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THREEFOLD PROPERTIES OF SPEECH SOUNDS: ARTICULATORY, ACOUSTIC, AND AUDITORY PERSPECTIVES

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Annotation: Speech sounds, fundamental to human communication, can be analyzed through three primary dimensions: articulatory, acoustic, and auditory properties. This tripartite model provides a framework for understanding how sounds are produced, transmitted, and perceived in human languages. Each property offers unique insights: articulatory properties explore how speech organs generate sounds; acoustic properties analyze sound waves as they propagate; and auditory properties investigate how sounds are received and interpreted by listeners. This paper examines each of these dimensions, presenting insights from phonetics and cognitive linguistics, to outline a comprehensive model of speech sound properties.

Key words: speech sounds, articulatory properties, acoustic properties, auditory properties, phonetics, cognitive linguistics, articulatory phonetics

INTRODUCTION

Speech sounds are fundamental to human language, serving as the primary medium through which ideas, emotions, and information are communicated. Linguistic science categorizes these sounds according to their articulatory, acoustic, and auditory properties. Each of these threefold properties contributes uniquely to the process of spoken communication, offering a holistic view of how speech is produced, transmitted, and understood. Articulatory properties focus on the physiological aspects of sound production, detailing how the lungs, vocal folds, and articulators (such as the tongue, lips, and teeth) create distinct sounds. Acoustic properties, by contrast, describe the sound waves as they travel from speaker to listener, analyzing characteristics like frequency, amplitude, and duration. Finally, auditory properties cover the perception of sounds, emphasizing the role of the human ear and brain in interpreting and differentiating sounds, which is crucial for language comprehension. A deeper understanding of these three properties allows researchers to uncover the intricate processes involved in human speech and offers valuable insights for applications in technology, language education, and healthcare. This article will explore each property in detail, outlining their significance within the broader context of linguistic science

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and communication. By adopting this tripartite approach, we gain a clearer understanding of the complexity of spoken language and its underlying mechanisms.

MATERIALS AND METHOD

Articulatory Properties

Articulatory phonetics focuses on the biological processes that enable sound production, primarily involving the lungs, vocal folds, and articulators (e.g., tongue, lips, teeth). When producing sounds, air is pushed from the lungs and shaped by the vocal tract to produce distinct sounds. Classification of Sounds:

Speech sounds can be categorized by several articulatory factors:

Place of Articulation: Where in the vocal tract the airflow is constricted (e.g., bilabial, alveolar, velar). Examples:

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

Alveolar: Tongue touches the alveolar ridge just behind the teeth (e.g., /t/, /d/).

Velar: Back of the tongue contacts the soft part of the roof of the mouth, the velum (e.g., /k/, /g/).

Manner of Articulation: How airflow is modified, such as stopping it completely (plosives), restricting it (fricatives), or allowing it to resonate (nasals). Describes how the airstream is modified by the speech organs to create different sounds. Examples:

Stop: Complete closure of the vocal tract followed by release (e.g., /p/, /t/, /k/).

Fricative: Narrowing of the vocal tract causing friction (e.g., /f/, /s/).

Nasal: Airflow passes through the nose due to lowered velum (e.g., /m/, /n/).

Voicing: The vibration of the vocal cords. Sounds are either voiced (vocal cords vibrate) or voiceless (no vibration). Determines whether the vocal cords vibrate during sound production.

Types:

Voiced: Vocal cords vibrate (e.g., /b/, /d/, /g/).

Voiceless: Vocal cords do not vibrate (e.g., /p/, /t/, /k/).

Airstream Mechanism refers to how air is pushed out to create sounds.

Types:

Pulmonic Egressive: Air is pushed out from the lungs, used in most speech sounds.

Glottalic Egressive: Air is pushed out by the glottis (e.g., ejective sounds in some languages).

Velaric Ingressive: Air is drawn in through a closure at the velum (e.g., click sounds).

The brain’s role in controlling speech articulation is complex, requiring precise coordination of multiple muscle groups. Research shows that brain regions involved in motor control and auditory feedback play an essential role, highlighting a cognitive feedback loop that corrects and adjusts sound production in real-time.

Acoustic Properties

The acoustic features of three classes of complex sounds (complex tones, vowels and voiceless fricatives) were analyzed using a model of auditory signal processing. The model consists of a peripheral cochlear component followed by two central neural networks. At the peripheral stage the asymmetrical shape of the cochlear filters, in combination with the preservation of the fine-temporal structure of their outputs, provide for a robust spatio-temporal representation of speech sounds. The cochlear patterns are subsequently processed by two separate layers of lateral inhibitory networks (LINs) in order to extract perceptually significant features of the input signal. For speech-like signals the LIN output emphasizes the spectral components in the region of the formant peaks. The LIN patterns generated in response to vowels spoken by male and female speakers contain some variability, particularly with respect to the location of formant peaks. However, the relative amplitudes of the LIN peaks (or, more precisely, the weight distribution of the LIN patterns) provide a more stable representation of each of the major vocalic classes. With respect to the voiceless fricatives, the model suggests that the most distinctive acoustic feature is the location of the high-frequency edge of the signal spectrum. Once produced, speech sounds exist as sound waves with specific physical characteristics. Key parameters in the acoustic study of speech sounds include:

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

Amplitude: The loudness of the sound, corresponding to the wave's energy.

Duration: The length of time a sound persists, crucial for distinguishing between phonemes in many languages.

Acoustic properties are often analyzed through spectrograms, which visually represent frequencies over time. Spectrograms reveal formants, the resonant frequencies of the vocal tract, which are crucial for distinguishing vowel sounds. For example, the first and second formants (F1 and F2) help differentiate vowels like /i/ and /a/. The phenomenon of coarticulation, where speech sounds influence each other, leads to acoustic variations that must be analyzed. For instance, the vowel in “bat” has a different acoustic profile than the vowel in “bit,” even though both may be similarly articulated. These variations underline the dynamic nature of speech sounds in natural language.

Auditory Properties

The auditory system's role in speech processing begins when sound waves reach the ear and are converted to neural signals. This involves several steps:

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1. Outer Ear: Funnels sound into the ear canal, amplifying certain frequencies.
2. Middle Ear: Transmits vibrations from the eardrum to the cochlea.
3. Inner Ear: The cochlea translates vibrations into neural signals sent to the brain.

Listeners categorize speech sounds into distinct phonemes, enabling language comprehension. Phoneme discrimination is influenced by the context of sounds, prior exposure, and linguistic background. For instance, Japanese speakers often struggle to distinguish between English /r/ and /l/, as these sounds do not represent distinct phonemes in Japanese. Beyond mechanical processing, the brain's cognitive regions interpret and assign meaning to sounds. Studies show that auditory feedback plays a role in speech production as well, indicating that we use real-time auditory information to correct and adjust speech sounds. In computational linguistics, these properties are crucial for developing effective speech synthesis and recognition technologies. Understanding articulatory properties aids in generating realistic-sounding speech, while acoustic properties are essential for processing sound waves accurately. Auditory insights help fine-tune these systems to interpret sounds in varied auditory environments. Phonetic research increasingly uses the threefold model to examine how language influences cognitive processing and vice versa. For example, studies of bilingual individuals show that phonetic distinctions in one language can affect auditory processing in another, illustrating the profound cognitive impact of speech sound properties.

CONCLUSION

The threefold properties of speech sounds articulatory, acoustic, and auditory offer a comprehensive framework for analyzing spoken language. By examining how speech is produced, transmitted, and perceived, researchers can deepen their understanding of human communication and apply these insights across diverse fields, from artificial intelligence to language therapy. Continued research in this triad will likely yield new insights into the complexities of speech, advancing both theoretical knowledge and practical applications in linguistics and beyond.

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