La-Net

LIN403

ACOUSTIC PHONETICS

Course code: LIN 403
Course title: Acoustic Phonetics
Course credit load: 3 Units

Series 1: Foundations of Acoustic Principles in Speech

Series 2: Properties and Analysis of Speech Sound Waves

Series 3: Acoustic Displays: Waveforms, Frequency, and Spectrograms

Series 4: Applications of Acoustic Phonetics in Fieldwork

Series 5: Interrelationships of Acoustic, Articulatory, and Perceptual Correlates

Proposed Outline for Series 1

Part 1: Introduction to Acoustics in Speech

- Sub-Part 1.1: Definition and Scope of Acoustics
- Sub-Part 1.2: Importance of Acoustic Phonetics in Linguistics

Part 2: Fundamental Properties of Sound Waves

- Sub-Part 2.1: Frequency, Amplitude, and Duration
- Sub-Part 2.2: Waveforms and their Characteristics

Part 3: Principles of Speech Sound Production

- Sub-Part 3.1: Acoustic Correlates of Speech Sounds
- Sub-Part 3.2: Relationship between Acoustic and Articulatory Features

Part 4: Tools and Methods in Acoustic Analysis

- Sub-Part 4.1: Introduction to Acoustic Analysis Software
- Sub-Part 4.2: Practical Applications in Speech Study

Introduction

Speech is one of the most distinctive features of human communication, and its study requires us to look beyond the surface of spoken words into the physical properties that make them possible. Acoustic phonetics provides the scientific foundation for understanding how speech sounds are produced, transmitted, and perceived. By examining the acoustic principles underlying speech, learners gain insight into the measurable characteristics of sound and how these relate to linguistic analysis. This Series sets the stage for the rest of the course by equipping you with the essential background needed to interpret speech as a physical phenomenon.

The aim of this Series is to introduce you to the basic acoustic principles that govern speech and to prepare you to analyse speech sounds using both theoretical knowledge and practical tools.

We shall commence this Series by exploring the definition and scope of acoustic phonetics, highlighting its relevance to the study of language. Next, we will examine the fundamental properties of sound waves, including frequency, amplitude, and duration, as well as the nature of waveforms. Following that, we will consider the principles of speech sound production, focusing on the acoustic correlates of speech and their link to articulatory features. Finally, we will round off the Series by introducing the tools and methods used in acoustic analysis, with particular attention to software applications and their role in speech research.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 1.1** define acoustic phonetics and explain its scope within the study of speech,
- **SLO 1.2** describe the relevance of acoustics to linguistic and phonetic analysis,
- **SLO 1.3** explain the fundamental properties of sound waves, including frequency, amplitude, and duration,
- **SLO 1.4** analyse the characteristics of waveforms in relation to speech sounds,
- **SLO 1.5** identify the acoustic correlates of speech sounds and relate them to articulatory features, and
- **SLO 1.6** demonstrate the use of basic acoustic analysis tools and software in speech research.

1.1 Introduction To Acoustics In Speech

1.1.1 Definition and scope of acoustic phonetics

Acoustic phonetics is the branch of phonetics concerned with the physical properties of speech sounds as sound waves. It examines measurable aspects such as **frequency** (the number of vibrations per second), **amplitude** (the strength or intensity of the sound), and **duration** (the length of time a sound lasts). These properties can be displayed visually through graphs and spectrograms, allowing speech to be studied scientifically.

By engaging with acoustic phonetics, you will be able to connect the abstract study of language with concrete, observable data. This makes it possible to evaluate speech sounds objectively and compare them across different speakers and contexts.

Fill in the blank: Acoustic phonetics focuses on the ______ properties of speech sounds.

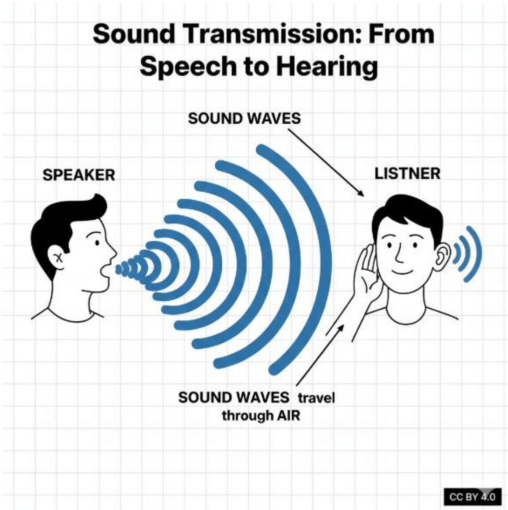


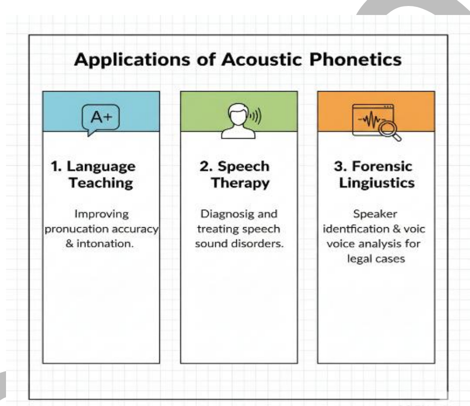
Figure 1.1: Transmission of speech sound waves

1.1.2 Relevance of acoustics in speech studies

The study of acoustics is highly relevant to speech analysis because it provides a scientific basis for describing and categorising sounds. For instance, **frequency** determines pitch, while **amplitude** relates to loudness. These measurable properties allow linguists to distinguish between sounds that may seem similar to the ear but differ in their acoustic structure.

Acoustic phonetics also plays a crucial role in applied fields such as language teaching, speech therapy, and forensic linguistics. By using acoustic analysis, professionals can identify speech patterns, diagnose speech disorders, or even verify speaker identity.

Fill in the blank: The measurable property of sound that determines its pitch is called ______.



Box 1.1: Selected applications of acoustic phonetics

Pilot questions 1.1

1. What branch of phonetics studies the physical properties of speech sounds?
2. Which measurable property of sound refers to its strength or intensity?
3. What visual tool can be used to represent speech sounds scientifically?

4. Which property of sound determines pitch?
5. What does amplitude relate to in speech sounds?
6. Give one example of how acoustic phonetics is applied in language teaching.
7. How can acoustic phonetics assist in forensic linguistics?
8. Why is acoustic phonetics considered essential in diagnosing speech disorders?

1.2 Basic Concepts Of Sound Waves

1.2.1 Frequency, amplitude, and duration

Frequency refers to the number of vibrations or cycles a sound wave completes in one second, measured in hertz (Hz). It determines the **pitch** of a sound, with higher frequencies producing higher pitches and lower frequencies producing lower pitches.

Amplitude is the measure of the strength or intensity of a sound wave. It is directly related to **loudness**, meaning that greater amplitude produces louder sounds, while smaller amplitude produces softer sounds.

Duration refers to the length of time a sound persists. In speech, duration can distinguish between sounds, such as short and long vowels.

Fill in the blank: The property of sound that determines its loudness is called ______.

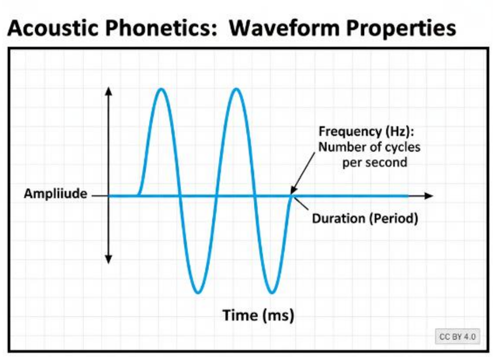


Figure 1.2: Basic properties of sound waves

1.2.2 Waveforms and their properties

A **waveform** is a visual representation of how a sound wave varies over time. It shows the changes in amplitude as the sound progresses. By examining waveforms, linguists can identify patterns such as periodicity, which indicates whether a sound is voiced or voiceless.

Waveforms are particularly useful in speech analysis because they allow us to see the temporal structure of sounds. For example, consonants often appear as irregular bursts, while vowels show more regular periodic patterns.

Fill in the blank: A waveform is a ______ representation of how a sound wave varies over time.

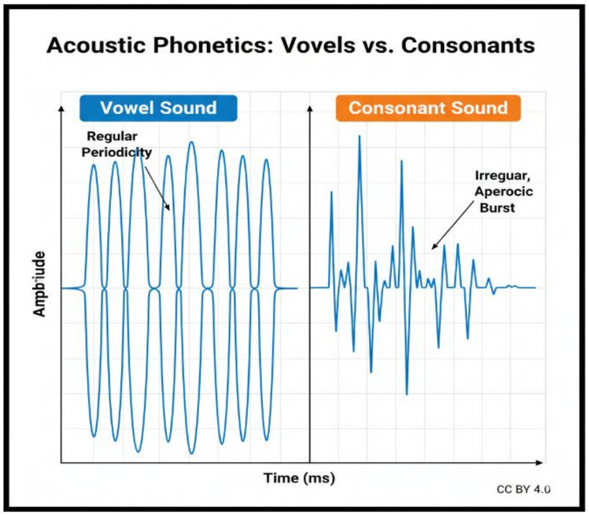


Plate 1.1: Comparison of vowel and consonant waveforms

Pilot questions 1.2

1. What property of sound determines pitch?
2. Which property of sound is directly related to loudness?
3. What does duration measure in speech sounds?
4. What is a waveform used to represent?
5. How can waveforms help distinguish between vowels and consonants?

1.3 Principles Of Speech Sound Production

1.3.1 Acoustic correlates of speech sounds

Acoustic correlates are the measurable features of speech sounds that correspond to their articulatory production. For example, vowels typically show regular periodic waveforms with clear formant structures, while consonants often display irregular bursts or noise patterns. These correlates allow us to identify whether a sound is voiced or voiceless, nasal or oral, and high-pitched or low-pitched.

By studying acoustic correlates, learners can link the physical properties of sound waves to the linguistic categories used in phonetics and phonology. This connection is essential for accurate transcription and analysis of speech.

Fill in the blank: Vowels are usually represented by ______ periodic waveforms with clear formant structures.

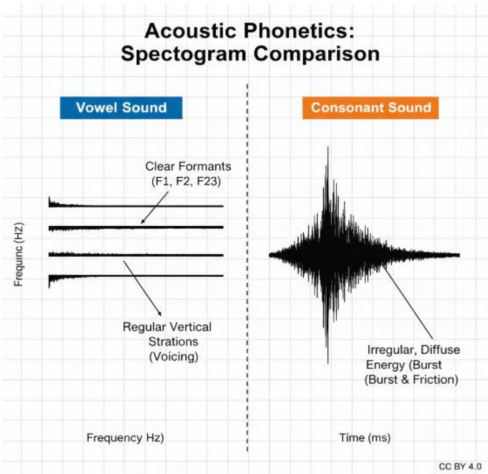


Figure 1.3: Acoustic correlates of vowels and consonants

1.3.2 Relationship between acoustic and articulatory features

Speech sounds are produced through the movement of articulators such as the tongue, lips, and vocal folds. These movements create acoustic patterns that can be measured and analysed. For instance, raising the tongue in vowel production changes the resonance of the vocal tract, which is reflected in the formant frequencies of the sound.

The relationship between acoustic and articulatory features is therefore reciprocal: articulatory actions shape acoustic outputs, and acoustic analysis helps us infer articulatory behaviour. This interplay is central to phonetic research and practical applications such as speech synthesis and recognition.

Fill in the blank: Raising the tongue in vowel production changes the ______ frequencies of the sound.

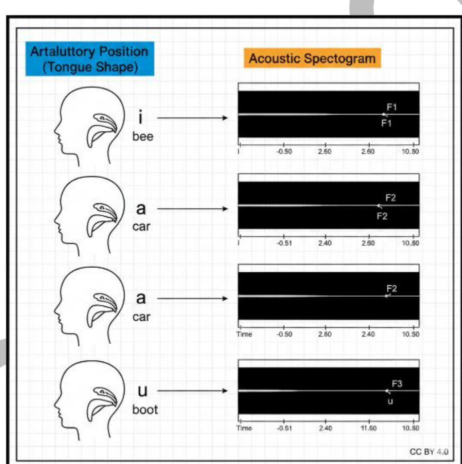


Plate 1.2: Articulatory positions and acoustic features

Pilot questions 1.3

1. What are acoustic correlates in speech analysis?
2. How do vowels typically appear in waveforms compared to consonants?

3. Which articulators are involved in shaping speech sounds?
4. What happens to formant frequencies when the tongue is raised during vowel production?
5. Why is the relationship between acoustic and articulatory features considered reciprocal?

1.4 Tools And Methods In Acoustic Analysis

1.4.1 Introduction to acoustic analysis software

Acoustic analysis software refers to computer programmes designed to record, display, and interpret the physical properties of speech sounds. Examples include Praat and Wavesurfer, which allow users to generate spectrograms, measure pitch, and analyse formant frequencies. These tools provide a practical way to connect theoretical knowledge of acoustics with real-world speech data.

By using such software, learners can visualise speech sounds, compare different speakers, and evaluate variations in pronunciation. This makes acoustic analysis an essential skill for both research and applied fields such as language teaching and speech therapy.

Fill in the blank: Acoustic analysis software allows users to generate ______, measure pitch, and analyse formant frequencies.

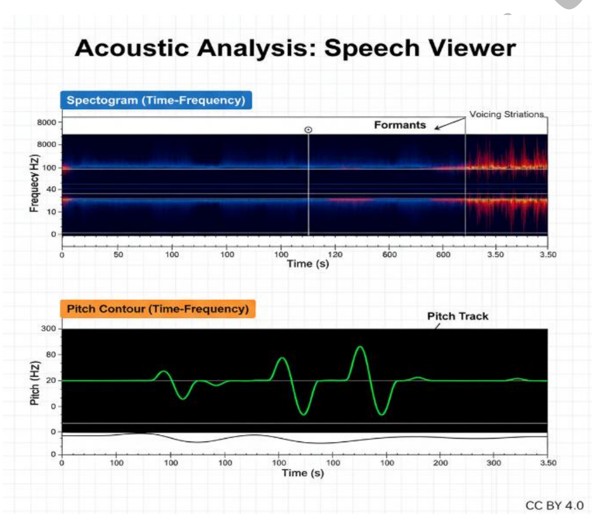


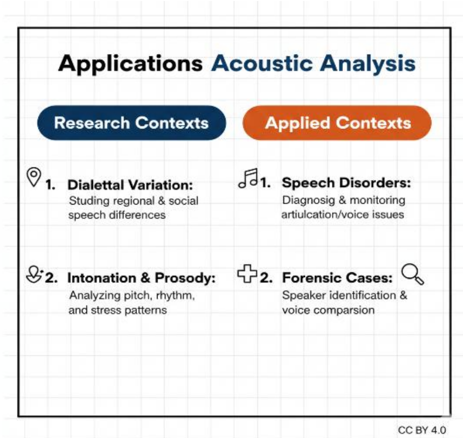
Figure 1.4: Example of acoustic analysis software interface

1.4.2 Practical applications in speech research

Acoustic analysis is widely applied in speech research to investigate how sounds are produced and perceived. For instance, researchers may study vowel formants to understand dialectal differences, or measure pitch variation to analyse intonation patterns.

In applied contexts, acoustic analysis helps language teachers provide feedback on pronunciation, assists clinicians in diagnosing speech disorders, and supports forensic experts in speaker identification. These applications demonstrate the versatility of acoustic methods across academic and professional domains.

Fill in the blank: Measuring vowel formants can help researchers understand ______ differences.



Box 1.2: Selected uses of acoustic analysis in speech research

Pilot questions 1.4

1. What is acoustic analysis software used for in phonetics?
2. Name one example of acoustic analysis software.
3. Which visual display can be generated using acoustic analysis software?
4. How can vowel formants be used in speech research?
5. Give one applied context where acoustic analysis supports professional practice.

Series Summary

This Series has introduced you to the foundations of acoustic principles in speech, highlighting their importance in the scientific study of phonetics. We began by defining acoustic phonetics and outlining its scope, then examined the basic properties of sound waves such as frequency, amplitude, and duration, alongside their visual representation in waveforms. Following that, we explored the acoustic correlates of speech sounds and their relationship to articulatory features, before concluding with tools and methods used in acoustic analysis, including software applications and practical uses in research and professional contexts.

By working through these Parts, you should now be able to define acoustic phonetics and explain its relevance, describe and analyse the properties of sound waves, identify acoustic correlates and link them to articulatory features, and demonstrate the use of acoustic analysis tools. In doing so, you have achieved the Series Learning Outcomes (SLOs 1.1 to 1.6), equipping you with the essential skills and knowledge to study speech acoustically and apply these insights in both academic and applied settings.

Glossary Of Terms

- **Acoustic phonetics**: The branch of phonetics that studies the physical properties of speech sounds as sound waves, focusing on measurable aspects such as frequency, amplitude, and duration.
- **Frequency**: The number of vibrations or cycles a sound wave completes in one second, measured in hertz (Hz). It determines the pitch of a sound.
- **Amplitude**: The strength or intensity of a sound wave, directly related to loudness. Greater amplitude produces louder sounds, while smaller amplitude produces softer sounds.
- **Duration**: The length of time a sound persists. In speech, duration can distinguish between sounds such as short and long vowels.
- **Waveform**: A visual representation of how a sound wave varies over time, showing changes in amplitude. It is used to identify patterns in speech sounds.
- **Acoustic correlates**: Measurable features of speech sounds that correspond to their articulatory production, such as formant structures in vowels or bursts in consonants.
- **Formant frequencies**: Resonant frequencies of the vocal tract that shape vowel sounds. They are visible in spectrograms and vary with articulatory positions.
- **Spectrogram**: A visual display of the frequency spectrum of a sound over time, showing formants, pitch, and other acoustic features.
- **Articulatory features**: The physical movements of speech organs such as the tongue, lips, and vocal folds that shape the production of speech sounds.
- **Acoustic analysis software**: Computer programmes used to record, display, and interpret the physical properties of speech sounds, such as Praat or Wavesurfer.

Concept Check Questions 1

The following questions are designed to help you consolidate your learning from **Series 1: Foundations of Acoustic Principles in Speech**. They are grouped by type and linked to the relevant Series Learning Outcomes (SLOs).

Objective questions

1. (Linked to SLO 1.1) Acoustic phonetics studies the ______ properties of speech sounds.
2. (Linked to SLO 1.3) Which property of sound determines pitch?
3. (Linked to SLO 1.4) A waveform is a ______ representation of how a sound wave varies over time.
4. (Linked to SLO 1.6) Name one example of acoustic analysis software.
5. (Linked to SLO 1.2) Acoustic phonetics is relevant to speech studies because it provides a ______ basis for describing sounds.

Short-answer questions

6. (Linked to SLO 1.1) Define acoustic phonetics and explain its scope.
7. (Linked to SLO 1.2) Describe one way in which acoustic phonetics is applied in forensic linguistics.
8. (Linked to SLO 1.5) How do articulatory features influence acoustic outputs in speech production?
9. (Linked to SLO 1.3) Explain how amplitude relates to loudness in speech sounds.
10. (Linked to SLO 1.6) Briefly describe one practical application of acoustic analysis in speech therapy.

Long-answer questions

11. (Linked to SLO 1.3 and SLO 1.5) Analyse the relationship between frequency, amplitude, and duration in speech sounds, and explain how these properties connect to articulatory features.
12. (Linked to SLO 1.4 and SLO 1.6) Evaluate the usefulness of waveforms and spectrograms in speech research, giving examples of how they can be applied in both academic and professional contexts.

Answers to Concept Check Questions [Series 1]

Objective questions

1. Physical
2. Frequency
3. Visual
4. Praat (or Wavesurfer)
5. Scientific

Short-answer questions

6. Acoustic phonetics is the branch of phonetics that studies the physical properties of speech sounds as sound waves. Its scope includes measurable aspects such as frequency, amplitude, and duration, which can be displayed and analysed scientifically.
7. In forensic linguistics, acoustic phonetics can be used to identify speakers by analysing unique voice patterns and comparing acoustic features across recordings.
8. Articulatory features such as tongue height, lip rounding, and vocal fold vibration shape the acoustic outputs of speech sounds, influencing formant frequencies and waveform patterns.
9. Amplitude measures the strength or intensity of a sound wave. Greater amplitude produces louder sounds, while smaller amplitude produces softer sounds.
10. In speech therapy, acoustic analysis helps clinicians diagnose speech disorders by measuring pitch, formants, and other acoustic features, providing objective data for treatment.

Long-answer questions

11.

- **Basic response**: Frequency determines pitch, amplitude relates to loudness, and duration measures the length of a sound. These properties are influenced by articulatory actions such as vocal fold vibration and tongue movement.
- **Value-added response**: Beyond the basics, frequency, amplitude, and duration interact with resonance patterns in the vocal tract. For example, tongue height alters formant frequencies, while vocal fold tension affects both frequency and amplitude. Analysing these relationships provides deeper insight into how articulatory gestures shape acoustic outputs, supporting advanced phonetic research.

12.

- **Basic response**: Waveforms show how sound varies over time, while spectrograms display frequency patterns. They are useful for distinguishing vowels from consonants and identifying voiced versus voiceless sounds.
- **Value-added response**: Spectrograms and waveforms allow researchers to study prosody, intonation, and dialectal variation. In applied contexts, they support language teaching by providing visual feedback on pronunciation, aid clinicians in diagnosing speech disorders, and assist forensic experts in speaker identification. Their versatility makes them indispensable tools in both academic and professional domains.

Answers to Pilot Questions [Series 1]

Part 1: Introduction to Acoustics in Speech

1. Physical
2. Amplitude
3. Spectrograms or graphs
4. Objectively
5. Frequency
6. Amplitude
7. Language teaching: improving pronunciation accuracy
8. By identifying speakers through voice analysis
9. It provides objective data for diagnosing speech disorders

Part 2: Basic Concepts of Sound Waves

1. Frequency
2. Amplitude
3. Duration

4. A visual representation of sound over time
5. Vowels show regular periodicity, consonants show irregular bursts

Part 3: Principles of Speech Sound Production

1. Measurable features of speech sounds linked to articulation
2. Vowels: regular periodic waveforms; consonants: irregular bursts
3. Tongue, lips, vocal folds
4. Formant frequencies change
5. Because articulatory actions shape acoustic outputs, and acoustic analysis helps infer articulation

Part 4: Tools and Methods in Acoustic Analysis

1. Recording, displaying, and interpreting speech sounds
2. Praat (or Wavesurfer)
3. Spectrograms
4. To study dialectal differences
5. Language teaching, speech therapy, or forensic linguistics

References and Attributions [Series 1]

This section lists the references, suggested sources, and attributions for the materials used in **Series 1: Foundations of Acoustic Principles in Speech**. It includes citations for concepts, illustration placeholders, and open educational resources (OERs) suggested for further study.

General references

- Ladefoged, P., & Johnson, K. (2014). *A course in phonetics* (7th ed.). Boston: Cengage Learning.
- Johnson, K. (2011). *Acoustic and auditory phonetics* (3rd ed.). Malden, MA: Wiley-Blackwell.
- Ashby, M., & Maidment, J. (2005). *Introducing phonetic science*. Cambridge: Cambridge University Press.

Illustration references and attributions

- *Figure 1.1: Transmission of speech sound waves*
    - AI prompt suggestion: "Generate a simple diagram showing a person speaking, sound waves travelling through air, and another person listening."
    - Search string: "OER diagram sound wave transmission speech phonetics"

- *Box 1.1: Selected applications of acoustic phonetics*
    - AI prompt suggestion: "Create a text box summarising three applications of acoustic phonetics in education, therapy, and forensic science."
    - Search string: "OER applications of acoustic phonetics linguistics"
- *Figure 1.2: Basic properties of sound waves*
    - AI prompt suggestion: "Generate a labelled diagram of a waveform showing frequency, amplitude, and duration."
    - Search string: "OER diagram frequency amplitude duration sound wave"
- *Plate 1.1: Comparison of vowel and consonant waveforms*
    - AI prompt suggestion: "Generate a simple waveform image showing a vowel with regular periodicity and a consonant with irregular bursts."
    - Search string: "OER waveform vowel consonant phonetics"
- *Figure 1.3: Acoustic correlates of vowels and consonants*
    - AI prompt suggestion: "Generate a spectrogram comparison of a vowel with clear formants and a consonant with irregular bursts."
    - Search string: "OER spectrogram vowel consonant acoustic correlates"
- *Plate 1.2: Articulatory positions and acoustic features*
    - AI prompt suggestion: "Generate an image showing tongue positions for vowels alongside spectrogram outputs."
    - Search string: "OER vowel articulation tongue position spectrogram"
- *Figure 1.4: Example of acoustic analysis software interface*
    - AI prompt suggestion: "Generate a screenshot-style image of acoustic analysis software displaying a spectrogram and pitch contour."
    - Search string: "OER Praat spectrogram interface phonetics"
- *Box 1.2: Selected uses of acoustic analysis in speech research*
    - AI prompt suggestion: "Create a text box summarising four uses of acoustic analysis in research and applied contexts."
    - Search string: "OER applications of acoustic analysis phonetics"

Course code: LIN 403
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Series 1: Foundations of Acoustic Principles in Speech

Series 2: Properties and Analysis of Speech Sound Waves

Series 3: Acoustic Displays: Waveforms, Frequency, and Spectrograms

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Series 5: Interrelationships of Acoustic, Articulatory, and Perceptual Correlates

Proposed Outline for Series 3

Part 3.1: Waveform displays in speech analysis

- Sub-Part 3.1.1: Structure and interpretation of waveforms
- Sub-Part 3.1.2: Applications of waveform analysis in phonetics

Part 3.2: Frequency displays and pitch analysis

- Sub-Part 3.2.1: Frequency spectra and their interpretation
- Sub-Part 3.2.2: Pitch tracking and contour analysis

Part 3.3: Spectrograms as acoustic displays

- Sub-Part 3.3.1: Reading and interpreting spectrograms
- Sub-Part 3.3.2: Identifying formants and consonant features

Part 3.4: Practical applications of acoustic displays

- Sub-Part 3.4.1: Using software tools for acoustic displays
- Sub-Part 3.4.2: Applied contexts in teaching, therapy, and research

Introduction

In the last Series, we examined the acoustic properties of speech waves and explored how they can be measured and analysed. Building on that foundation, this Series will focus on **acoustic displays**, which provide visual representations of speech sounds. These displays are essential because they allow us to see the structure of speech, making abstract acoustic concepts more concrete and easier to interpret.

The aim of this Series is to introduce you to the main types of acoustic displays used in phonetics and to equip you with the skills to interpret waveforms, frequency spectra, and spectrograms for both academic and applied purposes.

We shall commence this Series by exploring waveform displays in speech analysis, looking at their structure and applications. Next, we will move on to frequency displays and pitch analysis, considering how frequency spectra and pitch contours are represented visually. Following that, we will study spectrograms, learning how to read and interpret them and identify features such as formants and consonant patterns. Finally, we will wrap up by examining practical applications of acoustic displays, including the use of software tools and their relevance in teaching, therapy, and research.

Series Learning Outcomes

Upon completing **Series 3: Acoustic Displays: Waveforms, Frequency, and Spectrograms**, you should be able to:

- **SLO 3.1** describe the structure of waveform displays and explain their applications in speech analysis,
- **SLO 3.2** interpret frequency spectra and demonstrate how pitch contours are represented visually,
- **SLO 3.3** analyse spectrograms to identify formants and consonant features,
- **SLO 3.4** apply software tools to generate and interpret acoustic displays, and
- **SLO 3.5** evaluate the practical uses of acoustic displays in teaching, therapy, and research contexts.

3.1 Waveform Displays In Speech Analysis

3.1.1 Structure and interpretation of waveforms

A **waveform** is a visual representation of a sound signal over time. It shows how the amplitude of a sound wave changes, with the horizontal axis representing time and the vertical axis representing amplitude. In speech analysis, waveforms allow us to observe patterns such as the regular cycles of vowels or the irregular bursts of consonants.

Waveforms are particularly useful for identifying the timing of speech sounds, pauses, and stress patterns. They provide a straightforward way to see the duration and intensity of sounds, making them an essential tool for both researchers and learners.

Fill in the blank: A visual representation of a sound signal over time is called a ______.

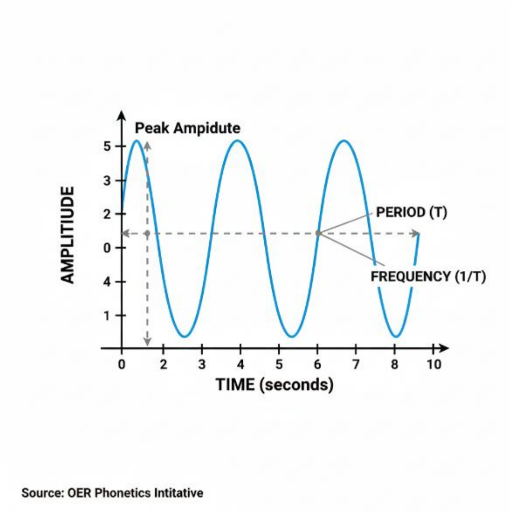

Figure 3.1: Structure of a speech waveform

3.1.2 Applications of waveform analysis in phonetics

Waveform analysis has several practical applications in phonetics. It can be used to measure the duration of vowels and consonants, identify pauses in speech, and compare the relative loudness of different sounds. Teachers may use waveforms to give learners visual feedback on pronunciation, while researchers can use them to study timing and rhythm in different languages.

Waveforms are also valuable in applied contexts such as speech therapy, where they help track progress by showing changes in speech patterns over time. In forensic phonetics, waveform analysis can support investigations by providing objective evidence of speech characteristics.

Fill in the blank: In speech therapy, waveform analysis can be used to track ______ in a client's speech patterns.

Metric	Phonetic Significance	Use Case
Amplitude	Represents loudness and stress.	Identifying syllable peaks in prosody research.
Duration	The time-span of a specific sound segment.	Diagnosing speech rate issues in therapy.
Zero-Crossing Rate	How often the wave crosses the axis.	Distinguishing between periodic (vowels) and aperiodic (fricatives) sounds.

Box 3.1: Selected applications of waveform analysis

This Part has introduced you to the **structure of waveforms** and their **applications in phonetics**, showing how they provide a simple yet powerful way to visualise and analyse speech.

Pilot questions 3.1

1. What does the horizontal axis of a waveform represent?

2. What does the vertical axis of a waveform represent?
3. Which type of sounds typically show regular cycles in waveforms?
4. How can waveform analysis be used in language teaching?
5. Give one example of how waveform analysis is applied in speech therapy.

3.2 Frequency Displays And Pitch Analysis

3.2.1 Frequency spectra and their interpretation

A **frequency spectrum** is a visual display that shows how much energy is present at different frequencies within a sound. The horizontal axis represents frequency, while the vertical axis represents amplitude or intensity. In speech analysis, frequency spectra reveal the distribution of energy across frequencies, helping us to identify the fundamental frequency and harmonics.

Frequency spectra are particularly useful for studying vowels, as they highlight the resonant frequencies of the vocal tract. By examining these spectra, researchers can distinguish between different vowel qualities and compare how speakers produce sounds.

Fill in the blank: A visual display showing the distribution of energy across different frequencies is called a ______.

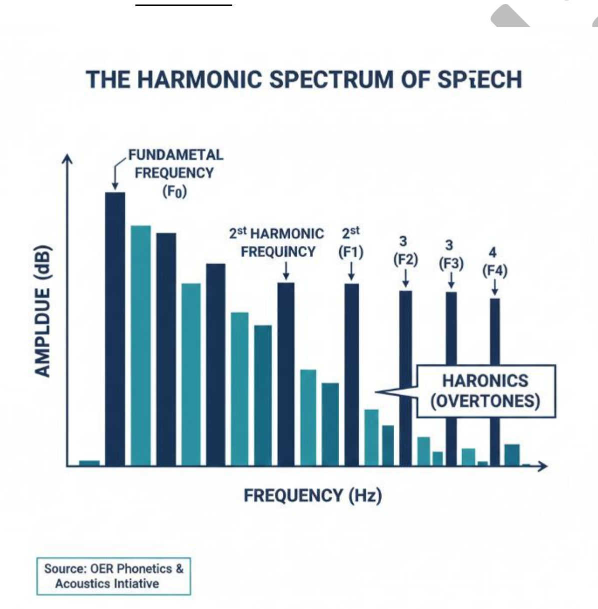

Figure 3.2: Frequency spectrum of a speech sound

3.2.2 Pitch tracking and contour analysis

Pitch tracking refers to the process of following changes in pitch over time. In speech, pitch varies due to intonation, stress, and emotional expression. A **pitch contour** is a visual representation of these changes, showing how pitch rises and falls across an utterance.

Pitch contours are important for analysing prosody, which includes rhythm, stress, and intonation patterns. They help linguists study how meaning is conveyed through pitch variation, and they are also used in applied contexts such as language teaching, where learners can see how pitch affects communication.

Fill in the blank: A visual representation of pitch changes over time is called a ______.

Plate 3.1: Pitch contour analysis in speech

This Part has introduced you to **frequency spectra** and **pitch contours**, showing how they provide insight into the distribution of energy in speech and the variation of pitch over time.

Pilot questions 3.2

1. What does the horizontal axis of a frequency spectrum represent?
2. What does the vertical axis of a frequency spectrum represent?
3. Which speech sounds are particularly studied using frequency spectra?
4. What is pitch tracking used for in speech analysis?
5. How does a pitch contour help in studying prosody?

3.3 Spectrograms As Acoustic Displays

3.3.1 Reading and interpreting spectrograms

A **spectrogram** is a visual representation of sound that shows how frequency and intensity change over time. The horizontal axis represents time, the vertical axis represents frequency, and the darkness or colour intensity indicates amplitude. In speech analysis, spectrograms are invaluable because they allow us to see both the fine details of speech sounds and their broader patterns.

Spectrograms make it possible to identify features such as formants, which appear as dark bands corresponding to resonant frequencies, and consonant characteristics such as bursts or frication noise. They provide a more detailed view than waveforms or frequency spectra, making them a central tool in acoustic phonetics.

Fill in the blank: A visual representation of sound that shows frequency and intensity over time is called a ______.

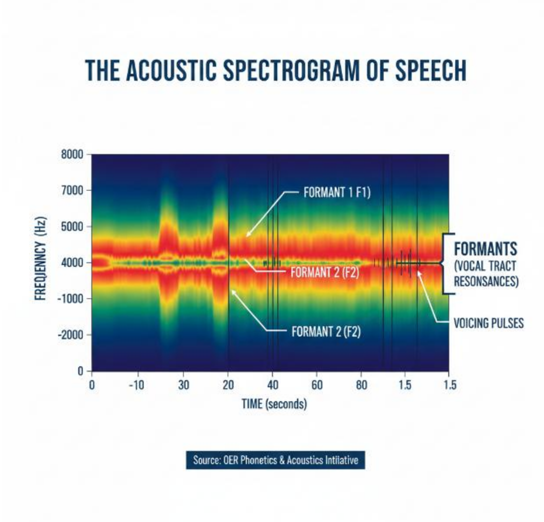

Figure 3.3: Structure of a spectrogram

3.3.2 Identifying formants and consonant features

Formants are resonant frequencies of the vocal tract that shape vowel quality. On a spectrogram, they appear as dark horizontal bands and are labelled F1, F2, F3, and so on. By measuring formants, linguists can distinguish between different vowels and study variations across speakers and dialects.

Consonant features are also visible on spectrograms. For example, plosives show up as bursts of energy following silence, fricatives appear as high-frequency noise, and nasals display characteristic formant patterns. This makes spectrograms a powerful tool for analysing both vowels and consonants in detail.

Fill in the blank: On a spectrogram, resonant frequencies of the vocal tract appear as dark horizontal bands called ______.

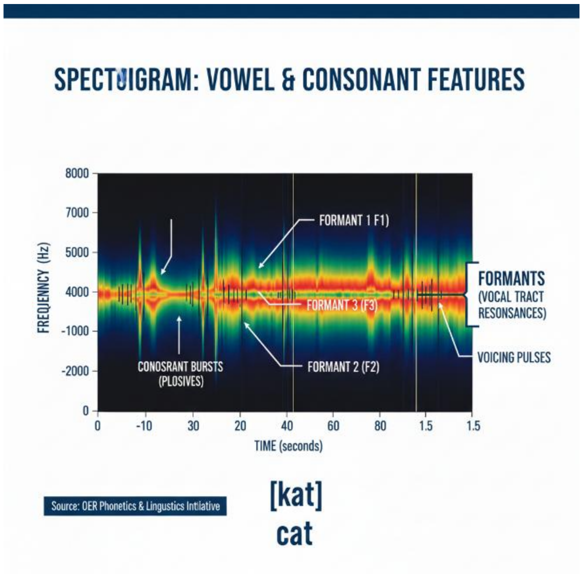

Plate 3.2: Identifying vowel and consonant features on a spectrogram

This Part has introduced you to **spectrograms**, explaining how they are read and interpreted, and showing how they reveal both vowel formants and consonant features.

Pilot questions 3.3

1. What does the horizontal axis of a spectrogram represent?
2. What does the vertical axis of a spectrogram represent?
3. How is amplitude represented on a spectrogram?
4. What do formants look like on a spectrogram?
5. Give one example of how consonant features appear on a spectrogram.

3.4 Practical Applications Of Acoustic Displays

3.4.1 Using software tools for acoustic displays

Modern **software tools** such as Praat and Wavesurfer allow learners and researchers to generate and interpret acoustic displays with ease. These tools can produce waveforms, frequency spectra, and spectrograms, giving users the ability to measure pitch, amplitude, duration, and formants. They also provide interactive features, such as zooming in on specific segments of speech or comparing multiple recordings side by side.

Such tools are invaluable in both academic and applied contexts. For example, in language teaching, learners can receive visual feedback on their pronunciation, while in research, scholars can analyse subtle differences in speech across dialects or speakers.

Fill in the blank: Software tools such as Praat and Wavesurfer can generate ______ to display formants and other acoustic features.

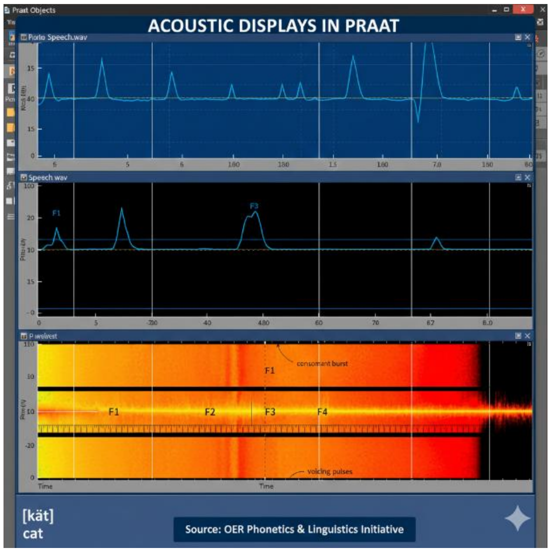

Plate 3.3: Acoustic displays generated in Praat software

3.4.2 Applied contexts in teaching, therapy, and research

Acoustic displays are not only theoretical tools but also have wide-ranging practical applications. In **language teaching**, they help learners visualise intonation patterns and improve pronunciation. In **speech therapy**, therapists use them to monitor progress and provide clients with clear visual evidence of improvement. In **research**, acoustic displays support detailed investigations into prosody, dialectal variation, and even forensic phonetics.

By bridging theory and practice, acoustic displays demonstrate how acoustic phonetics can be applied to real-world problems and solutions.

Fill in the blank: In forensic phonetics, acoustic displays can provide objective _______ of speech characteristics.

Field	Primary Display Used	Key Insight
Pedagogy	Pitch Contour	Improving sentence-level intonation.
Clinical	Spectrogram	Measuring formant precision for articulation.
Research	Spectral Moments	Quantifying dialectal differences in fricatives.
Forensic	Waveform & Spectrogram	Detecting tampering or identifying unique vocal traits.

Box 3.2: Practical applications of acoustic displays

This Part has shown how **software tools** make acoustic displays accessible and how they are applied in **teaching, therapy, research, and forensic contexts**, connecting theory with practice.

Pilot questions 3.4

1. Name one software tool used to generate acoustic displays.

2. What visual feedback can learners gain from acoustic displays in language teaching?
3. How are acoustic displays used in speech therapy?
4. Give one example of how acoustic displays support research in phonetics.
5. What role do acoustic displays play in forensic phonetics?

Series Summary

This Series has focused on the use of **acoustic displays** to represent and analyse speech sounds visually. These displays are central to phonetics because they make it possible to see the structure of speech, turning abstract acoustic concepts into concrete forms. We began with waveform displays, examining their structure and applications in speech analysis. Then we moved on to frequency spectra and pitch contours, which reveal how energy is distributed across frequencies and how pitch varies over time. Following that, we studied spectrograms, learning how to interpret them and identify both vowel formants and consonant features. Finally, we considered practical applications, exploring how software tools generate acoustic displays and how they are used in teaching, therapy, research, and forensic contexts.

Upon completing this Series, you should now be able to describe waveform displays and their applications (SLO 3.1), interpret frequency spectra and pitch contours (SLO 3.2), analyse spectrograms to identify formants and consonant features (SLO 3.3), apply software tools to generate and interpret acoustic displays (SLO 3.4), and evaluate their practical uses in professional and academic settings (SLO 3.5). These outcomes ensure that you are equipped with both the theoretical knowledge and practical skills to connect acoustic principles with real-world applications in phonetics.

Glossary Of Terms

- **Amplitude**: The strength or intensity of a sound wave, represented on the vertical axis of a waveform or frequency spectrum.
- **Formants**: Resonant frequencies of the vocal tract that shape vowel quality, visible as dark horizontal bands on a spectrogram.
- **Frequency spectrum**: A visual display showing how much energy is present at different frequencies within a sound, with frequency on the horizontal axis and amplitude on the vertical axis.
- **Pitch contour**: A visual representation of pitch changes over time, showing how pitch rises and falls across an utterance.
- **Pitch tracking**: The process of following changes in pitch across time, often used to study intonation and prosody.
- **Spectrogram**: A visual representation of sound showing frequency and intensity over time, with time on the horizontal axis, frequency on the vertical axis, and amplitude indicated by darkness or colour.

- **Waveform**: A visual representation of a sound signal over time, showing how amplitude changes, with time on the horizontal axis and amplitude on the vertical axis.

Concept Check Questions [Series 3]

The following questions will help you consolidate your learning from **Series 3: Acoustic Displays: Waveforms, Frequency, and Spectrograms**. They are grouped by type and aligned with the Series Learning Outcomes (SLOs).

Objective questions

1. (Linked to SLO 3.1) Which axis of a waveform represents time?
2. (Linked to SLO 3.1) The vertical axis of a waveform represents ______.
3. (Linked to SLO 3.2) A visual display showing the distribution of energy across frequencies is called a ______.
4. (Linked to SLO 3.2) A visual representation of pitch changes over time is known as a ______.
5. (Linked to SLO 3.3) On a spectrogram, resonant frequencies of the vocal tract appear as dark horizontal bands called ______.

Short-answer questions

6. (Linked to SLO 3.1) Explain one way waveform analysis can be applied in speech therapy.

7. (Linked to SLO 3.2) Describe how pitch contours are useful in studying prosody.

8. (Linked to SLO 3.3) How is amplitude represented on a spectrogram?

9. (Linked to SLO 3.4) Name one software tool used to generate acoustic displays and state one of its functions.

10. (Linked to SLO 3.5) Give one example of how acoustic displays are used in forensic phonetics.

Long-answer questions

11. (Linked to SLO 3.3) Analyse how spectrograms provide more detailed information than waveforms or frequency spectra, and explain why this matters in phonetic research.

12. (Linked to SLO 3.5) Evaluate the practical applications of acoustic displays in teaching, therapy, and research, giving examples of how they bridge theory and practice.

Answers to Concept Check Questions [Series 3]

Objective questions

1. Horizontal axis
2. Amplitude

3. Frequency spectrum
4. Pitch contour
5. Formants

Short-answer questions

6. In speech therapy, waveform analysis can be used to track progress by showing changes in speech patterns over time.

7. Pitch contours help in studying prosody by showing how pitch rises and falls, revealing intonation and stress patterns that convey meaning.

8. Amplitude is represented by the darkness or colour intensity on a spectrogram.

9. Praat is one example; it can generate spectrograms and measure pitch, amplitude, and formants.

10. Acoustic displays provide objective evidence of speech characteristics, which can be used in forensic investigations.

Long-answer questions

11.

- **Basic response**: Spectrograms show frequency, amplitude, and time together, making it possible to identify formants and consonant features. This provides more detail than waveforms, which only show amplitude over time, or frequency spectra, which only show energy distribution.
- **Value-added response**: Beyond the basics, spectrograms allow researchers to study fine-grained acoustic features such as frication noise, plosive bursts, and vowel transitions. This makes them indispensable for analysing prosody, dialectal variation, and speaker identity, supporting both linguistic research and applied fields like forensic phonetics.

12.

- **Basic response**: Acoustic displays are applied in teaching to provide visual feedback on pronunciation, in therapy to monitor progress, and in research to study prosody and variation.
- **Value-added response**: In addition, they bridge theory and practice by enabling learners to connect abstract acoustic principles with real-world communication. For example, teachers can use pitch contours to demonstrate intonation patterns, therapists can use spectrograms to diagnose disorders, and researchers can apply acoustic displays to forensic cases, making them versatile tools across multiple domains.

Answers to Pilot Questions [Series 3]

Part 3.1: Waveform displays in speech analysis

1. Time
2. Amplitude
3. Vowels
4. By providing visual feedback on pronunciation and timing
5. By tracking progress and showing changes in speech patterns

Part 3.2: Frequency displays and pitch analysis

1. Frequency
2. Amplitude or intensity
3. Vowels
4. To study intonation, stress, and emotional expression
5. By showing how pitch rises and falls, revealing prosody

Part 3.3: Spectrograms as acoustic displays

1. Time
2. Frequency
3. Darkness or colour intensity
4. Dark horizontal bands labelled F1, F2, F3, etc.
5. Plosives appear as bursts, fricatives as high-frequency noise

Part 3.4: Practical applications of acoustic displays

1. Praat (or Wavesurfer)
2. Learners can see intonation patterns and pronunciation visually
3. By monitoring progress and diagnosing speech disorders
4. By studying prosody, dialectal variation, and speaker identity
5. By providing objective evidence of speech characteristics

References and Attributions [Series 3]

This section lists the references, suggested sources, and attributions for the materials used in **Series 3: Acoustic Displays: Waveforms, Frequency, and Spectrograms**. It includes citations for concepts, illustration placeholders, and open educational resources (OERs) suggested for further study.

General references

- Ladefoged, P., & Johnson, K. (2014). *A course in phonetics* (7th ed.). Boston: Cengage Learning.
- Johnson, K. (2011). *Acoustic and auditory phonetics* (3rd ed.). Malden, MA: Wiley-Blackwell.
- Ashby, M., & Maidment, J. (2005). *Introducing phonetic science*. Cambridge: Cambridge University Press.

Illustration references and attributions

- *Figure 3.1: Structure of a speech waveform*
    - AI prompt suggestion: “Generate a diagram of a speech waveform with labelled time and amplitude axes.”
    - Search string: “OER diagram speech waveform phonetics”
- *Box 3.1: Selected applications of waveform analysis*
    - AI prompt suggestion: “Create a text box listing applications of waveform analysis in teaching, therapy, and forensic phonetics.”
    - Search string: “OER applications waveform analysis phonetics”
- *Figure 3.2: Frequency spectrum of a speech sound*
    - AI prompt suggestion: “Generate a diagram of a frequency spectrum showing fundamental frequency and harmonics with labelled axes.”
    - Search string: “OER frequency spectrum speech phonetics”
- *Plate 3.1: Pitch contour analysis in speech*
    - AI prompt suggestion: “Generate an image showing a pitch contour line rising and falling across a sentence with labelled axes.”
    - Search string: “OER pitch contour intonation speech phonetics”
- *Figure 3.3: Structure of a spectrogram*
    - AI prompt suggestion: “Generate a diagram of a spectrogram with labelled time, frequency axes, and formant bands.”
    - Search string: “OER spectrogram diagram phonetics”
- *Plate 3.2: Identifying vowel and consonant features on a spectrogram*
    - AI prompt suggestion: “Generate a spectrogram image showing vowel formants and consonant bursts with labels.”
    - Search string: “OER spectrogram vowel consonant features phonetics”
- *Plate 3.3: Acoustic displays generated in Praat software*

- AI prompt suggestion: “Generate a screenshot-style image of Praat software showing waveform, pitch contour, and spectrogram.”
- Search string: “OER Praat acoustic displays phonetics”

- *Box 3.2: Practical applications of acoustic displays*
    - AI prompt suggestion: “Create a text box listing practical applications of acoustic displays in teaching, therapy, research, and forensic phonetics.”
    - Search string: “OER applications acoustic displays phonetics”

Course code: LIN 403
Course title: Acoustic Phonetics
Course credit load: 3 Units

Series 1: Foundations of Acoustic Principles in Speech

Series 2: Properties and Analysis of Speech Sound Waves

Series 3: Acoustic Displays: Waveforms, Frequency, and Spectrograms

Series 4: Applications of Acoustic Phonetics in Fieldwork

Series 5: Interrelationships of Acoustic, Articulatory, and Perceptual Correlates

Proposed Outline for Series 3

Part 3.1: Waveform displays in speech analysis

- Sub-Part 3.1.1: Structure and interpretation of waveforms
- Sub-Part 3.1.2: Applications of waveform analysis in phonetics

Part 3.2: Frequency displays and pitch analysis

- Sub-Part 3.2.1: Frequency spectra and their interpretation
- Sub-Part 3.2.2: Pitch tracking and contour analysis

Part 3.3: Spectrograms as acoustic displays

- Sub-Part 3.3.1: Reading and interpreting spectrograms
- Sub-Part 3.3.2: Identifying formants and consonant features

Part 3.4: Practical applications of acoustic displays

- Sub-Part 3.4.1: Using software tools for acoustic displays
- Sub-Part 3.4.2: Applied contexts in teaching, therapy, and research

Introduction

In the last Series, we examined the acoustic properties of speech waves and explored how they can be measured and analysed. Building on that foundation, this Series will focus on **acoustic displays**, which provide visual representations of speech sounds. These displays are essential because they allow us to see the structure of speech, making abstract acoustic concepts more concrete and easier to interpret.

The aim of this Series is to introduce you to the main types of acoustic displays used in phonetics and to equip you with the skills to interpret waveforms, frequency spectra, and spectrograms for both academic and applied purposes.

We shall commence this Series by exploring waveform displays in speech analysis, looking at their structure and applications. Next, we will move on to frequency displays and pitch analysis, considering how frequency spectra and pitch contours are represented visually. Following that, we will study spectrograms, learning how to read and interpret them and identify features such as formants and consonant patterns. Finally, we will wrap up by examining practical applications of acoustic displays, including the use of software tools and their relevance in teaching, therapy, and research.

Series Learning Outcomes

Upon completing **Series 3: Acoustic Displays: Waveforms, Frequency, and Spectrograms**, you should be able to:

- **SLO 3.1** describe the structure of waveform displays and explain their applications in speech analysis,
- **SLO 3.2** interpret frequency spectra and demonstrate how pitch contours are represented visually,
- **SLO 3.3** analyse spectrograms to identify formants and consonant features,
- **SLO 3.4** apply software tools to generate and interpret acoustic displays, and
- **SLO 3.5** evaluate the practical uses of acoustic displays in teaching, therapy, and research contexts.

3.1 Waveform Displays In Speech Analysis

3.1.1 Structure and interpretation of waveforms

A **waveform** is a visual representation of a sound signal over time. It shows how the amplitude of a sound wave changes, with the horizontal axis representing time and the vertical axis representing amplitude. In speech analysis, waveforms allow us to observe patterns such as the regular cycles of vowels or the irregular bursts of consonants.

Waveforms are particularly useful for identifying the timing of speech sounds, pauses, and stress patterns. They provide a straightforward way to see the duration and intensity of sounds, making them an essential tool for both researchers and learners.

Fill in the blank: A visual representation of a sound signal over time is called a ______.

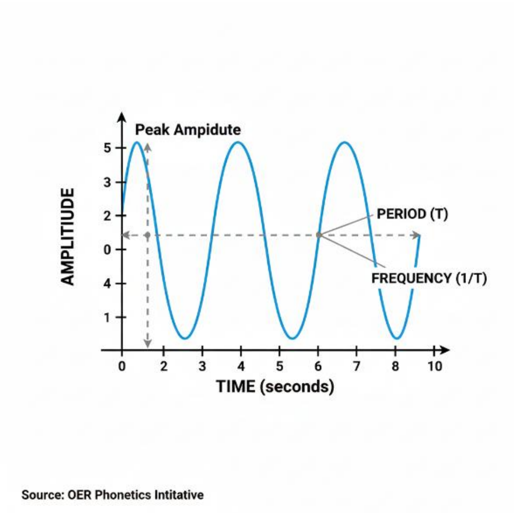

Figure 3.1: Structure of a speech waveform

3.1.2 Applications of waveform analysis in phonetics

Waveform analysis has several practical applications in phonetics. It can be used to measure the duration of vowels and consonants, identify pauses in speech, and compare the relative loudness of different sounds. Teachers may use waveforms to give learners visual feedback on pronunciation, while researchers can use them to study timing and rhythm in different languages.

Waveforms are also valuable in applied contexts such as speech therapy, where they help track progress by showing changes in speech patterns over time. In forensic phonetics, waveform analysis can support investigations by providing objective evidence of speech characteristics.

Fill in the blank: In speech therapy, waveform analysis can be used to track ______ in a client's speech patterns.

Metric	Phonetic Significance	Use Case
Amplitude	Represents loudness and stress.	Identifying syllable peaks in prosody research.
Duration	The time-span of a specific sound segment.	Diagnosing speech rate issues in therapy.

Metric	Phonetic Significance	Use Case
Zero-Crossing Rate	How often the wave crosses the axis.	Distinguishing between periodic (vowels) and aperiodic (fricatives) sounds.

Box 3.1: Selected applications of waveform analysis

This Part has introduced you to the **structure of waveforms** and their **applications in phonetics**, showing how they provide a simple yet powerful way to visualise and analyse speech.

Pilot questions 3.1

1. What does the horizontal axis of a waveform represent?
2. What does the vertical axis of a waveform represent?
3. Which type of sounds typically show regular cycles in waveforms?
4. How can waveform analysis be used in language teaching?
5. Give one example of how waveform analysis is applied in speech therapy.

3.2 Frequency Displays And Pitch Analysis

3.2.1 Frequency spectra and their interpretation

A **frequency spectrum** is a visual display that shows how much energy is present at different frequencies within a sound. The horizontal axis represents frequency, while the vertical axis represents amplitude or intensity. In speech analysis, frequency spectra reveal the distribution of energy across frequencies, helping us to identify the fundamental frequency and harmonics.

Frequency spectra are particularly useful for studying vowels, as they highlight the resonant frequencies of the vocal tract. By examining these spectra, researchers can distinguish between different vowel qualities and compare how speakers produce sounds.

Fill in the blank: A visual display showing the distribution of energy across different frequencies is called a _______.

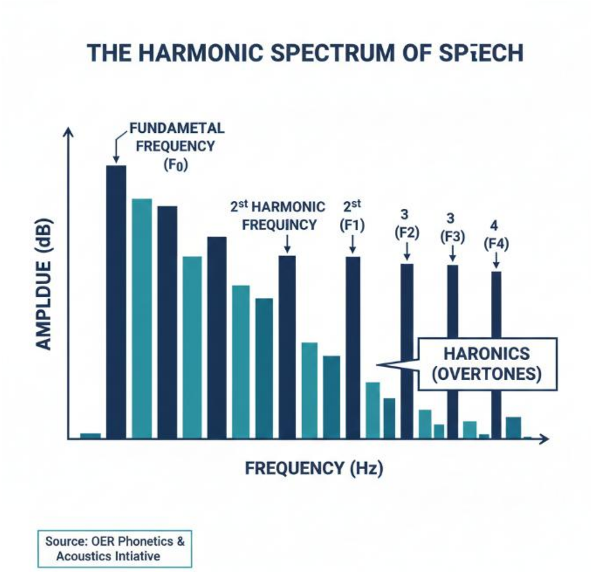

Figure 3.2: Frequency spectrum of a speech sound

3.2.2 Pitch tracking and contour analysis

Pitch tracking refers to the process of following changes in pitch over time. In speech, pitch varies due to intonation, stress, and emotional expression. A **pitch contour** is a visual representation of these changes, showing how pitch rises and falls across an utterance.

Pitch contours are important for analysing prosody, which includes rhythm, stress, and intonation patterns. They help linguists study how meaning is conveyed through pitch variation, and they are also used in applied contexts such as language teaching, where learners can see how pitch affects communication.

Fill in the blank: A visual representation of pitch changes over time is called a ______.

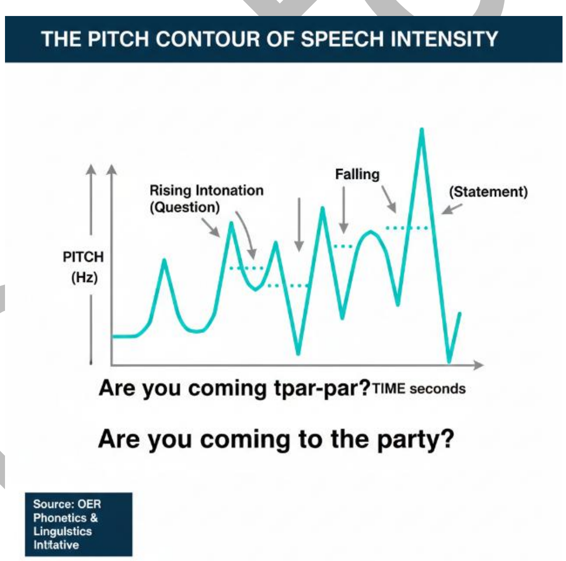

Plate 3.1: Pitch contour analysis in speech

This Part has introduced you to **frequency spectra** and **pitch contours**, showing how they provide insight into the distribution of energy in speech and the variation of pitch over time.

Pilot questions 3.2

1. What does the horizontal axis of a frequency spectrum represent?
2. What does the vertical axis of a frequency spectrum represent?
3. Which speech sounds are particularly studied using frequency spectra?
4. What is pitch tracking used for in speech analysis?
5. How does a pitch contour help in studying prosody?

3.3 Spectrograms As Acoustic Displays

3.3.1 Reading and interpreting spectrograms

A **spectrogram** is a visual representation of sound that shows how frequency and intensity change over time. The horizontal axis represents time, the vertical axis represents frequency, and the darkness or colour intensity indicates amplitude. In speech analysis, spectrograms are invaluable because they allow us to see both the fine details of speech sounds and their broader patterns.

Spectrograms make it possible to identify features such as formants, which appear as dark bands corresponding to resonant frequencies, and consonant characteristics such as bursts or frication noise. They provide a more detailed view than waveforms or frequency spectra, making them a central tool in acoustic phonetics.

Fill in the blank: A visual representation of sound that shows frequency and intensity over time is called a ______.

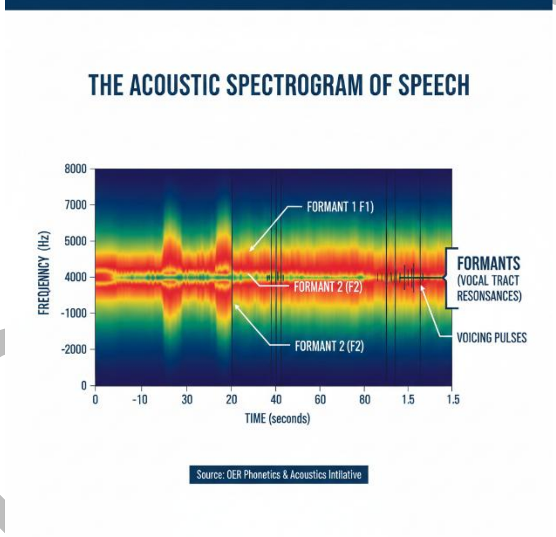

Figure 3.3: Structure of a spectrogram

3.3.2 Identifying formants and consonant features

Formants are resonant frequencies of the vocal tract that shape vowel quality. On a spectrogram, they appear as dark horizontal bands and are labelled F1, F2, F3, and so on. By measuring formants, linguists can distinguish between different vowels and study variations across speakers and dialects.

Consonant features are also visible on spectrograms. For example, plosives show up as bursts of energy following silence, fricatives appear as high-frequency noise, and nasals display characteristic formant patterns. This makes spectrograms a powerful tool for analysing both vowels and consonants in detail.

Fill in the blank: On a spectrogram, resonant frequencies of the vocal tract appear as dark horizontal bands called ______.

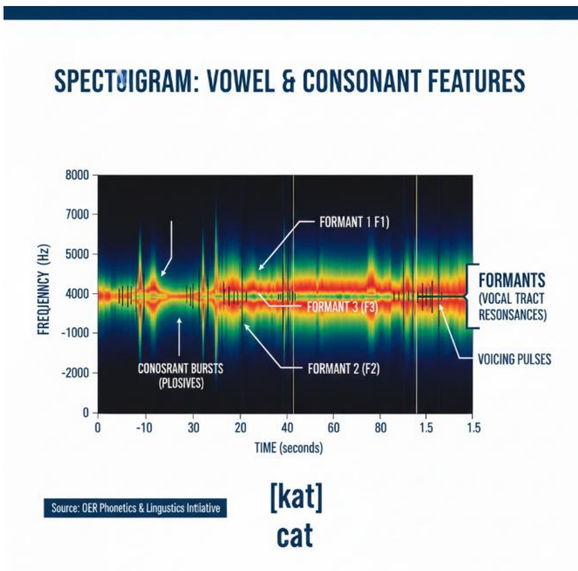

Plate 3.2: Identifying vowel and consonant features on a spectrogram

This Part has introduced you to **spectrograms**, explaining how they are read and interpreted, and showing how they reveal both vowel formants and consonant features.

Pilot questions 3.3

1. What does the horizontal axis of a spectrogram represent?
2. What does the vertical axis of a spectrogram represent?
3. How is amplitude represented on a spectrogram?
4. What do formants look like on a spectrogram?
5. Give one example of how consonant features appear on a spectrogram.

3.4 Practical Applications Of Acoustic Displays

3.4.1 Using software tools for acoustic displays

Modern **software tools** such as Praat and Wavesurfer allow learners and researchers to generate and interpret acoustic displays with ease. These tools can produce waveforms, frequency spectra, and spectrograms, giving users the ability to measure pitch, amplitude, duration, and formants. They also provide interactive features, such as zooming in on specific segments of speech or comparing multiple recordings side by side.

Such tools are invaluable in both academic and applied contexts. For example, in language teaching, learners can receive visual feedback on their pronunciation, while in research, scholars can analyse subtle differences in speech across dialects or speakers.

Fill in the blank: Software tools such as Praat and Wavesurfer can generate ______ to display formants and other acoustic features.

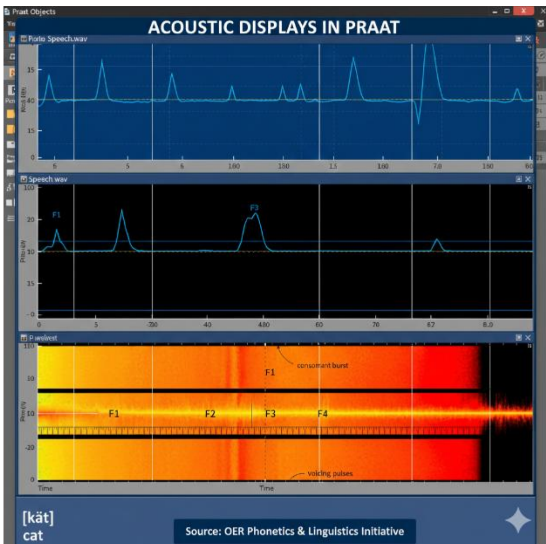

Plate 3.3: Acoustic displays generated in Praat software

3.4.2 Applied contexts in teaching, therapy, and research

Acoustic displays are not only theoretical tools but also have wide-ranging practical applications. In **language teaching**, they help learners visualise intonation patterns and improve pronunciation. In **speech therapy**, therapists use them to monitor progress and provide clients with clear visual evidence of improvement. In **research**, acoustic displays support detailed investigations into prosody, dialectal variation, and even forensic phonetics.

By bridging theory and practice, acoustic displays demonstrate how acoustic phonetics can be applied to real-world problems and solutions.

Fill in the blank: In forensic phonetics, acoustic displays can provide objective ______ of speech characteristics.

Field	Primary Display Used	Key Insight
Pedagogy	Pitch Contour	Improving sentence-level intonation.
Clinical	Spectrogram	Measuring formant precision for articulation.

Field	Primary Display Used	Key Insight
Research	Spectral Moments	Quantifying dialectal differences in fricatives.
Forensic	Waveform & Spectrogram	Detecting tampering or identifying unique vocal traits.

Box 3.2: Practical applications of acoustic displays

This Part has shown how **software tools** make acoustic displays accessible and how they are applied in **teaching, therapy, research, and forensic contexts**, connecting theory with practice.

Pilot questions 3.4

1. Name one software tool used to generate acoustic displays.
2. What visual feedback can learners gain from acoustic displays in language teaching?
3. How are acoustic displays used in speech therapy?
4. Give one example of how acoustic displays support research in phonetics.
5. What role do acoustic displays play in forensic phonetics?

Series Summary

This Series has focused on the use of **acoustic displays** to represent and analyse speech sounds visually. These displays are central to phonetics because they make it possible to see the structure of speech, turning abstract acoustic concepts into concrete forms. We began with waveform displays, examining their structure and applications in speech analysis. Then we moved on to frequency spectra and pitch contours, which reveal how energy is distributed across frequencies and how pitch varies over time. Following that, we studied spectrograms, learning how to interpret them and identify both vowel formants and consonant features. Finally, we considered practical applications, exploring how software tools generate acoustic displays and how they are used in teaching, therapy, research, and forensic contexts.

Upon completing this Series, you should now be able to describe waveform displays and their applications (SLO 3.1), interpret frequency spectra and pitch contours (SLO 3.2), analyse spectrograms to identify formants and consonant features (SLO 3.3), apply software tools to generate and interpret acoustic displays (SLO 3.4), and evaluate their practical uses in professional and academic settings (SLO 3.5). These outcomes ensure that you are equipped with both the theoretical knowledge and practical skills to connect acoustic principles with real-world applications in phonetics.

Glossary Of Terms

- **Amplitude**: The strength or intensity of a sound wave, represented on the vertical axis of a waveform or frequency spectrum.

- **Formants**: Resonant frequencies of the vocal tract that shape vowel quality, visible as dark horizontal bands on a spectrogram.
- **Frequency spectrum**: A visual display showing how much energy is present at different frequencies within a sound, with frequency on the horizontal axis and amplitude on the vertical axis.
- **Pitch contour**: A visual representation of pitch changes over time, showing how pitch rises and falls across an utterance.
- **Pitch tracking**: The process of following changes in pitch across time, often used to study intonation and prosody.
- **Spectrogram**: A visual representation of sound showing frequency and intensity over time, with time on the horizontal axis, frequency on the vertical axis, and amplitude indicated by darkness or colour.
- **Waveform**: A visual representation of a sound signal over time, showing how amplitude changes, with time on the horizontal axis and amplitude on the vertical axis.

Concept Check Questions [Series 3]

The following questions will help you consolidate your learning from **Series 3: Acoustic Displays: Waveforms, Frequency, and Spectrograms**. They are grouped by type and aligned with the Series Learning Outcomes (SLOs).

Objective questions

1. (Linked to SLO 3.1) Which axis of a waveform represents time?
2. (Linked to SLO 3.1) The vertical axis of a waveform represents ______.
3. (Linked to SLO 3.2) A visual display showing the distribution of energy across frequencies is called a ______.
4. (Linked to SLO 3.2) A visual representation of pitch changes over time is known as a ______.
5. (Linked to SLO 3.3) On a spectrogram, resonant frequencies of the vocal tract appear as dark horizontal bands called ______.

Short-answer questions

6. (Linked to SLO 3.1) Explain one way waveform analysis can be applied in speech therapy.
7. (Linked to SLO 3.2) Describe how pitch contours are useful in studying prosody.
8. (Linked to SLO 3.3) How is amplitude represented on a spectrogram?
9. (Linked to SLO 3.4) Name one software tool used to generate acoustic displays and state one of its functions.

10. (Linked to SLO 3.5) Give one example of how acoustic displays are used in forensic phonetics.

Long-answer questions

11. (Linked to SLO 3.3) Analyse how spectrograms provide more detailed information than waveforms or frequency spectra, and explain why this matters in phonetic research.

12. (Linked to SLO 3.5) Evaluate the practical applications of acoustic displays in teaching, therapy, and research, giving examples of how they bridge theory and practice.

Answers to Concept Check Questions [Series 3]

Objective questions

1. Horizontal axis
2. Amplitude
3. Frequency spectrum
4. Pitch contour
5. Formants

Short-answer questions

6. In speech therapy, waveform analysis can be used to track progress by showing changes in speech patterns over time.

7. Pitch contours help in studying prosody by showing how pitch rises and falls, revealing intonation and stress patterns that convey meaning.

8. Amplitude is represented by the darkness or colour intensity on a spectrogram.

9. Praat is one example; it can generate spectrograms and measure pitch, amplitude, and formants.

10. Acoustic displays provide objective evidence of speech characteristics, which can be used in forensic investigations.

Long-answer questions

11.

- **Basic response**: Spectrograms show frequency, amplitude, and time together, making it possible to identify formants and consonant features. This provides more detail than waveforms, which only show amplitude over time, or frequency spectra, which only show energy distribution.
- **Value-added response**: Beyond the basics, spectrograms allow researchers to study fine-grained acoustic features such as frication noise, plosive bursts, and vowel transitions. This makes them indispensable for analysing prosody, dialectal variation, and speaker identity, supporting both linguistic research and applied fields like forensic phonetics.

12.

- **Basic response**: Acoustic displays are applied in teaching to provide visual feedback on pronunciation, in therapy to monitor progress, and in research to study prosody and variation.
- **Value-added response**: In addition, they bridge theory and practice by enabling learners to connect abstract acoustic principles with real-world communication. For example, teachers can use pitch contours to demonstrate intonation patterns, therapists can use spectrograms to diagnose disorders, and researchers can apply acoustic displays to forensic cases, making them versatile tools across multiple domains.

Answers to Pilot Questions [Series 3]

Part 3.1: Waveform displays in speech analysis

1. Time
2. Amplitude
3. Vowels
4. By providing visual feedback on pronunciation and timing
5. By tracking progress and showing changes in speech patterns

Part 3.2: Frequency displays and pitch analysis

1. Frequency
2. Amplitude or intensity
3. Vowels
4. To study intonation, stress, and emotional expression
5. By showing how pitch rises and falls, revealing prosody

Part 3.3: Spectrograms as acoustic displays

1. Time
2. Frequency
3. Darkness or colour intensity
4. Dark horizontal bands labelled F1, F2, F3, etc.
5. Plosives appear as bursts, fricatives as high-frequency noise

Part 3.4: Practical applications of acoustic displays

1. Praat (or Wavesurfer)
2. Learners can see intonation patterns and pronunciation visually

3. By monitoring progress and diagnosing speech disorders
4. By studying prosody, dialectal variation, and speaker identity
5. By providing objective evidence of speech characteristics

References and Attributions [Series 3]

This section lists the references, suggested sources, and attributions for the materials used in **Series 3: Acoustic Displays: Waveforms, Frequency, and Spectrograms**. It includes citations for concepts, illustration placeholders, and open educational resources (OERs) suggested for further study.

General references

- Ladefoged, P., & Johnson, K. (2014). *A course in phonetics* (7th ed.). Boston: Cengage Learning.
- Johnson, K. (2011). *Acoustic and auditory phonetics* (3rd ed.). Malden, MA: Wiley-Blackwell.
- Ashby, M., & Maidment, J. (2005). *Introducing phonetic science*. Cambridge: Cambridge University Press.

Illustration references and attributions

- *Figure 3.1: Structure of a speech waveform*
  - AI prompt suggestion: "Generate a diagram of a speech waveform with labelled time and amplitude axes."
  - Search string: "OER diagram speech waveform phonetics"
- *Box 3.1: Selected applications of waveform analysis*
  - AI prompt suggestion: "Create a text box listing applications of waveform analysis in teaching, therapy, and forensic phonetics."
  - Search string: "OER applications waveform analysis phonetics"
- *Figure 3.2: Frequency spectrum of a speech sound*
  - AI prompt suggestion: "Generate a diagram of a frequency spectrum showing fundamental frequency and harmonics with labelled axes."
  - Search string: "OER frequency spectrum speech phonetics"
- *Plate 3.1: Pitch contour analysis in speech*
  - AI prompt suggestion: "Generate an image showing a pitch contour line rising and falling across a sentence with labelled axes."
  - Search string: "OER pitch contour intonation speech phonetics"
- *Figure 3.3: Structure of a spectrogram*

        - AI prompt suggestion: "Generate a diagram of a spectrogram with labelled time, frequency axes, and formant bands."
        - Search string: "OER spectrogram diagram phonetics"
- *Plate 3.2: Identifying vowel and consonant features on a spectrogram*
    - AI prompt suggestion: "Generate a spectrogram image showing vowel formants and consonant bursts with labels."
    - Search string: "OER spectrogram vowel consonant features phonetics"
- *Plate 3.3: Acoustic displays generated in Praat software*
    - AI prompt suggestion: "Generate a screenshot-style image of Praat software showing waveform, pitch contour, and spectrogram."
    - Search string: "OER Praat acoustic displays phonetics"
- *Box 3.2: Practical applications of acoustic displays*
    - AI prompt suggestion: "Create a text box listing practical applications of acoustic displays in teaching, therapy, research, and forensic phonetics."
    - Search string: "OER applications acoustic displays phonetics"

Course code: LIN 403
Course title: Acoustic Phonetics
Course credit load: 3 Units

Series 1: Foundations of Acoustic Principles in Speech

Series 2: Properties and Analysis of Speech Sound Waves

Series 3: Acoustic Displays: Waveforms, Frequency, and Spectrograms

Series 4: Applications of Acoustic Phonetics in Fieldwork

Series 5: Interrelationships of Acoustic, Articulatory, and Perceptual Correlates

Proposed Outline for Series 4

Part 4.1: Preparing for fieldwork in acoustic phonetics

- Sub-Part 4.1.1: Planning and selecting recording equipment
- Sub-Part 4.1.2: Ethical considerations and participant consent

Part 4.2: Collecting speech data in the field

- Sub-Part 4.2.1: Recording techniques and managing background noise
- Sub-Part 4.2.2: Practical challenges in diverse field settings

Part 4.3: Analysing field recordings

- Sub-Part 4.3.1: Using acoustic displays to interpret field data
- Sub-Part 4.3.2: Identifying vowels, consonants, and prosodic features

Part 4.4: Applying findings to linguistic research

- Sub-Part 4.4.1: Documenting endangered languages
- Sub-Part 4.4.2: Comparing dialects and sociophonetic variation

Introduction

In the last Series, we explored acoustic displays such as waveforms, frequency spectra, and spectrograms, learning how they provide visual insights into the structure of speech. This Series takes us a step further by focusing on how acoustic phonetics can be applied in real-world fieldwork. Fieldwork is a vital part of linguistic research, especially when documenting languages, studying dialects, or working with communities where speech data must be collected and analysed directly.

The aim of this Series is to equip you with the knowledge and skills needed to prepare for, collect, and analyse speech data in fieldwork settings, and to show how acoustic phonetics contributes to broader linguistic research and practical applications.

We shall commence this Series by examining how to prepare for fieldwork, including planning, equipment selection, and ethical considerations. Next, we will move on to collecting speech data, focusing on recording techniques and managing challenges in diverse environments. Following that, we will study how to analyse field recordings using acoustic displays to identify vowels, consonants, and prosodic features. Finally, we will wrap up by applying these findings to linguistic research, considering how acoustic phonetics supports language documentation, dialect comparison, and sociophonetic studies.

Series Learning Outcomes

Upon completing **Series 4: Applications of Acoustic Phonetics in Fieldwork**, you should be able to:

- **SLO 4.1** define the essential planning steps required before conducting acoustic phonetics fieldwork,
- **SLO 4.2** explain how to select appropriate recording equipment for different fieldwork contexts,
- **SLO 4.3** demonstrate awareness of ethical considerations in fieldwork, including participant consent,

- **SLO 4.4** apply effective recording techniques to collect speech data while managing background noise,
- **SLO 4.5** analyse practical challenges encountered in diverse field settings and propose solutions,
- **SLO 4.6** interpret field recordings using acoustic displays to identify vowels, consonants, and prosodic features,
- **SLO 4.7** evaluate the role of acoustic phonetics in documenting endangered languages,
- **SLO 4.8** compare dialects and sociophonetic variation using fieldwork data.

4.1 Preparing For Fieldwork In Acoustic Phonetics

4.1.1 Planning and selecting recording equipment

Before embarking on fieldwork, careful **planning** is essential. Planning refers to the process of organising resources, identifying objectives, and anticipating challenges. In acoustic phonetics, this involves deciding what type of speech data to collect, choosing suitable locations, and ensuring that equipment is available and functional.

A key part of preparation is selecting appropriate **recording equipment**, which refers to the devices used to capture speech sounds. Common tools include portable digital recorders, high-quality microphones, and headphones for monitoring. The choice of equipment depends on the environment: quiet indoor settings may require basic recorders, while noisy outdoor contexts demand more advanced microphones with noise-reduction features.

Fill in the blank: The devices used to capture speech sounds during fieldwork are called ______.

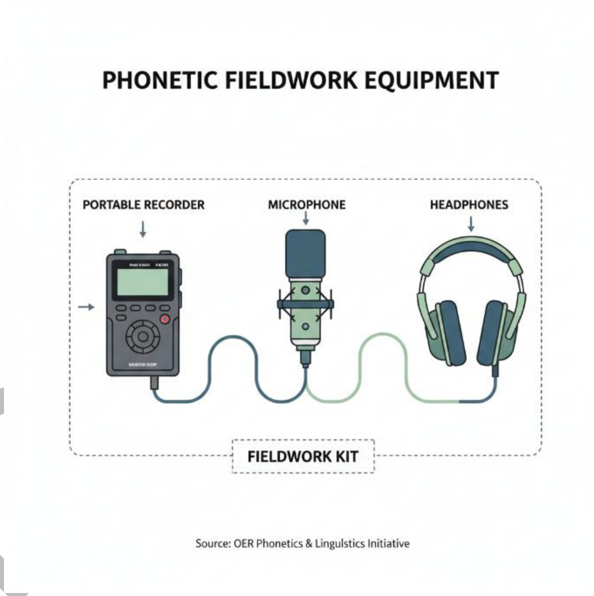

Figure 4.1: Basic recording equipment for acoustic phonetics fieldwork

4.1.2 Ethical considerations and participant consent

Fieldwork in acoustic phonetics also requires attention to **ethical considerations**, which are principles guiding responsible research. These include respecting participants' privacy, ensuring voluntary participation, and avoiding harm. Researchers must be transparent about the purpose of the study and how recordings will be used.

An important aspect of ethics is **participant consent**, which means obtaining clear permission from individuals before recording their speech. Consent should be informed, meaning participants understand the goals of the research, the procedures involved, and their right to withdraw at any time. Written consent forms are often used, but verbal consent may be acceptable in certain cultural contexts.

Fill in the blank: Obtaining clear permission from individuals before recording their speech is known as ______.

Step	Action	Why it matters
Pre-Recording	Institutional Review Board (IRB) approval.	Ensures the study design meets legal and ethical safety standards.
During Recording	Regular "check-ins" with the participant.	Confirms they are still comfortable as the session progresses.
Post-Recording	Secure data storage and encryption.	Prevents unauthorized access to sensitive vocal data.

Box 4.1: Key ethical principles in acoustic phonetics fieldwork

This Part has introduced you to the importance of **planning and equipment selection** as well as **ethical considerations and participant consent**, laying the foundation for responsible and effective fieldwork in acoustic phonetics.

Pilot questions 4.1

1. What is the purpose of planning before conducting fieldwork in acoustic phonetics?
2. Name two examples of recording equipment commonly used in fieldwork.
3. Why might different environments require different types of recording equipment?
4. What are ethical considerations in fieldwork?
5. What is participant consent, and why is it important?

4.2 Collecting Speech Data In The Field

4.2.1 Recording techniques and managing background noise

Effective fieldwork requires careful attention to **recording techniques**, which are methods used to capture clear and reliable speech data. This includes positioning the microphone at an appropriate distance from the speaker, monitoring sound levels during recording, and ensuring that the environment is suitable for speech capture.

One of the biggest challenges in fieldwork is **background noise**, which refers to unwanted sounds that interfere with speech recordings. Common sources include traffic, wind, or conversations nearby. To manage background noise, researchers may use directional microphones, windshields, or select quieter locations. In some cases, repeated recordings may be necessary to ensure accuracy.

Fill in the blank: Unwanted sounds that interfere with speech recordings are called ______.

Figure 4.2: Recording speech data and managing background noise

4.2.2 Practical challenges in diverse field settings

Fieldwork often takes place in diverse environments, ranging from quiet villages to bustling urban centres. Each setting presents unique **practical challenges**, which are difficulties that affect the process of collecting speech data. For example, rural areas may lack electricity for charging equipment, while urban areas may have constant noise. Cultural factors can also play a role, such as participants feeling uncomfortable with recording devices.

Researchers must be adaptable, finding creative solutions to overcome these challenges. This might include carrying backup batteries, using portable shelters to reduce noise, or building trust with communities to encourage participation.

Fill in the blank: Difficulties that affect the process of collecting speech data in different environments are called ______.

Challenge	Quick Fix	Long-term Solution
Wind/Ambient Noise	Use a directional (cardioid) mic.	Record during "low-traffic" hours (e.g., dawn).
Power Loss	Carry 3x the batteries you think you need.	Invest in a ruggedized solar array.

Challenge	Quick Fix	Long-term Solution
Room Echo	Hang blankets around the speaker.	Use a portable "vocal shield" or "reflection filter."

Box 4.2: Common challenges in fieldwork settings

This Part has introduced you to **recording techniques** and strategies for managing **background noise**, as well as the **practical challenges** encountered in diverse fieldwork settings.

Pilot questions 4.2

1. What are recording techniques in fieldwork?
2. Give one example of background noise that can affect speech recordings.
3. Name one tool or method used to reduce background noise.
4. What are practical challenges in fieldwork?
5. Give one example of a cultural challenge that may arise during speech data collection.

4.3 Analysing Field Recordings

4.3.1 Using acoustic displays to interpret field data

Once speech data has been collected, the next step is to analyse it using **acoustic displays**, which are visual representations of sound signals. These include waveforms, frequency spectra, pitch contours, and spectrograms. Each display provides different insights: waveforms show timing and amplitude, frequency spectra reveal energy distribution, pitch contours illustrate intonation, and spectrograms combine time, frequency, and amplitude for detailed analysis.

By applying these displays to field recordings, researchers can identify speech patterns, measure sound properties, and compare features across speakers or contexts. This process transforms raw recordings into meaningful data that can be studied systematically.

Fill in the blank: Visual representations of sound signals used in analysis are called ______.

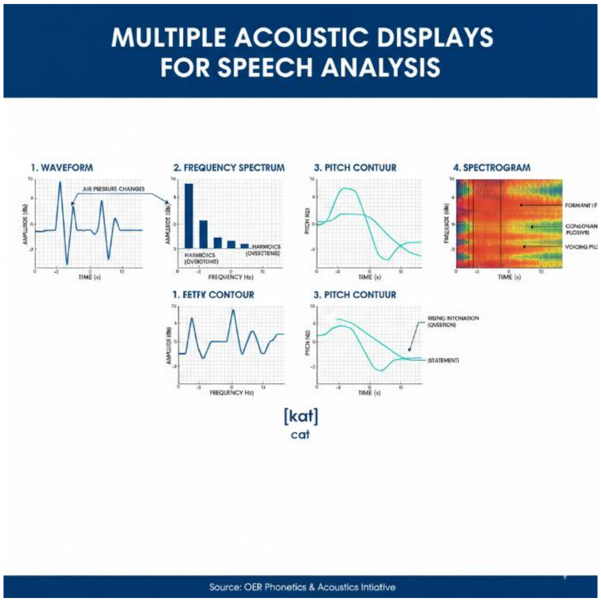

Figure 4.3: Acoustic displays used in fieldwork analysis

4.3.2 Identifying vowels, consonants, and prosodic features

Field recordings often contain a wide range of speech sounds, and acoustic analysis helps to distinguish them. **Vowels** are identified by their formants, which appear as dark horizontal bands on spectrograms. **Consonants** can be recognised by features such as bursts (plosives), frication noise (fricatives), or nasal formant patterns.

Beyond individual sounds, researchers also study **prosodic features**, which refer to rhythm, stress, and intonation in speech. These are visible in pitch contours and waveforms, showing how speakers use pitch and timing to convey meaning. Analysing these features is crucial for understanding language variation and communication styles in different communities.

Fill in the blank: Rhythm, stress, and intonation in speech are collectively referred to as ______.

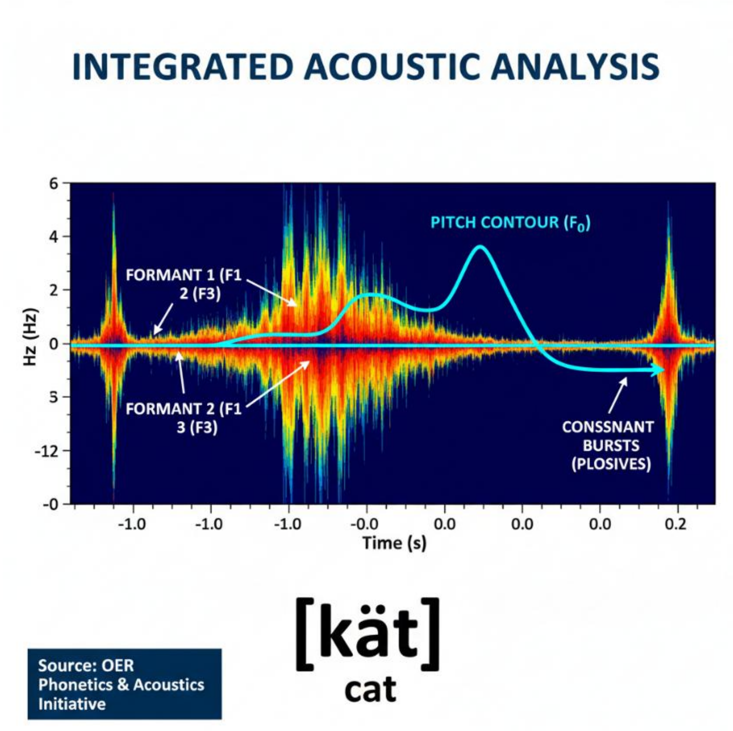

Plate 4.1: Identifying vowels, consonants, and prosodic features in field recordings

This Part has introduced you to the use of **acoustic displays** in interpreting field data and the identification of **vowels, consonants, and prosodic features**, showing how raw recordings can be transformed into structured linguistic evidence.

Pilot questions 4.3

1. Name two types of acoustic displays used in fieldwork analysis.
2. What do formants represent in vowel analysis?
3. How are plosives typically visible on a spectrogram?
4. What are prosodic features in speech?
5. Which acoustic display is most useful for studying intonation patterns?

4.4 Applying Findings To Linguistic Research

4.4.1 Documenting endangered languages

One of the most significant applications of acoustic phonetics in fieldwork is **language documentation**, which refers to the systematic recording and analysis of languages, especially those at risk of extinction. Acoustic analysis provides objective evidence of how sounds are produced and used, preserving details that might otherwise be lost. By capturing vowel formants, consonant features, and prosodic patterns, researchers create a permanent record that can support revitalisation efforts and future linguistic study.

This process is particularly important for endangered languages, where every recording contributes to safeguarding cultural heritage. Acoustic phonetics ensures that the documentation is not only descriptive but also scientifically rigorous.

Fill in the blank: The systematic recording and analysis of languages, especially those at risk of extinction, is called ______.

Plate 4.2: Documenting endangered languages through fieldwork

4.4.2 Comparing dialects and sociophonetic variation

Another important application is the study of **dialects**, which are regional or social varieties of a language, and **sociophonetic variation**, which refers to differences in speech sounds influenced by social factors such as age, gender, or community identity. Acoustic phonetics allows researchers to measure these variations precisely, comparing vowel formants, consonant timing, and prosodic features across groups.

Such comparisons help linguists understand how languages evolve and how social identity is expressed through speech. They also provide valuable insights into language change, contact, and diversity.

Fill in the blank: Differences in speech sounds influenced by social factors such as age or community identity are called ______.

Focus Area	Key Tool	Research Outcome
Documentation	Spectrogram & Waveform	Precise phonemic inventory and grammar description.
Dialectology	Vowel Plotting ($F1/F2$ charts)	Mapping "isoglosses" or boundaries between dialects.

Focus Area	Key Tool	Research Outcome
Sociophonetics	Statistical Modeling (R/Praat)	Correlating acoustic shifts with social variables.
Diachronic Change	Longitudinal Databases	Tracking sound shifts over decades or centuries.

Box 4.3: Applications of acoustic phonetics in linguistic research

This Part has shown how acoustic phonetics contributes to **documenting endangered languages** and **comparing dialects and sociophonetic variation**, demonstrating its value in preserving linguistic diversity and understanding language change.

Pilot questions 4.4

1. What is language documentation?
2. Why is acoustic phonetics important in documenting endangered languages?
3. What are dialects?
4. What is sociophonetic variation?
5. How does acoustic phonetics help in studying language change?

Series Summary

This Series has focused on the **applications of acoustic phonetics in fieldwork**, showing how theoretical tools can be used in real-world contexts to collect, analyse, and apply speech data. We began by preparing for fieldwork, considering planning, equipment selection, and ethical responsibilities. Then we explored techniques for collecting speech data, including strategies for managing background noise and overcoming practical challenges in diverse environments. Following that, we examined how to analyse field recordings using acoustic displays to identify vowels, consonants, and prosodic features. Finally, we applied these findings to linguistic research, highlighting their importance in documenting endangered languages and comparing dialects and sociophonetic variation.

By completing this Series, you should now be able to define planning steps and equipment needs (SLO 4.1, SLO 4.2), explain ethical considerations and participant consent (SLO 4.3), apply effective recording techniques and manage challenges (SLO 4.4, SLO 4.5), interpret field recordings using acoustic displays (SLO 4.6), and evaluate the role of acoustic phonetics in language documentation and sociophonetic research (SLO 4.7, SLO 4.8). These outcomes ensure that you are equipped to connect acoustic phonetics with practical fieldwork, bridging theory and application in meaningful ways.

Glossary Of Terms

- **Acoustic displays**: Visual representations of sound signals, such as waveforms, frequency spectra, pitch contours, and spectrograms, used to analyse speech data.

- **Background noise**: Unwanted sounds that interfere with speech recordings, such as traffic, wind, or nearby conversations.
- **Dialect**: A regional or social variety of a language, distinguished by differences in pronunciation, vocabulary, and grammar.
- **Ethical considerations**: Principles guiding responsible research, including respect for privacy, voluntary participation, and avoidance of harm.
- **Language documentation**: The systematic recording and analysis of languages, especially those at risk of extinction, to preserve linguistic and cultural heritage.
- **Participant consent**: Clear permission obtained from individuals before recording their speech, ensuring they understand the purpose and procedures of the research.
- **Planning**: The process of organising resources, identifying objectives, and anticipating challenges before conducting fieldwork.
- **Practical challenges**: Difficulties encountered during fieldwork, such as lack of electricity, constant noise, cultural discomfort, or adverse weather conditions.
- **Prosodic features**: Rhythm, stress, and intonation in speech, which convey meaning beyond individual sounds.
- **Recording equipment**: Devices used to capture speech sounds during fieldwork, including portable recorders, microphones, and headphones.
- **Recording techniques**: Methods used to capture clear and reliable speech data, such as microphone positioning and monitoring sound levels.
- **Sociophonetic variation**: Differences in speech sounds influenced by social factors such as age, gender, or community identity.

Concept Check Questions [Series 4]

The following questions will help you consolidate your learning from **Series 4: Applications of Acoustic Phonetics in Fieldwork**. They are grouped by type and aligned with the Series Learning Outcomes (SLOs).

Objective questions

1. (Linked to SLO 4.1) Which term refers to the process of organising resources and anticipating challenges before conducting fieldwork?
2. (Linked to SLO 4.2) Portable recorders, microphones, and headphones are examples of ______.
3. (Linked to SLO 4.3) Obtaining clear permission from participants before recording their speech is called ______.
4. (Linked to SLO 4.4) What term describes unwanted sounds that interfere with speech recordings?

5. (Linked to SLO 4.6) Dark horizontal bands on a spectrogram that represent vowel qualities are called ______.

Short-answer questions

6. (Linked to SLO 4.2) Explain why different environments may require different types of recording equipment.
7. (Linked to SLO 4.3) Describe one ethical principle that must be followed during fieldwork.
8. (Linked to SLO 4.5) Give one example of a practical challenge that may occur in diverse field settings.
9. (Linked to SLO 4.6) How can acoustic displays help in identifying prosodic features?
10. (Linked to SLO 4.8) What is sociophonetic variation, and why is it important in linguistic research?

Long-answer questions

11. (Linked to SLO 4.6) Analyse how acoustic displays transform raw field recordings into structured linguistic evidence, and explain why this matters in phonetic research.
12. (Linked to SLO 4.7 & 4.8) Evaluate the role of acoustic phonetics in documenting endangered languages and comparing dialects, giving examples of how these applications contribute to linguistic diversity.

Answers to Concept Check Questions [Series 4]

Objective questions

1. Planning
2. Recording equipment
3. Participant consent
4. Background noise
5. Formants

Short-answer questions

6. Environments differ in noise levels and conditions; for example, outdoor settings may require directional microphones, while quiet indoor settings may only need basic recorders.
7. Respecting participants' privacy is one ethical principle, ensuring that recordings are not misused.
8. A lack of electricity for charging equipment is one practical challenge.
9. Acoustic displays such as pitch contours show rhythm, stress, and intonation, helping to identify prosodic features.
10. Sociophonetic variation refers to differences in speech sounds influenced by social factors such as age or community identity, and it is important for understanding language diversity and change.

Long-answer questions

11.

- **Basic response**: Acoustic displays such as waveforms, spectra, and spectrograms allow researchers to visualise and measure speech features, turning raw recordings into structured data. This makes it possible to identify vowels, consonants, and prosody systematically.
- **Value-added response**: Beyond the basics, acoustic displays enable detailed analysis of fine-grained features like frication noise, plosive bursts, and vowel transitions. This supports advanced research in prosody, dialectal variation, and speaker identity, making them indispensable in both linguistic and applied contexts such as forensic phonetics.

12.

- **Basic response**: Acoustic phonetics helps document endangered languages by preserving sound features scientifically, and it allows comparison of dialects by measuring differences in vowels, consonants, and prosody.
- **Value-added response**: In addition, these applications safeguard cultural heritage and provide insights into language change and diversity. For example, documenting endangered languages ensures future generations can study them, while sociophonetic analysis reveals how social identity is expressed through speech, enriching our understanding of human communication.

Answers to Pilot Questions [Series 4]

Part 4.1: Preparing for fieldwork in acoustic phonetics

1. To organise resources, identify objectives, and anticipate challenges.
2. Portable recorders and microphones.
3. Because noise levels and conditions vary, requiring different equipment types.
4. Principles guiding responsible research such as privacy and voluntary participation.
5. Participant consent, which ensures individuals give clear permission before recording.

Part 4.2: Collecting speech data in the field

1. Methods used to capture clear and reliable speech data.
2. Traffic noise.
3. Directional microphones.
4. Difficulties that affect the process of collecting speech data.
5. Cultural discomfort with recording devices.

Part 4.3: Analysing field recordings

1. Waveforms and spectrograms.
2. Resonant frequencies that shape vowel quality.
3. As bursts visible on the spectrogram.
4. Rhythm, stress, and intonation.
5. Pitch contour.

Part 4.4: Applying findings to linguistic research

1. The systematic recording and analysis of languages.
2. It preserves sound features scientifically and supports revitalisation.
3. Regional or social varieties of a language.
4. Differences in speech sounds influenced by social factors.
5. By measuring and comparing sound features to reveal change and diversity.

References and Attributions [Series 4]

This section lists the references, suggested sources, and attributions for the materials used in **Series 4: Applications of Acoustic Phonetics in Fieldwork**. It includes citations for concepts, illustration placeholders, and open educational resources (OERs) suggested for further study.

General references

- Ladefoged, P., & Johnson, K. (2014). *A course in phonetics* (7th ed.). Boston: Cengage Learning.
- Johnson, K. (2011). *Acoustic and auditory phonetics* (3rd ed.). Malden, MA: Wiley-Blackwell.
- Ashby, M., & Maidment, J. (2005). *Introducing phonetic science*. Cambridge: Cambridge University Press.
- Nathan, G. S. (2008). *Phonology: A cognitive grammar introduction*. Amsterdam: John Benjamins.

Illustration references and attributions

- *Figure 4.1: Basic recording equipment for acoustic phonetics fieldwork*
    - AI prompt suggestion: "Generate a diagram showing a portable recorder, microphone, and headphones labelled as fieldwork equipment."
    - Search string: "OER diagram recording equipment phonetics fieldwork"
- *Box 4.1: Key ethical principles in acoustic phonetics fieldwork*
    - AI prompt suggestion: "Create a text box listing ethical principles for acoustic phonetics fieldwork."

- Search string: “OER ethics participant consent linguistics fieldwork”

- *Figure 4.2: Recording speech data and managing background noise*
  - AI prompt suggestion: “Generate a diagram of a fieldwork recording setup with speaker, microphone, and background noise sources labelled.”
  - Search string: “OER diagram speech recording fieldwork phonetics”
- *Box 4.2: Common challenges in fieldwork settings*
  - AI prompt suggestion: “Create a text box listing common challenges in diverse fieldwork settings for speech data collection.”
  - Search string: “OER challenges fieldwork linguistics phonetics”
- *Figure 4.3: Acoustic displays used in fieldwork analysis*
  - AI prompt suggestion: “Generate a diagram showing waveform, frequency spectrum, pitch contour, and spectrogram side by side with labels.”
  - Search string: “OER acoustic displays phonetics analysis”
- *Plate 4.1: Identifying vowels, consonants, and prosodic features in field recordings*
  - AI prompt suggestion: “Generate an image of a spectrogram with vowel formants, consonant bursts, and a pitch contour overlay labelled.”
  - Search string: “OER spectrogram vowels consonants prosody phonetics”
- *Plate 4.2: Documenting endangered languages through fieldwork*
  - AI prompt suggestion: “Generate an image of a researcher recording a speaker of an endangered language using a microphone and recorder.”
  - Search string: “OER language documentation endangered languages fieldwork phonetics”
- *Box 4.3: Applications of acoustic phonetics in linguistic research*
  - AI prompt suggestion: “Create a text box listing applications of acoustic phonetics in linguistic research, including documentation and dialect comparison.”
  - Search string: “OER sociophonetics dialect variation acoustic phonetics”

Course code: LIN 403
Course title: Acoustic Phonetics
Course credit load: 3 Units

Series 1: Foundations of Acoustic Principles in Speech

Series 2: Properties and Analysis of Speech Sound Waves

Series 3: Acoustic Displays: Waveforms, Frequency, and Spectrograms

Series 4: Applications of Acoustic Phonetics in Fieldwork

Series 5: Interrelationships of Acoustic, Articulatory, and Perceptual Correlates

Proposed Outline for Series 5

Part 5.1: Acoustic correlates of speech sounds

- Sub-Part 5.1.1: Measuring frequency, amplitude, and duration
- Sub-Part 5.1.2: Acoustic features of vowels and consonants

Part 5.2: Articulatory correlates of speech sounds

- Sub-Part 5.2.1: Tongue, lips, and vocal tract movements
- Sub-Part 5.2.2: Linking articulation to acoustic output

Part 5.3: Perceptual correlates of speech sounds

- Sub-Part 5.3.1: Auditory processing of vowels and consonants
- Sub-Part 5.3.2: Perception of prosody and intonation

Part 5.4: Integrating acoustic, articulatory, and perceptual perspectives

- Sub-Part 5.4.1: Case studies in speech analysis
- Sub-Part 5.4.2: Applications in teaching, therapy, and research

Series Learning Outcomes

Upon completing **Series 5: Interrelationships of Acoustic, Articulatory, and Perceptual Correlates**, you should be able to:

- **SLO 5.1** define the main acoustic correlates of speech sounds, including frequency, amplitude, and duration,
- **SLO 5.2** explain how vowels and consonants are represented acoustically,
- **SLO 5.3** describe articulatory correlates of speech sounds, focusing on tongue, lips, and vocal tract movements,
- **SLO 5.4** analyse how articulatory processes link to acoustic output,
- **SLO 5.5** demonstrate how listeners perceive vowels and consonants through auditory processing,
- **SLO 5.6** interpret prosodic features such as rhythm, stress, and intonation from a perceptual perspective,
- **SLO 5.7** evaluate case studies that integrate acoustic, articulatory, and perceptual perspectives, and

- **SLO 5.8** apply these interrelationships to practical contexts in teaching, therapy, and research.

5.1 Acoustic Correlates Of Speech Sounds

5.1.1 Measuring frequency, amplitude, and duration

Speech sounds can be described in terms of their **acoustic correlates**, which are measurable properties of sound signals. The three most important correlates are **frequency**, **amplitude**, and **duration**.

- **Frequency** refers to the number of vibrations per second, measured in Hertz (Hz). It determines the pitch of a sound.
- **Amplitude** refers to the strength or intensity of the sound wave, often perceived as loudness.
- **Duration** refers to the length of time a sound lasts, measured in milliseconds or seconds.

These correlates are essential because they allow researchers to quantify speech sounds and compare them across speakers, contexts, and languages.

Fill in the blank: The number of vibrations per second that determines the pitch of a sound is called ______.

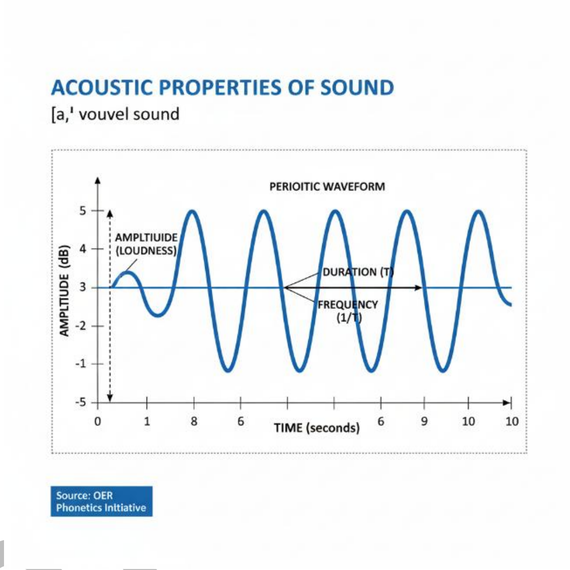

Figure 5.1: Acoustic correlates of speech sounds

5.1.2 Acoustic features of vowels and consonants

Different classes of speech sounds have distinct acoustic features. **Vowels** are characterised by **formants**, which are resonant frequencies of the vocal tract. These appear as dark horizontal bands on a spectrogram and are crucial for distinguishing vowel qualities.

Consonants, on the other hand, are identified by features such as bursts (plosives), frication noise (fricatives), and nasal formant patterns. For example, plosives show a sudden spike in energy, while fricatives display continuous high-frequency noise.

By analysing these acoustic features, phoneticians can classify sounds and understand how they function in communication.

Fill in the blank: Resonant frequencies of the vocal tract that distinguish vowel qualities are called ______.

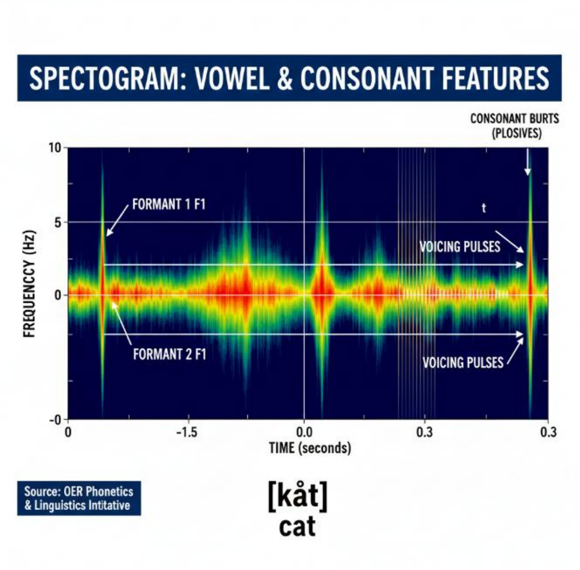

Plate 5.1: Acoustic features of vowels and consonants

This Part has introduced you to the measurable **acoustic correlates** of speech sounds and the distinctive **acoustic features** of vowels and consonants, laying the foundation for linking acoustic properties with articulatory and perceptual perspectives in later Parts.

Pilot questions 5.1

1. What are the three main acoustic correlates of speech sounds?
2. Which acoustic correlate determines the pitch of a sound?
3. What do formants represent in vowel analysis?
4. How are plosives typically visible on a spectrogram?
5. Why are acoustic correlates important in phonetic research?

5.2 Articulatory Correlates Of Speech Sounds

5.2.1 Tongue, lips, and vocal tract movements

Speech sounds are shaped by **articulatory correlates**, which are the physical movements of the tongue, lips, and other parts of the vocal tract during speech production. The **tongue** plays a central role in vowel production, with its height and position (front, central, or back) determining vowel quality. The **lips** contribute by rounding or spreading, which alters resonance. The **vocal tract**, including the oral and nasal cavities, modifies airflow to produce different consonant types.

These movements are crucial because they directly influence the acoustic output of speech. For example, raising the tongue produces high vowels, while lowering it produces low vowels. Similarly, lip rounding lowers certain formant frequencies, changing the acoustic profile of vowels.

Fill in the blank: The physical movements of the tongue, lips, and vocal tract during speech production are called ______.

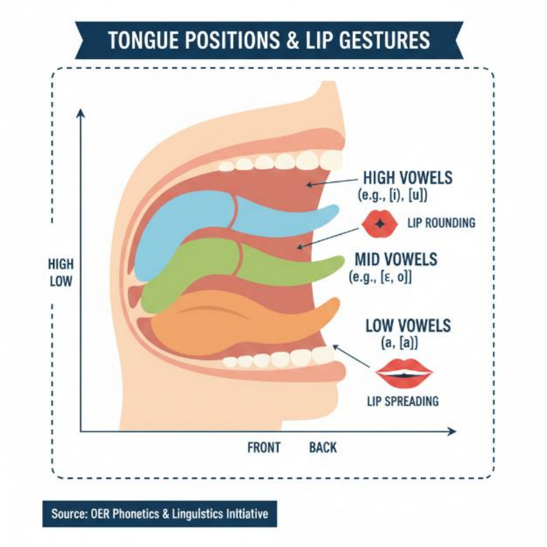

Figure 5.2: Articulatory correlates of vowel production

5.2.2 Linking articulation to acoustic output

Articulatory movements are not isolated; they are directly linked to the **acoustic output** of speech. For instance, the tongue's position changes the resonant frequencies of the vocal tract, producing distinct vowel formants. Consonant articulation, such as closure for plosives or constriction for fricatives, creates characteristic acoustic patterns like bursts or noise bands.

This relationship between articulation and acoustics allows phoneticians to predict how a sound will appear on a spectrogram based on how it is produced. It also helps in teaching pronunciation, designing speech therapy exercises, and conducting linguistic research.

Fill in the blank: The relationship between physical movements of the vocal tract and the resulting sound patterns is known as ______.

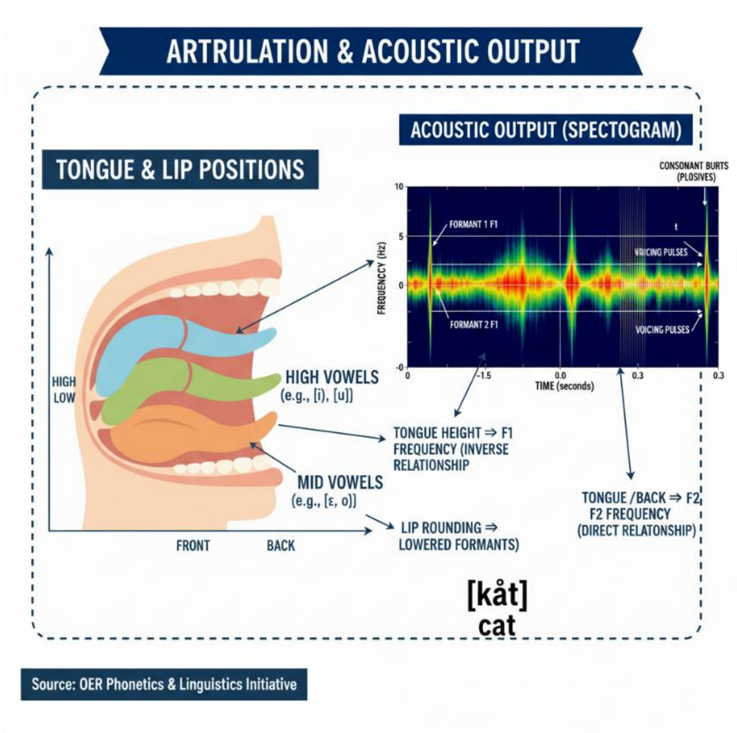

Plate 5.2: Linking articulation to acoustic output

This Part has introduced you to the **articulatory correlates** of speech sounds and explained how they are linked to **acoustic output**, reinforcing the connection between physical movements and measurable sound properties.

Pilot questions 5.2

1. What are articulatory correlates in speech production?
2. How does tongue height affect vowel quality?
3. What effect does lip rounding have on vowel acoustics?
4. How do plosives and fricatives differ in their acoustic output?
5. Why is the link between articulation and acoustics important in phonetic research?

5.3 Perceptual Correlates Of Speech Sounds

5.3.1 Auditory processing of vowels and consonants

Speech perception involves **auditory processing**, which refers to how the ear and brain work together to interpret sound signals. When vowels are heard, listeners rely on the recognition of **formants**, the resonant frequencies that distinguish vowel qualities. Consonants are perceived through cues such as bursts, frication noise, and timing differences.

Listeners do not simply hear raw acoustic signals; they interpret them based on patterns learned from their language environment. This explains why speakers of different languages may perceive the same sound differently.

Fill in the blank: The process by which the ear and brain interpret sound signals is called ______.

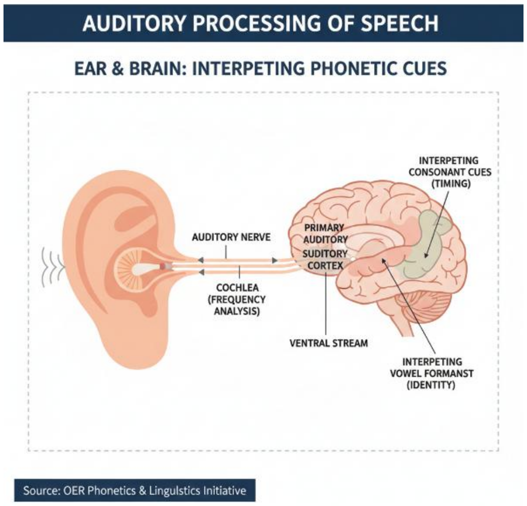

Figure 5.3: Auditory processing of vowels and consonants

5.3.2 Perception of prosody and intonation

Beyond individual sounds, listeners also perceive **prosody**, which refers to rhythm, stress, and intonation in speech. These features help convey meaning, emotion, and emphasis. For example, rising intonation may signal a question, while stress patterns can distinguish words such as *record* (noun) and *record* (verb).

The perception of prosody is crucial for effective communication, as it allows listeners to interpret not only what is said but also how it is said. Acoustic cues such as pitch contours and timing are processed by the auditory system to give speech its expressive qualities.

Fill in the blank: Rhythm, stress, and intonation in speech are collectively referred to as ______.

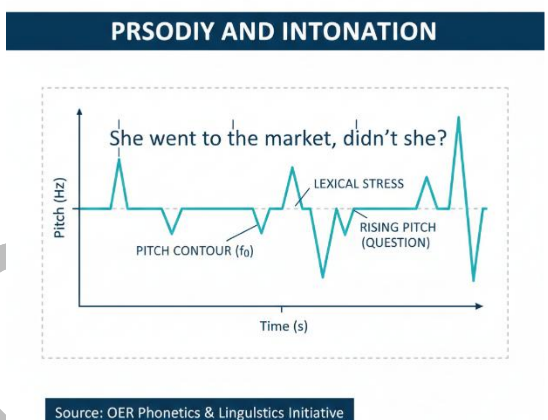

Plate 5.3: Perception of prosody and intonation

This Part has introduced you to the **auditory processing** of vowels and consonants and the perception of **prosody and intonation**, highlighting how listeners interpret both segmental and suprasegmental features of speech.

Pilot questions 5.3

1. What is auditory processing in speech perception?
2. Which acoustic cues help listeners perceive vowels?
3. How are consonants perceived differently from vowels?
4. What is prosody in speech?
5. Why is the perception of intonation important in communication?

5.4 Integrating Acoustic, Articulatory, And Perceptual Perspectives

5.4.1 Case studies in speech analysis

The study of speech becomes most meaningful when **acoustic**, **articulatory**, and **perceptual correlates** are considered together. A **case study** in speech analysis refers to a detailed examination of how these three perspectives interact in real examples. For instance, analysing a plosive sound involves observing the articulatory closure of the vocal tract, measuring the acoustic burst on a spectrogram, and noting how listeners perceive the sharp onset of the sound.

By combining these perspectives, researchers gain a holistic understanding of speech. This integration also highlights how small changes in articulation can alter acoustic properties and, in turn, affect perception.

Fill in the blank: A detailed examination of how acoustic, articulatory, and perceptual correlates interact in real examples is called a ______.

Perspective	Domain	Key Indicator
Articulatory	Physiology	Tongue-to-alveolar ridge contact.
Acoustic	Physics	Sudden release burst and "stop gap" on a spectrogram.
Perceptual	Psychology	Recognition of a sharp, voiceless dental/alveolar onset.

Box 5.1: Example of integrated speech analysis

5.4.2 Applications in teaching, therapy, and research

The integration of acoustic, articulatory, and perceptual perspectives has practical applications. In **teaching**, it helps language learners improve pronunciation by linking physical movements with acoustic feedback and perceptual cues. In **therapy**, speech-language pathologists use these insights to diagnose and treat speech disorders, guiding patients to adjust articulation for clearer acoustic output and better perception. In **research**, integration supports studies of language variation, speech technology, and forensic phonetics.

This applied dimension shows that phonetics is not only theoretical but also directly useful in everyday communication, education, and clinical practice.

Fill in the blank: When speech-language pathologists use articulatory, acoustic, and perceptual insights to treat speech disorders, this is an example of ______.

Plate 5.4: Applications of integrated perspectives in teaching, therapy, and research

This Part has demonstrated how **case studies** reveal the interplay of acoustic, articulatory, and perceptual correlates, and how this integration is applied in **teaching, therapy, and research**, making phonetics both practical and impactful.

Pilot questions 5.4

1. What is a case study in speech analysis?
2. How do articulatory, acoustic, and perceptual perspectives interact in analysing a plosive sound?
3. Why is integration of these perspectives important in phonetics?
4. Give one example of how integration is applied in teaching.
5. How can integration support therapy for speech disorders?

Series Summary

This Series has focused on the **interrelationships of acoustic, articulatory, and perceptual correlates**, showing how speech can be studied as a dynamic system where sound properties, physical movements, and listener perception are closely connected. We began by examining acoustic correlates such as frequency, amplitude, and duration, and then explored how vowels and consonants are represented acoustically. Next, we moved on to articulatory correlates, considering tongue, lips, and vocal tract movements, and how these link directly to acoustic output. Following that, we studied perceptual correlates, looking at how listeners process vowels, consonants, and prosody. Finally, we integrated these perspectives through case studies and explored their applications in teaching, therapy, and research.

By completing this Series, you should now be able to define and explain acoustic correlates (SLO 5.1, SLO 5.2), describe and analyse articulatory correlates (SLO 5.3, SLO 5.4), demonstrate and interpret perceptual correlates (SLO 5.5, SLO 5.6), and evaluate and apply integrated perspectives in practical contexts (SLO 5.7, SLO 5.8). These outcomes ensure that you can connect the measurable, physical, and perceptual dimensions of speech, reinforcing your ability to study phonetics holistically and apply it meaningfully in both academic and applied settings.

Glossary Of Terms

- **Acoustic correlates**: Measurable properties of speech sounds, including frequency, amplitude, and duration.
- **Amplitude**: The strength or intensity of a sound wave, often perceived as loudness.
- **Articulatory correlates**: Physical movements of the tongue, lips, and vocal tract that shape speech sounds.
- **Auditory processing**: The way the ear and brain interpret sound signals, allowing listeners to perceive speech.
- **Case study**: A detailed examination of how acoustic, articulatory, and perceptual perspectives interact in real examples of speech.
- **Consonant bursts**: Sudden spikes of energy in speech signals, typically associated with plosive sounds.
- **Duration**: The length of time a sound lasts, measured in milliseconds or seconds.
- **Formants**: Resonant frequencies of the vocal tract that distinguish vowel qualities, visible as dark bands on spectrograms.
- **Frequency**: The number of vibrations per second of a sound wave, measured in Hertz (Hz), which determines pitch.
- **Perceptual correlates**: Listener-based interpretations of speech sounds, including recognition of vowels, consonants, and prosody.
- **Pitch contour**: A visual representation of how pitch rises and falls across speech, often used to study intonation.
- **Prosody**: Rhythm, stress, and intonation in speech, which convey meaning and emotion beyond individual sounds.
- **Spectrogram**: A visual display showing time, frequency, and amplitude of speech sounds, used to analyse acoustic features.
- **Vocal tract**: The cavity and structures (oral and nasal) that shape airflow and resonance during speech production.

Concept Check Questions [Series 5]

The following questions will help you consolidate your learning from **Series 5: Interrelationships of Acoustic, Articulatory, and Perceptual Correlates**. They are grouped by type and aligned with the Series Learning Outcomes (SLOs).

Objective questions

1. (Linked to SLO 5.1) Which acoustic correlate determines the pitch of a sound?
2. (Linked to SLO 5.2) Resonant frequencies of the vocal tract that distinguish vowel qualities are called ______.
3. (Linked to SLO 5.3) Which articulatory organ is most central to vowel production?
4. (Linked to SLO 5.5) The process by which the ear and brain interpret sound signals is known as ______.
5. (Linked to SLO 5.6) Rhythm, stress, and intonation in speech are collectively referred to as ______.

Short-answer questions

6. (Linked to SLO 5.1) Define amplitude and explain how it is perceived in speech.
7. (Linked to SLO 5.2) Describe how plosives and fricatives differ in their acoustic features.
8. (Linked to SLO 5.3) Explain how tongue height influences vowel quality.
9. (Linked to SLO 5.4) Analyse how lip rounding affects acoustic output.
10. (Linked to SLO 5.5) Give one example of how listeners perceive consonants differently from vowels.

Long-answer questions

11. (Linked to SLO 5.6) Discuss the role of prosody in communication, explaining how acoustic cues are processed perceptually.
12. (Linked to SLO 5.7 & 5.8) Evaluate the importance of integrating acoustic, articulatory, and perceptual perspectives, giving examples of applications in teaching, therapy, and research.

Answers to Concept Check Questions [Series 5]

Objective questions

1. Frequency
2. Formants
3. Tongue
4. Auditory processing
5. Prosody

Short-answer questions

6. Amplitude is the strength or intensity of a sound wave, perceived as loudness.
7. Plosives show sudden bursts of energy, while fricatives display continuous high-frequency noise.
8. High tongue positions produce high vowels, while low positions produce low vowels.
9. Lip rounding lowers certain formant frequencies, altering vowel acoustics.
10. Consonants are perceived through cues such as bursts and timing, while vowels rely on formant recognition.

Long-answer questions

11.

- **Basic response**: Prosody refers to rhythm, stress, and intonation, which help convey meaning and emotion. Acoustic cues such as pitch contours and timing are processed by the auditory system to interpret these features.
- **Value-added response**: Beyond the basics, prosody also plays a role in distinguishing sentence types (e.g., questions vs. statements), signalling speaker attitude, and managing conversational flow. Advanced research shows that prosody is crucial in second language learning and in clinical contexts such as diagnosing speech disorders.

12.

- **Basic response**: Integrating acoustic, articulatory, and perceptual perspectives provides a holistic understanding of speech. It allows researchers to connect physical movements with measurable sound properties and listener interpretations.
- **Value-added response**: Integration is vital in applied contexts. In teaching, it helps learners improve pronunciation by linking articulation with acoustic feedback. In therapy, speech-language pathologists use it to treat disorders by guiding patients to adjust articulation for clearer acoustic output. In research, integration supports studies in sociophonetics, forensic phonetics, and speech technology, making phonetics both practical and impactful.

Answers to Pilot Questions [Series 5]

Part 5.1: Acoustic correlates of speech sounds

1. Frequency, amplitude, and duration.
2. Frequency.
3. Formants.
4. As bursts visible on a spectrogram.
5. They allow researchers to quantify and compare speech sounds systematically.

Part 5.2: Articulatory correlates of speech sounds

1. Physical movements of the tongue, lips, and vocal tract.

2. High tongue positions produce high vowels, while low positions produce low vowels.
3. Lip rounding lowers certain formant frequencies.
4. Plosives show sudden bursts of energy, while fricatives display continuous noise.
5. It helps predict acoustic patterns and supports teaching, therapy, and research.

Part 5.3: Perceptual correlates of speech sounds

1. Auditory processing.
2. Recognition of formants.
3. Through cues such as bursts, frication noise, and timing differences.
4. Rhythm, stress, and intonation.
5. It signals meaning, emotion, and sentence type in communication.

Part 5.4: Integrating acoustic, articulatory, and perceptual perspectives

1. A case study.
2. Articulatory closure, acoustic burst, and perceptual sharp onset.
3. It provides a holistic understanding of speech.
4. By linking articulation with acoustic feedback to improve pronunciation.
5. By guiding patients to adjust articulation for clearer acoustic output.

References and Attributions [Series 5]

This section lists the references, suggested sources, and attributions for the materials used in **Series 5: Interrelationships of Acoustic, Articulatory, and Perceptual Correlates**. It includes citations for concepts, illustration placeholders, and open educational resources (OERs) suggested for further study.

General references

- Ladefoged, P., & Johnson, K. (2014). *A course in phonetics* (7th ed.). Boston: Cengage Learning.
- Johnson, K. (2011). *Acoustic and auditory phonetics* (3rd ed.). Malden, MA: Wiley-Blackwell.
- Ashby, M., & Maidment, J. (2005). *Introducing phonetic science*. Cambridge: Cambridge University Press.
- Nathan, G. S. (2008). *Phonology: A cognitive grammar introduction*. Amsterdam: John Benjamins.

Illustration references and attributions

- *Figure 5.1: Acoustic correlates of speech sounds*
    - AI prompt suggestion: "Generate a diagram of a waveform with frequency, amplitude, and duration labelled."
    - Search string: "OER waveform frequency amplitude duration phonetics"
- *Plate 5.1: Acoustic features of vowels and consonants*
    - AI prompt suggestion: "Generate an image of a spectrogram with vowel formants and consonant bursts labelled."
    - Search string: "OER spectrogram vowels consonants phonetics"
- *Figure 5.2: Articulatory correlates of vowel production*
    - AI prompt suggestion: "Generate a diagram showing tongue positions for high, mid, and low vowels, with arrows for lip rounding and spreading."
    - Search string: "OER diagram tongue positions vowels phonetics"
- *Plate 5.2: Linking articulation to acoustic output*
    - AI prompt suggestion: "Generate an image showing a spectrogram next to a diagram of tongue and lip positions, illustrating articulation linked to acoustic output."
    - Search string: "OER articulation acoustic output spectrogram phonetics"
- *Figure 5.3: Auditory processing of vowels and consonants*
    - AI prompt suggestion: "Generate a diagram showing the ear receiving sound waves and the brain interpreting vowel formants and consonant cues."
    - Search string: "OER auditory processing vowels consonants phonetics"
- *Plate 5.3: Perception of prosody and intonation*
    - AI prompt suggestion: "Generate an image showing a pitch contour line rising and falling across a sentence, with stress markers indicated."
    - Search string: "OER prosody intonation perception phonetics"
- *Box 5.1: Example of integrated speech analysis*
    - AI prompt suggestion: "Create a text box showing articulatory, acoustic, and perceptual perspectives of the sound /t/."
    - Search string: "OER integrated speech analysis phonetics case study"
- *Plate 5.4: Applications of integrated perspectives in teaching, therapy, and research*
    - AI prompt suggestion: "Generate an image showing three panels: a teacher guiding pronunciation, a therapist working with a patient, and a researcher analysing spectrograms."

- Search string: “OER phonetics applications teaching therapy research”