often unmarked)	9. /◌̰/ – creaky + advanced tongue root 10. /◌ʱʷ/ – breathy aspiraed voiced + labialized 11. /◌ʰ̪/ – aspirated + dental 12. /◌̬ʳ/ – voiced + trill 13. /◌̬ʰ/ – voiced + aspirated 14. /◌͡β/ – tie bar + labialized 15. /◌̰̃/ – nasal + mor rounded 16. /◌̟ˠ/ – advanced tongue root + velarized 17. /◌̰̃˩/ – nasal + low tone 18. /◌̬⁼/ – voiced + unaspirated 19. /◌̪ʱ/ – dental + breathy voiced aspirated 20. /◌ʰˢ/ - aspirated fricative 21. /◌̄ʰ/ – unreleased + aspirated 22. /◌̩ʰ/ – linguolabial + aspirated 23. Unaspirated Nasalization /◌̃⁼/ 24. Nasalized Dental Expression /◌̪̃/ 25. sliding articulation	advanced tongue root + aspirated + velarized 5. /◌̰ˠ/ – creaky + advanced tongue root + velarized 6. /◌̞ˠ/ – advanced tongue root + voiceless + velarized 7. /◌̰̟ʱˠ/ – creaky + advanced tongue root + breathy + velarized 8. /(◌̪̰ʱ)/ – dental + creaky + partial devoiced + breathy 9. /◌̰⁼/ – creaky + advanced tongue root + unaspirated 10. /◌̪̈ʰˠ/ – dental + aspirated + breathy + velarized 11. /(◌̪̃)/ – partial devoiced + nasal + dental 12. /(◌̪̃ʱ)/ – dental + nasal +

30. unintelligible speech /◌/	/◌◌/ 26. double articulation /◌◌/	partial devoiced + breathy voiced aspirated

Figure 234: extIPA Symbols in Terms of Diacritics Display

Pre-Palatalization /ʲ◌/ is new for the existing extIPA chart for disordered speech. Also, /◌ˢ/ – sibilant, which is presented as one diacritic. /◌ˢ/, is used in some extended or informal transcription practices to indicate a sibilant or strident-type secondary articulation, meaning the sound has added 'hissing' or sibilant-like noise quality layered onto the base segment. However, it is not an official IPA-defined modifier with a single fixed phonetic value. /◌ʰˢ/, is also new, this is a composite notation combining aspiration (/ʰ/) with a sibilant or strident quality (/ˢ/). It generally suggests a consonant that is both aspirated and has added sibilant/fricative-like release noise. In strict IPA terms, this is an analytical or descriptive stack rather than a formally standardized single diacritic combination.

Unintelligible speech /◌/ can also be suggested as new. Low tone (˩), Extra-Low Tone (˩̩), Weak Articulation (◌̽), Retracted Tongue-Root Position (◌̘) are prominent in most utterances. In a few cases, Post-Alveolar Clicks (◌!) and Palatal Clicks (◌ǂ) were observed. Various places of articulation include: /◌̼/ – linguolabial, /◌ʷ/ – labialized, /◌̪/ – dental, bidental /◌̪̪/, /◌ˠ/ – velarized, pre-palatalized /ʲ◌/, and manners of articulation include: /◌ˢ/ – sibilant, /◌̃/ – nasalized, nasal release /◌ⁿ/, /◌ʳ/ – trill/tap.

Chapter Five
Conclusion

The research can be concluded by listing the most common features of atypical speech which are release/nasalized 5.13%, labialized 4.19%, lip compression 3.51%, laminal 4.06%, velarized 6.3%, pre-palatalization 1.45%, post-alveolar click 1.54%, dental expression 1.37%, fricative release 2.39%, rhotic release 1.45%, voiced 2.48%, voiceless 2.78%, partial devoicing 1.37%, devoicing 1.41%, strong/weak articulation 2.39%, inconsistent /ɦ/ 2.35%, aspirated 2.39%, unaspirated 2.31%, pre-aspirated 2.39%, low tone 3.81%, extra-low tone 3.93%, rising-falling tone 5.64%, rising tone 1.5%, breathy-voiced 2.86, creaky-voiced 5.7%, sliding articulation 1.45%, retracted tongue-root position 5.6%, more roundedness 0.98%, no audible release 5.6%, sound substitution 3.81%, substitution with unintelligible speech 0.98%, double articulation 2.65%, sound addition 1.45%, glottal stop addition 1.41%, post-alveolar click addition 1.37%.

The highest form of atypical speech occurs due to velarization and nasal release/nasalization which is a phonological matter and it can be considered under distortion. Other significant errors happen due to retracted tongue-root position, creaky-voice, rising-falling tone, nasal release/nasalization and no audible release. Creaky-voice and rising-falling tone can be considered as suprasegmental features, and retracted tongue-root position can cause phonological or acoustic errors which all leads to distortion. No audible release, on the other hand, can lead to omission. As per ratio analyses, pre-palatalization /◌ʲ/, nasal release /◌ⁿ/, lip compression /◌̫/, fricative release /◌ˣ/ (and /◌ˢ/, /◌ᶠ/ as systematic release markers), strong articulation /◌̳/, weak articulation /◌̗/, inconsistent /O/, unaspirated /◌̄ʰ/ (often unmarked), unintelligible speech /◌/. pre-aspirated /ʰ◌/ should be in the extIPA for Aphasic patients who speak Bangla as L1. In case of two, partial devoicing /◌̥/, sliding articulation /◌◌̲/, double articulation /◌͡◌/, aspirated fricative /◌ʰˢ/ are used. The rest for two and three or more include addition or stacking qualities and are not necessarily new symbols. Unintelligible speech /◌/ can also be suggested as

new. Low tone (˩), Extra-Low Tone (˩̗), Weak Articulation (◌̗), Retracted Tongue-Root Position (◌̘) are prominent in most utterances. In a few cases, Post-Alveolar Clicks (◌!) and Palatal Clicks (◌ǂ) were observed. Various places of articulation include: /◌̪/ – linguolabial, /◌ʷ/ – labialized, /◌̪/ – dental, bidental /◌̪̈/, /◌ˠ/ – velarized, pre-palatalized /ʲ◌/, and manners of articulation include: /◌ˢ/ – sibilant, /◌̃/ – nasalized, nasal release /◌ⁿ/, /◌ʳ/ – trill/tap. As for organs, soft palate/Velum , back and the root of the tongue are mostly affected.

In addition, the research shows that in dialect variation, F1-F2 relationships shift in predictable and consistent ways. For example, a dialect shows lower or flat F1 or an F2 transition while maintaining F1 and F2 spacing. The ratio remains coherent and rule-governed. As opposed to atypical speech, often disrupts this geometry. It shows inconsistent F2 transitions and the spacing is larger or shorter. Also, mispronunciation which is complete replacement of sounds because of mispronunciation due to misunderstand of the word or habitual use etc. (e.g. মোরগ) as opposed to Tensed/Reiteration with greater effort or repeated bursts and closure, Voice Onset Time (VOT) to denote dialect-specific voicing/aspiration timing (e.g., shorter VOT in /p̄/) as opposed to inconsistent or abnormal VOT or excessive delay and Jitter Report normal range < 1.0% denotes that is is dialect feature unlike > 2.0% which might denote atypical stage. Other than that, the sounds do not have phonological errors.

For direction for updating the extIPA, precise diacritics for partial or inconsistent realizations can be suggested. In addition to that the prosodic features in terms of irregular timed patterns, unstable pitch markers etc. can be expanded. The formants analysis can also make significant contributions in terms of extIPA modifications. These can benefit the researchers and clinical practitioners for atypical speech analysis.

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Appendix 01

Approval Letters

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ভাষাবিজ্ঞান বিভাগ
ঢাকা বিশ্ববিদ্যালয়

Department of Linguistics
University of Dhaka

TO WHOM IT MAY CONCERN

28th of May, 2025

To
The Chairman
Prof. Dr. Dhiman Chowdhury
Department of Neuro Surgery
Bangladesh Medical University (BMU)

Subject: Recommendation to PhD Researcher

Dear Prof. Dr. Dhiman Chowdhury,

I'm pleased to recommend Tanzia Siddiqua, PhD researcher of the Department of Linguistics to advance her research titled 'Phonetic and Phonological Features of Typical and Atypical Speech: Insights from Bangla Language', under the supervisor of Prof. Dr. Syed Shahrier Rahman. In order to analyze the atypical speech patterns, she needs to observe 10 patients between age 18-25, who speak standard Bangla as L1, and are diagnosed with Specific Language Impairment (SLI). For the study she would like the patients to say a set of words with related images only which might take 3-4 visits in total. For the research purpose, she might need the proof of their atypical speech disorders. All the information will be kept **strictly confidential** and be used for research purpose only.

Kind Regards,

Syed Shahrier Rahman PhD
Professor
Department of Linguistics
University of Dhaka
28 MAY 2025

Professor Dr. Dhiman Chowdhury
Professor & Chairman
Department of Neurosurgery
Bangladesh Medical University
Shahbag, Dhaka-1000.

Recommended by:
Dr. Monira Begum
Associate Professor &
Chairman
Department of Linguistics
Faculty of Arts
University of Dhaka

Recommended by:
Dr. Syed Shahrier Rahman
Professor (PhD Supervisor)
Department of Linguistics
Faculty of Arts
University of Dhaka

Approved by:
Prof. Dr. Dhiman Chowdhury
Chairman, Department of
Neuro Surgery
Bangladesh Medical
University (BMU)

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28 MAY 2025

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University of Dhaka

Department of Linguistics

Dear Sir/Madam,

I'm currently conducting my PhD research on 'Phonetic and Phonological Features of Typical and Atypical Speech: Insights from Bangla Language', under the Department of Linguistics, Faculty of Arts, University of Dhaka. In order to analyze the atypical speech patterns, I need to observe 100 patients between age 18-25, who speak standard Bangla as L1, are of at least 5th grade standard and are diagnosed with Specific Language Impairment (SLI).

For the study I would like the patients to say a set of words with related images only which might take 3-4 visits in total. For the research purpose, I would need the proof of their atypical speech disorders. I might add here that, all the information will be kept **strictly confidential** and be used for research purpose only.

Thank you in advance for your cooperation.

Tanzia Siddiqua
PhD Researcher
Department of Linguistics
Faculty of Arts
University of Dhaka

Recommended
06.06.2024
Syed Shahrier Rahman PhD
Professor
Department of Linguistics
University of Dhaka

Permitted
Afzal Hossain
3-10-2024
Mohammed Afzal Hossain
MBBS, FCPS, FICS
Ex Professor & Chairman
Department of Neurosurgery
Bangabandhu Sheikh Mujib Medical University
Shahbag, Dhaka-1000, Bangladesh

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Appendix 02

Patient's Medical History and Diagnosis

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Patient's Medical History and Diagnosis

The following summarizes the patient's medical diagnoses relevant to the speech analysis only. The V Scale (0-5) are V5 (Oriented: fluent speech, comprehension and production are intact), V4 (Confused Conversation: speech is connected but disoriented), V3 (Inappropriate Words: random or irrelevant words, affected comprehension), V2 (Incomprehensible Sounds: moans, no real words, severe speech/language breakdown), V1 (None/Coma: no verbal output). Detailed information has been omitted to maintain medical confidentiality.

Sl No. P1

General Information and Diagnosis	*Name: Kamal Uddin*	*Age: 55*	*Sex: Male*
2025 Spasmodic	Patient experienced gradual progression of headache on the right side aggravated during coughing, vomiting, eye pain, vertigo and has been diagnosed with glioblastoma at right temporo-parieto-occipital lobe ICSOL, perilesional edema, mass effect with midline displacement. *Examination Relevant to Speech-Language Analysis* 1. GCS (E4V5M6) The V (verbal response) score: patient is oriented, able to speak on command and coherently, content is intact 2. Cranial Nerves V, VII, IX, X, XII are crucial for speech, voice, swallowing: no swallowing difficulties, voice and speech are on command (speech data to be analyzed) 3. Motor System (UL, LL, Reflexes, Plantar, Clonus): reflects motor pathways, UMN lesions can also involve corticobulbar tracts leading to slurred speech or even Aphasia if		

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	lesion is cortical and left-sided (speech data to be analyzed)

Sl No. P2

General Information and Diagnosis	*Name: Kolpona Begum*	*Age: 50*	*Sex: Female*
2025 Spasmodic	Patient experienced headache: suggestive of convexity meningioma over left parietal lobe, perilesional edema, mass effect with midline displacement. *Examination Relevant to Speech-Language Analysis* 1. GCS (E4V5M6) The V (verbal response) score: patient is oriented, able to speak on command and coherently, content is intact 2. Cranial Nerves V, VII, IX, X, XII are crucial for speech, voice, swallowing: no swallowing difficulties, voice and speech on command (to be analyzed) 3. Motor System (UL, LL, Reflexes, Plantar, Clonus): reflects motor pathways, UMN lesions can also involve corticobulbar tracts leading to slurred speech or even Aphasia if lesion is cortical and left-sided (to be analyzed)		

Sl No. P3

General Information and Diagnosis	*Name: Jannatul Ferdous*	*Age: 24*	*Sex: Female*

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History: 2012-2023	In 2012, experienced headache, vomiting, double vision, diagnosed as a post fossa SOL and operated by posterior midline approach to remove the SOL and VP shunt followed by removal of the tumor in the right sub-occipital approach and was diagnosed as hemangioblastoma in the year of 2014. In 2023, she again got admitted with headaches, vomiting, and dimness of vision and diagnosed as recurrence of post fossa SOL and operated through right sub-occipital approach and removal of tumor took place. Histopathology came out to be Hemangioblastoma, WHO grade 1.
Present Day: 2025 Recurring	Now, in 2025, for the last 6 months, her symptoms are, headaches aggravated during coughing and sneezing, gradual decrease of vision and tendency to fall towards left. *On Nervous System Examination* Higher Psychic Function Intact, GCS 15, Right handed Speech-Scanning, Gait-Ataxic, Lobe Sign: Absent No signs of meningeal irritation

Sl No. P4

General Information and Diagnosis	*Name: Bilkis*	*Age: 45*	*Sex: Female*
Present Day: 2025 Recurring	Patient experienced headache, total blindness of the right eye, diagnosed with meningioma bone/recurrence-remnant of lesion at the right sphenoidal wings with meningeal thickening and mild right proptosis.		

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	GCS (E4V5M6) The V (verbal response) score: patient is oriented, able to speak on command and coherently, content is intact

Sl No. P5

General Information and Diagnosis	*Name: Hosne Ara*	*Age: 60*	*Sex: Female*
Present Day: 2025 *Recurring*	Patient experienced headache, diagnosed with left jagular foramen SOL (space-occupying lesion, e.g. tumor). GCS (E4V5M6) The V (verbal response) score: patient is oriented, able to speak on command and coherently, content is intact Cranial Nerves: possibly affected IX (Glossopharyngeal), X (Vagus), XI (Accessory): affected IX: difficulty swallowing, reduced pharyngeal control X: breathy voice, vocal cord paralysis, impaired pitch, hypernasality, laryngeal closure X: weakness in head-turning		

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Appendix 03 (For Patients)

A. Task-based Phonological Test: Picture Naming Flashcards

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 1b, 29b	 2a	 2c	 3c
 5c, 26a	 7b	 7c	 8c, 22b
 9a	 9c	 10b	 10c
 11a, 27b	 12a	 13a	 13c
 14a	 14c	 15b	 15c
 17c	 17d	 19a	 19c, 28b
 20c	 22c	 24d	 25c
 25d	 26b, 29a	 27c	 28c

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Appendix 04 (For Patients)

B. Task-based Phonological Test: Word Naming Flashcards

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পুঁইশাক	পাপ	লাফানো	ব্যায়াম	সবুজ	ভাল
1a	1c	2b	3a	3b	4a
অভাব	বিক্ষোভ	তবুও	দ্বিতীয়	থামিয়ে	কোথাও
4b	4c	5a	5b	6a	6b
পথ	দেয়না	ধোঁয়া	অর্ধেক	আটক	ঠিকানা
6c	7a	8a	8b	9b	10a
আড্ডা	রড	বেঢপ	টৈটৈ	টুঁ	আচার
11b	11c	12b	12c	12d	13b
বছর	যেও	ঝাউবন	অঝোর	ঝাঁঝ	কুয়াশা
14b	15a	16a	16b	16c	17a
দোকান	খেয়া	কখন	আখ	আগামী	ঘেউঘেউ
17b	18a	18b	18c	19b	20a
আঘাত	সূফী	আস্থা	আফসোস	সেদিকেই	শ্বাস
20b	21a	21b	21c	22a	22c
হও	বহুত	বাহ	ম্যাও	মিউ	থামিয়া
23a	23b	23c	24a	24b	24c
নুয়ে	অনেক	লয়া	রয়ে	পাঁপড়	
25a	25b	27a	28a	29b	

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Appendix 05 (For Patients)

Consent Form

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CONSENT

I have read and I understand the provided information and have had the opportunity to ask questions. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and without cost. I understand that I will be given a copy of this consent form. I voluntarily agree to take part in this study.

Participant's Signature _____ Date _____

Investigator's Signature _____ Date _____

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Appendix 06

Copyright Consent and License Agreement

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COPYRIGHT CONSENT AND LICENSE AGREEMENT

This document confirms that the digital drawings included in the methodology section were created by Ansa Tasfiha Suhi (the Artist) and have been purchased by Tanzia Siddiqua (the Researcher) to use exclusively within her academic research. The Artist hereby confirms that;

1. ***Copyright Ownership***
   The Artist is the sole creator and copyright holder of the digital drawings. Copyright in the artwork remains with the Artist at all times.
2. ***License Granted to the Researcher***
   The Artist grants the Researcher a non-exclusive, non-transferable license to use the drawings solely for the purposes of her research**,** including inclusion in academic submissions, presentations, publications, or related research activities.
3. ***Artist's Rights***
   The Artist retains the unrestricted right to use, publish, reproduce, modify, or distribute her drawings in any form and for any purpose.
4. ***Restrictions on Third Parties***
   No third party is permitted to copy, reproduce, distribute, display, or otherwise use the drawings without obtaining explicit written permission from the Artist. Unauthorized use may result in legal consequences under applicable copyright laws.
5. ***Acknowledgement***
   The Artist acknowledges receiving full payment for the artwork and confirms that this agreement reflects her full consent.

I, Ansa Tasfiha Suhi, have read, understood, and agree to the terms above.

Signature: Ansa Tasfiha Suhi

Date: 30/11/2025

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Appendix 07 (For Data Analyses)

A. Task-based Phonological Test: Picture and Word Naming Transcriptions

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Sl No.	Consonant Sounds		Text (Standard Bangla) (Interval Tier 01)	Transcriptions					
				IPA (Interval Tier 02)	List of Sounds				
					Consonant Sounds (Point Tier 01)			Vowels (Point Tier 02)	
					B	M	E	P	D
01	/p/	a	পুঁইশাক	[pũ͡ɪʃɐk]	[p]	[ʃ]	[k]	[ɐ]	[ũ͡ɪ]
		b	পিঁপড়া	[pĩpɽɐ]	[p]	[p]	[ɽ]	[ĩ], [ɐ]	
		c	পাপ	[pɐp]	[p]		[p]	[ɐ]	
02	/pʰ/	a	ফুল	[pʰul]	[pʰ]		[l]	[u]	
		b	লাফানো	[lɐpʰɐno]	[l]	[pʰ]	[n]	[ɐ], [o]	
		c	বরফ	[bɔɾopʰ]	[b]	[ɾ]	[pʰ]	[ɔ], [o]	
03	/b/	a	ব্যায়াম	[bæ͡ɐm]	[b]		[m]		[æ͡ɐ]
		b	সবুজ	[ʃobuɟ]	[ʃ]	[b]	[ɟ]	[o], [u]	
		c	লেবু	[lebu]	[l]		[b]	[e], [u]	
04	/bʱ/	a	ভাল	[bʱɐlo]	[bʱ]		[l]	[ɐ], [o]	
		b	অভাব	[ɔbʱɐb]		[bʱ]	[b]	[ɔ], [ɐ]	
		c	বিক্ষোভ	[bɪkkʰobʱ]	[b]	[k], [kʰ]	[bʱ]	[ɪ], [o]	
05	/t̪/	a	তবুও	[t̪obu͡o]	[t̪]		[b]	[o]	[u͡o]
		b	দ্বিতীয়	[d̪it̪u͡o]	[d̪]	[t̪]		[i]	[ɪ͡o]
		c	হাত	[ɦɐt̪]	[ɦ]		[t̪]	[ɐ]	
06	/t̪ʰ/	a	থামিয়ে	[t̪ʰɐmɪe͡]	[t̪ʰ]		[m]	[ɐ]	[ɪe͡]

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		b	কোথাও	[koʈʰɐo]	[k]	[ʈʰ]		[o]	[ɐo]
		c	পথ	[pɔʈʰ]	[p]		[ʈʰ]	[ɔ]	
07	/ɖ/	a	দেয়না	[ɖæenɐ]	[ɖ]		[n]	[ɐ]	[æe]
		b	ইঁদুর	[ĩɖuɾ]		[ɖ]	[ɾ]	[ĩ], [u]	
		c	চাঁদ	[cɐ̃ɖ]	[c]		[ɖ]	[ɐ̃]	
08	/ɖʱ/	a	ধোঁয়া	[ɖʱõɐ]	[ɖʱ]				[õɐ]
		b	অর্ধেক	[ɔrɖʱek]	[ɾ]	[ɖʱ]	[k]	[ɔ], [e]	
		c	ঔষধ	[ouʃɔɖʱ]		[ʃ]	[ɖʱ]	[ɔ]	[ou]
09	/ʈ/	a	টমেটো	[ʈɔmeʈo]	[ʈ]	[m]	[ʈ]	[ɔ], [e], [o]	
		b	আটক	[ɐʈok]		[ʈ]	[k]	[ɐ], [o]	
		c	খাট	[kʰɐʈ]	[kʰ]		[ʈ]	[ɐ]	
10	/ʈʰ/	a	ঠিকানা	[ʈʰikɐnɐ]	[ʈʰ]	[k]	[n]	[i], [ɐ]	
		b	কাঁঠাল	[kɐ̃ʈʰɐl]	[k]	[ʈʰ]	[l]	[ɐ̃]	
		c	কাঠ	[kɐʈʰ]	[k]		[ʈʰ]	[ɐ]	
11	/ɖ/	a	ডালিম	[ɖɐlim]	[ɖ]	[l]	[m]	[ɐ], [i]	
		b	আড্ডা	[ɐɖɖɐ]		[ɖ[	[ɖ]	[ɐ]	
		c	রড	[ɾɔɖ]	[ɾ]		[ɖ]	[ɔ]	
12	/ɖʱ/	a	ঢেঁড়স	[ɖʱæ̃ɽoʃ]	[ɖʱ]	[ɽ]	[ʃ]	[æ̃], [o]	
		b	বেঢপ	[beɖʱɔp]	[b]	[ɖʱ]	[p]	[e], [ɔ]	
		c	ঢৈঢৈ	[ɖʱoɪɖʱoɪ]	[ɖʱ]		[ɖʱ]		[oɪ]

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		d	ডুঁ	[dˠʱu]	[dˠʱ]			[u]	
13	/c/ or /t̪ɕ/	a	চড়াই	[cɔɽ͡ɐɪ]	[c]		[ɽ]	[ɔ]	[͡ɐɪ]
		b	আচার	[ɐcɐɾ]		[c]	[ɾ]	[ɐ]	
		c	চামচ	[cɐmoc]	[c]	[m]	[c]	[ɐ], [o]	
14	/cʰ/ or /t̪ɕʰ/	a	ছাগল	[cʰɐgol]	[cʰ]	[g]	[l]	[ɐ], [o]	
		b	বছর	[bɔcʰoɾ]	[b]	[cʰ]	[ɾ]	[ɔ], [o]	
		c	মাছ	[mɐcʰ]	[m]		[cʰ]	[ɐ]	
15	/ɟ/ or /d̪ʑ/	a	যেও	[ɟe͡o]	[ɟ]				[e͡o]
		b	গাজর	[gɐɟoɾ]	[g]	[ɟ]	[ɾ]	[ɐ], [o]	
		c	জাহাজ	[ɟɐɦɐɟ]	[ɟ]	[ɦ]	[ɟ]	[ɐ]	
16	/ɟʱ/ or /dʑʱ/	a	ঝাউবন	[ɟʱ͡ɐubɔn]	[ɟʱ]	[b]	[n]	[ɔ]	[͡ɐu]
		b	অঝোর	[ɔɟʱoɾ]		[ɟʱ]	[ɾ]	[ɔ], [o]	
		c	ঝাঁঝ	[ɟʱɐ̃ɟʱ]	[ɟʱ]		[ɟʱ]	[ɐ̃]	
17	/k/	a	কুয়াশা	[ku͡ɐʃɐ]	[k]		[ʃ]	[ɐ]	[u͡ɐ]
		b	দোকান	[d̪okɐn]	[d̪]	[k]	[n]	[o], [ɐ]	
		c	নৌকা	[no͡ukɐ]	[n]		[k]	[ɐ]	[o͡u]
		d	নাক	[nɐk]	[n]		[k]	[ɐ]	
18	/kʰ/	a	খেয়া	[kʰe͡ɐ]	[kʰ]				[e͡ɐ]
		b	কখন	[kɔkʰon]	[k]	[kʰ]	[n]	[ɔ], [o]	
		c	আখ	[ɐkʰ]			[kʰ]	[ɐ]	
19	/g/	a	গয়না	[gɔ͡ɪnɐ]	[g]		[n]	[ɐ]	[ɔ͡ɪ]
		b	আগামী	[ɐgɐmi]		[g]	[m]	[ɐ], [i]	

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		c	মোরগ	[morog]	[m]	[ɾ]	[g]	[o]	
20	/gʱ/	a	ঘেউঘেউ	[gʱe͡ugʱe͡u]	[gʱ]		[gʱ]		[e͡u]
		b	আঘাত	[ɐgʱɐt̪]		[gʱ]	[t̪]	[ɐ]	
		c	বাঘ	[bɐgʱ]	[b]		[gʱ]	[ɐ]	
21	/s/	a	সূফী	[supʰi]	[s]		[pʰ]	[u], [i]	
		b	আস্থা	[ɐst̪ʰɐ]		[s]	[t̪ʰ]	[ɐ]	
		c	আফসোস	[ɐpʰsos]	[pʰ]	[s]	[s]	[ɐ], [o]	
22	/ʃ/	a	সেদিকেই	[ʃed̪ɪke͡ɪ]	[ʃ]	[d̪]	[k]	[e], [ɪ]	[e͡ɪ]
		b	ওষুধ	[oʃud̪ʱ]		[ʃ]	[d̪]/	[o], [u]	
		c	শ্বাস	[ʃɐʃ]	[ʃ]		[ʃ]	[ɐ]	
23	/ɦ/	a	হও	[ɦɔ͡o]	[ɦ]				[ɔ͡o]
		b	বহুত	[boɦut̪]	[b]	[ɦ]	[t̪]	[o], [u]	
		c	বাহ	[bɐɦ]	[b]		[ɦ]	[ɐ]	
24	/m/	a	ম্যাও	[mæ͡o]	[m]				[æ͡o]
		b	মিউ	[mɪ͡u]	[m]				[ɪ͡u]
		c	থামিয়া	[t̪ʰɐmɪ͡ɐ]	[t̪ʰ]	[m]		[ɐ]	[ɪ͡ɐ]
		d	কলম	[kɔlom]	[k]	[l]	[m]	[ɔ], [o]	
25	/n/	a	নুয়ে	[nue͡]	[n]				[ue͡]
		b	অনেক	[ɔnek]		[n]	[k]	[ɔ], [e]	
		c	আয়না	[ɐ͡enɐ]			[n]	[ɐ]	[ɐ͡e]
		d	পান	[pɐn]	[p]		[n]	[ɐ]	
26	/ŋ/		N/A	N/A	N/A	N/A	N/A	N/A	N/A

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		a	আংটি	[ɐŋʈi]		[ŋ]	[ʈ]	[ɐ], [i]	
		b	ফড়িং	[pʰoɽɪŋ]	[pʰ]	[ɽ]	[ŋ]	[o], [ɪ]	
27	/l/	a	লয়া	[l͡ɔɐ]	[l]				[ɔ͡ɐ]
		b	ডালিম	[ɖɐlɪm]	[ɖ]	[l]	[m]	[ɐ], [ɪ]	
		c	কল	[kɔl]	[k]		[l]	[ɔ]	
28	/ɾ/	a	রয়ে	[ɾo͡e]	[ɾ]				[o͡e]
		b	মোরগ	[moɾog]	[m]	[ɾ]	[g]	[o]	
		c	বানর	[bɐnoɾ]	[b]	[n]	[ɾ]	[ɐ], [o]	
29	/ɽ/		N/A	N/A	N/A	N/A	N/A	N/A	N/A
		a	ফড়িং	[pʰoɽɪŋ]	[pʰ]	[ɽ]	[ŋ]	[o], [ɪ]	
		b	পাঁপড়	[pɐ̃poɽ]	[p]	[p]	[ɽ]	[ɐ̃] [o]	

Notes:

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Appendix 08 (For Data Analyses)

B. Feature Detection Checklist (Sample)

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Sl No.	Consonant Sounds		Text (Standard Bangla), IPA	Articulatory and Acoustic Features		
				Typical Features (Sample)	Atypical	
					Features (Sample)	Error Types
01	/p/	a	পুঁইশাক, /pũiʃɐk/	☐ Bilabial ☐ Labio-Dental ☐ Linguolabial ☐ Dental ☐ Alveolar ☐ Palato-Alveolar ☐ Retroflex ☐ Palatal ☐ Velar ☐ Uvular ☐ Pharyngeal ☐ Glottal ☐ Plosive ☐ Nasal ☐ Fricative ☐ Approximant ☐ Affricate ☐ Trill ☐ Egressive ☐ Front/Mid/ Back ☐ Rounded/ Unrounded ☐ Clustered ☐ [+V]/[-V]	☐ Dental ☐ Labialized ☐ Palatalized ☐ Velarized/ Pharyngealized ☐ Apical ☐ Laminal ☐ Nasalized ☐ Gliding ☐ Rhoticity ☐ Rounded (More/Less) ☐ Weak Syllable Deletion ☐ Clusters Reduction ☐ Linking ☐ Reiteration/ Double Articulation/ Pause ☐ Inconsistent /ɦ/ ☐ Whistled Articulation ☐ Ingressive	☐ Distortion ☐ Substitution ☐ Omission ☐ Insertion/ Addition
Notes:						