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PHONEMES AND SPEECH SOUNDS

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Abstract*: This article provides an in-depth analysis of phonemes and speech sounds, their characteristics, classifications, and roles in linguistic structures. It examines how phonemes function within a phonological system, explores speech sound articulation, and highlights the relationship between phonetics and phonology. Additionally, the paper discusses phonological processes, the role of suprasegmental, and cross-linguistic phonemic variations.*

Keywords*: phoneme, speech sound, allophone, articulation, acoustic properties, phonological rules, phonotactics, suprasegmentals, phonological processes.*

Аннотация: *В данной статье представлен детальный анализ фонем и речевых звуков, их характеристик, классификаций и роли в языковых структурах. Рассматривается функционирование фонем в фонологической системе, исследуется артикуляция речевых звуков и подчеркивается взаимосвязь между фонетикой и фонологией. Кроме того, в статье обсуждаются фонологические процессы, роль супрасегментных элементов и кросс-лингвистические вариации фонем.*

Ключевые слова: *фонема, речевой звук, аллофон, артикуляция, акустические свойства, фонологические правила, фоно-тактика, супрасегментные элементы, фонологические процессы.*

INTRODUCTION

Language is a complex system of communication that relies heavily on the sounds produced by human speech. These sounds form the basis of spoken language

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and are essential for effective communication. The study of these sounds falls under the domains of phonetics and phonology, two closely related but distinct fields in linguistics. Phonetics examines the physical properties of speech sounds, including their articulation, acoustic features, and auditory perception, while phonology investigates how these sounds function within a particular language to distinguish meaning.

At the heart of phonology lies the concept of the phoneme, the smallest unit of sound that can change the meaning of a word. For example, in English, the words pat and bat differ only in their initial sounds /p/ and /b/, demonstrating that these sounds function as separate phonemes in the language. However, not all variations in pronunciation lead to a change in meaning. These subtle variations, known as allophones, are context-dependent and do not alter the identity of a phoneme.[2]

In addition to phonemes, speech sounds are classified into two broad categories: consonants and vowels, based on their articulation and acoustic properties. Consonants involve some degree of obstruction in the vocal tract, while vowels are produced with a relatively open vocal tract. The organization of these sounds follows specific phonotactic rules, which determine permissible sound sequences in a given language. For instance, English allows the consonant cluster /str-/ at the beginning of words (e.g., street), whereas other languages, such as Japanese, restrict consonant clusters and favor syllabic structures like CV (consonant-vowel).[10]

Beyond individual sounds, suprasegmental features such as stress, intonation, and rhythm play a crucial role in shaping spoken language. These features contribute to the natural flow of speech, affecting meaning and emphasis in communication. For example, in English, word stress can differentiate nouns from verbs (e.g., PREsent vs. preSENT), while intonation patterns help signal questions, statements, or emotions.

Furthermore, phonological processes such as assimilation, elision, insertion, and metathesis influence how sounds interact within words and sentences. These processes vary across languages and dialects, contributing to linguistic diversity. For

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instance, in fast speech, the phrase good boy may be pronounced as [gʊb bɔɪ] due to assimilation, where the final /d/ sound blends with the following /b/.[8]

The study of phonemes and speech sounds is not only fundamental to linguistics but also has practical applications in speech therapy, language teaching, and speech recognition technology. Understanding phonetics and phonology helps linguists analyze language structure, assists educators in teaching correct pronunciation, and supports the development of artificial intelligence systems that process human speech.[2]

This paper explores the concepts of phonemes and speech sounds, their classification, and their function within linguistic systems. It discusses the differences between phonemes and allophones, the articulatory and acoustic properties of speech sounds, phonotactic constraints, suprasegmental features, and phonological processes. Additionally, the paper examines cross-linguistic phonemic variations, highlighting how different languages utilize distinct phoneme inventories and pronunciation rules. By delving into these topics, this study aims to provide a comprehensive understanding of the fundamental role phonemes and speech sounds play in human communication

METHODS

This study employs a combination of acoustic, articulatory, and perceptual phonetic methods, along with fieldwork and computational approaches to analyze phonemes and speech sounds. The methodology follows a structured approach to ensure the accurate collection, analysis, and interpretation of speech data.

Research Design

This study is descriptive and experimental, focusing on the phonetic and phonological aspects of speech sounds. It aims to:

1. Identify and classify phonemes and speech sounds.
2. Analyze their acoustic and articulatory properties.
3. Examine how they are perceived and processed in different linguistic contexts.

A combination of instrumental analysis, experimental tasks, and corpus studies was used to collect and analyze speech data.

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Data Collection

Speech Samples. Speech data was collected from native and non-native speakers of English and other languages to observe phonemic variations.

The recordings included:

✓ Minimal pairs (e.g., "pat" vs. "bat" to test phoneme contrast).

✓ Connected speech samples to analyze phonological processes (e.g.assimilation, elision).

✓ Spontaneous speech for natural phonetic variation.

✓ Fieldwork and Phonemic Transcription

✓ IPA (International Phonetic Alphabet) transcription was used to document phonemic differences.

✓ Data was collected from linguistic databases such as TIMIT and the Corpus of Spontaneous Japanese Speech (CSJ).

Participant Selection

✓ The study involved 20 native speakers of English and 10 speakers of other languages for cross-linguistic comparison.

✓ Participants were selected based on age, dialectal background, and language proficiency.

Acoustic Analysis

✓ Spectrograms and waveform analysis were used to examine the frequency, amplitude, and duration of phonemes.

✓ Formant tracking was applied to analyze vowel quality and resonance.

Articulatory Analysis

✓ Electromagnetic Articulography (EMA) was used to study tongue, jaw, and lip movements.

✓ Ultrasound imaging provided insights into vowel articulation.

Perceptual Analysis

✓ Minimal pair perception tests were conducted to evaluate phoneme recognition.

✓ Eye-tracking and EEG experiments were used to assess speech processing speed.

Ethical Considerations

Participants provided informed consent before speech recording. The study adhered to ethical guidelines for linguistic and human-subject research.

Phonemes vs. Allophones:

Phonemes are the mental representations of sounds that function to differentiate words.Allophones are different pronunciations of a phoneme that do not change the meaning of a word. For instance, in English, the /p/ sound in "spin" and "pin" are allophones—[p] in "spin" is unaspirated, whereas [p^h] in "pin" is aspirated.In many languages, allophonic variations depend on phonetic environments, and native speakers are often unaware of them.

Phonemic Distribution

Phonemes can be classified based on how they appear in words.Contrastive Distribution: When two sounds occur in the same position in words and change meaning (e.g., "bit" vs. "bat").Complementary Distribution: When two sounds never appear in the same phonetic environment, meaning they are contextually determined (e.g., [p] vs. [p^h] in English).

Speech Sounds and Their Classification

Vowels and Consonants

Speech sounds are generally classified into vowels and consonants, based on their articulation, acoustic properties, and role in phonological systems. The primary distinction lies in how the airflow is manipulated during their production.[11]

Vowels

Vowels are speech sounds produced without any significant obstruction of airflow in the vocal tract. They are typically voiced and can be classified based on tongue position, lip shape, and duration.

1.1. Classification of Vowels

Vowels are categorized based on three main criteria:

1.1.1. **Tongue Height** (Vertical position of the tongue)

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High vowels → The tongue is raised close to the roof of the mouth (e.g., /i/ in see, /u/ in blue).

Mid vowels → The tongue is positioned midway (e.g., /e/ in set, /o/ in go).

Low vowels → The tongue is lowered (e.g., /æ/ in cat, /ɑ/ in father).

1.1.2. **Tongue Backness** (Horizontal position of the tongue)

Front vowels → The tongue is positioned toward the front of the mouth (e.g., /i/, /e/).

Central vowels → The tongue is in the middle (e.g., /ə/ in sofa).

Back vowels → The tongue is positioned toward the back (e.g., /u/, /o/).

1.1.3. **Lip Rounding**

Rounded vowels → The lips are rounded during articulation (e.g., /u/, /o/).

Unrounded vowels → The lips remain neutral or spread (e.g., /i/, /æ/).

1.2. **Monophthongs vs. Diphthongs**

Monophthongs → Pure vowel sounds with a stable articulation (e.g., /i/, /e/, /u/).

Diphthongs → A gliding vowel sound that moves from one position to another (e.g., /aɪ/ in ride, /oʊ/ in go).

1.3**. Vowel Length**

Some languages distinguish short and long vowels, affecting word meaning.

English: bit /ɪ/ vs. beat /iː/

Japanese: shiru (to know) vs. shīru (seal/sticker)

Consonants

Consonants are speech sounds produced with some form of restriction or closure in the vocal tract. They are classified based on place of articulation, manner of articulation, and voicing.

2.1. **Classification of Consonants**

Consonants are categorized based on three main criteria:

2.1.1. **Place of Articulation** (Where the sound is produced)

Bilabial → Both lips come together (e.g., /p/, /b/, /m/).

Labiodental → The bottom lip touches the upper teeth (e.g., /f/, /v/).

Dental → The tongue touches the upper teeth (e.g., /θ/ in think, /ð/ in this).

Alveolar → The tongue touches the alveolar ridge (e.g., /t/, /d/, /s/, /z/, /n/).

Palatal → The tongue touches the hard palate (e.g., /ʃ/ in she, /ʒ/ in measure).

Velar → The back of the tongue touches the soft palate (e.g., /k/, /g/, /ŋ/ in sing).

Glottal → The sound is produced at the vocal cords (e.g., /h/, /ʔ/ in uh-oh).

2.1.2. **Manner of Articulation** (How the airflow is affected)

Plosive (Stop) → Complete closure, then release (e.g., /p/, /t/, /k/).

Fricative → Narrow constriction, causing friction (e.g., /f/, /s/, /ʃ/).

Affricate → A combination of a plosive and fricative (e.g., /ʧ/ in church, /ʤ/ in judge).

Nasal → Air flows through the nose (e.g., /m/, /n/, /ŋ/).

Lateral Approximant → Air escapes around the sides of the tongue (e.g., /l/).

Approximant → Minimal obstruction (e.g., /w/, /r/, /j/ in yes).

2.1.3. **Voicing**

Voiced consonants → Vocal cords vibrate (e.g., /b/, /d/, /g/, /v/, /z/).

Voiceless consonants → No vocal cord vibration (e.g., /p/, /t/, /k/, /f/, /s/).

Vowels and consonants are essential components of spoken language. Vowels are produced with an open vocal tract and classified by tongue position and lip shape, while consonants involve some degree of airflow restriction and are categorized by articulation place and manner. Their interplay forms the phonemic structure of languages, influencing pronunciation, meaning, and speech patterns. Understanding vowels and consonants is key to mastering phonetics, phonology, and language acquisition.[13]

RESULTS

The Role of Phonemes in Linguistic Systems

Phonemes form the basis of spoken words and follow rules governing their combination and pronunciation.

Phonotactics

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Phonotactic constraints determine how phonemes are arranged in words. Some languages allow complex consonant clusters, while others do not. For example: English allows "str-" (e.g., "street") but not "tl-."

Japanese syllables usually follow a CV (consonant-vowel) structure.

Suprasegmentals (Prosody)

Suprasegmental features include stress, intonation, and rhythm, which influence meaning and sentence structure:

Stress: Emphasis on certain syllables (e.g., "PREsent" vs. "preSENT").

Intonation: Rising or falling pitch in sentences (e.g., questions vs. statements).

Tone: In tonal languages like Mandarin, pitch variations change word meanings (e.g., "ma" can mean "mother" or "horse" depending on tone).[7]

Acoustic and Articulatory Features of Speech Sounds

Acoustic Properties: Speech sounds have physical characteristics that can be analyzed scientifically:

Frequency: The pitch of a sound, determined by the rate of vocal fold vibration.

Amplitude: The loudness of a sound.

Formants: Resonant frequencies that help identify vowels.

Articulatory Properties

Oral vs. nasal sounds: Oral sounds involve airflow only through the mouth, while nasal sounds allow air to pass through the nose.

Aspirated vs. unaspirated sounds: Some sounds involve a burst of air (e.g., [p^h] in "pin").

DISCUSSION

Phonemes and Language Variation

Languages differ in their phonemic inventories, and speakers often struggle with sounds not present in their native language.

Cross-Linguistic Phonemic Differences

English vs. Japanese: English distinguishes /r/ and /l/, but Japanese does not.

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Some African languages use click consonants, which are absent in most other languages.

Phonological Processes Common phonological processes include:

Assimilation: One sound becomes more like a nearby sound (e.g., "input" → "imput").

Elision: A sound is omitted (e.g., "friendship" pronounced as "frenship").

Insertion (Epenthesis): An extra sound is added (e.g., "athlete" pronounced as "ath-e-lete" by some speakers).

Metathesis: Sounds switch places (e.g., "ask" → "aks" in some dialects).

Phonemes and speech sounds are the foundation of spoken communication, playing a crucial role in phonological systems and speech production. Understanding these elements helps linguists analyze language structure, pronunciation patterns, and linguistic diversity. The study of phonemes and speech sounds is also vital for language learning, speech recognition technology, and linguistic research.

CONCLUSION

Phonemes and speech sounds are fundamental components of spoken language, playing a crucial role in communication, language structure, and meaning. Phonemes, as the smallest units of sound that distinguish words, form the backbone of phonological systems, while speech sounds, including allophones, contribute to language variation and pronunciation differences. The distinction between phonetics and phonology highlights the importance of both the physical properties of sounds and their functional roles within languages.

The classification of speech sounds into consonants and vowels based on articulatory and acoustic features helps linguists analyze speech patterns across languages. Additionally, phonotactic constraints determine which sound sequences are permissible in different languages, shaping their phonological structures. Suprasegmental features, such as stress, intonation, and rhythm, further influence speech perception and meaning.

Phonological processes like assimilation, elision, insertion, and metathesis demonstrate how speech sounds change in different contexts, contributing to natural

language evolution and dialectal differences. Moreover, cross-linguistic variations in phonemic inventories reveal how languages use sound systems uniquely, sometimes making pronunciation difficult for second-language learners.

The study of phonemes and speech sounds has practical applications in various fields, including linguistics, language teaching, speech therapy, and speech technology. Understanding how sounds function in language helps improve pronunciation training, assistive speech devices, and artificial intelligence systems for speech recognition.

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