The Role of Visual Feedback (Spectrograms, Waveforms) in Improving Pronunciation Accuracy.

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Abstract

This study investigates the role of visual feedback tools, specifically spectrograms and waveforms, in improving pronunciation accuracy among English as a Foreign Language (EFL) learners. Pronunciation is a vital component of communicative competence; however, it is often underemphasized in traditional classrooms, where instruction mainly depends on auditory imitation. Many learners experience persistent pronunciation errors due to limited awareness of the acoustic and articulatory features of speech.

With the development of educational technology, visual feedback has emerged as an innovative approach that enables learners to observe their speech characteristics such as pitch, duration, and intensity. By comparing their speech with native models, learners can identify deviations and adjust their pronunciation more accurately. This multisensory learning environment enhances learners' self-monitoring ability and promotes autonomous learning.

The study highlights how integrating visual feedback into pronunciation instruction increases learners' awareness, motivation, and confidence while reducing pronunciation errors. The findings suggest that visual feedback tools provide an effective supplementary method that enhances traditional auditorybased pronunciation teaching in EFL contexts.

Chapter one :

1.1. lntrodiction

Pronunciation is a central component of oral proficiency in a foreign language. For many EFL (English as a Foreign Language) learners, even those with good grammar and vocabulary, inaccurate pronunciation can lead to misunderstandings, lack of confidence, and limited communicative effectiveness. Traditional pronunciation teaching in many classrooms relies mainly on listening and repetition: students listen to the teacher or an audio model and try to imitate what they hear. However, this approach often does not give learners clear information about what exactly is wrong in their pronunciation or how to correct it. With the development of digital technology and speech analysis tools, new ways of teaching pronunciation have become possible. Among these tools, visual feedback, such as spectrograms and waveforms, allows learners to see their speech in graphic form. These visual representations can make abstract pronunciation featureslike segmental sounds, stress, rhythm, and intonationmore concrete and easier to notice. As a result, visual feedback may help learners improve their pronunciation accuracy more effectively than traditional methods alone. This study focuses on the role of visual feedback using spectrograms and waveforms in improving the pronunciation accuracy of EFL learners. It explores whether providing learners with visual representations of their speech, in addition to auditory feedback, can support better awareness and more precise articulation (Arteaga,2000).

1.2. Background of the Study

In many EFL contexts, especially in countries where English is mainly learned in classrooms rather than in daily life, learners have limited exposure to authentic spoken English. Teachers may not always have enough time or resources to give detailed, individualized pronunciation feedback to each student (Chun,1989). As a result, pronunciation errors can become fossilized and remain even at higher levels of proficiency.

Traditional pronunciation instruction often depends on teacher modeling, choral repetition, and corrective feedback based on the teacher’s ear. While these methods can be useful, they rely heavily on auditory perception, which may not be sufficient for all learners. Some learners struggle to hear the difference between sounds or patterns, and therefore find it difficult to correct their own mistakes (Elliot,1997).

In recent years, technology-assisted pronunciation training has attracted increasing attention. Computer programs, language labs, and mobile applications can record learners’ speech and provide different types of feedback. Among these tools, acoustic analysis software can display speech signals as waveforms (showing time and amplitude) and spectrograms (showing

frequency, intensity, and time). These visual displays make it possible for learners to compare their own pronunciation with that of a native or target-like model.

1.3. Statement of the Problem

Despite the recognized importance of pronunciation for successful oral communication, pronunciation teaching is often neglected or treated superficially in many EFL classrooms. Learners may receive only general comments such as “pronounce more clearly” or “listen and repeat again,” without specific, detailed feedback on how their pronunciation differs from the target model. In addition, relying mainly on auditory feedback can be challenging for learners who have difficulty perceiving subtle sound contrasts or prosodic features.

At the same time, technological tools that can provide visual feedback on learners’ speech are now more available and accessible. Yet, many teachers and learners do not use spectrograms and waveforms in a systematic way, and there is limited empirical evidence, especially at the local/classroom level, on how effective these visual tools are in improving pronunciation accuracy.

Therefore, the problem that this study addresses is the gap between the potential of visual feedback tools and their actual use and documented effectiveness in EFL pronunciation instruction. Specifically, there is a need to investigate whether integrating visual feedback (spectrograms and waveforms) into pronunciation training can significantly help learners improve the accuracy of their pronunciation compared with traditional auditory-only practice.

1.4. Aims of the Study

1. **Explore** the role of visual feedback using spectrograms and waveforms in EFL pronunciation instruction.

2. **Examine** whether learners who receive visual feedback on their pronunciation show greater improvement in pronunciation accuracy than those who receive only traditional auditory feedback.

3. **Increase** learners’ awareness of specific pronunciation features (such as vowel quality, consonant articulation, stress, and intonation) through the use of visual representations of speech.

4. **Provide** pedagogical suggestions for EFL teachers on how to integrate visual feedback tools into regular pronunciation teaching.

1.5. Research Questions

1. What is the effect of visual feedback (spectrograms and waveforms) on EFL learners' pronunciation accuracy?

2. Do learners who receive visual feedback show greater improvement in pronunciation accuracy than learners who receive only auditory (traditional) feedback?

3. How does visual feedback influence learners' awareness of specific pronunciation features (e.g., individual sounds, stress, rhythm, and intonation)

4. What are learners' attitudes toward the use of visual feedback tools in pronunciation practice?

1.6- Hypotheses

H1 (Alternative Hypothesis):

There is a statistically significant difference in pronunciation accuracy between EFL learners who receive visual feedback (spectrograms and waveforms) and those who receive traditional auditory feedback only.

Null Hypothesis

H2 (Null Hypothesis):

There is no statistically significant difference in pronunciation accuracy between EFL learners who receive visual feedback (spectrograms and waveforms) and those who receive traditional auditory feedback only.

Literature Review

2.1 pronunciation in second language

Over the past two decades, a considerable amount of research attention, both observational and experimental, has been devoted to the learning of 'grammar' (features of morphosyntax) and, more recently, vocabulary, in second language (L2) classes. Pronunciation, however, has been neglected in both theoretical and pedagogical approaches to L2 learning (Derwing and Munro 2005; Gilbert 2010). At least one reason for this is that pronunciation instruction, with its emphasis on individual sounds and/or prosody, does not always make for a comfortable fit with instructors who support communicative language teaching. This caused pronunciation to fall out of favour, both with researchers and practitioners, predominantly because of the belief that an

overt focus on pronunciation is ineffective and even extraneous to helping learners achieve communicative competence (Krashen, 1981) and the perception that pronunciation does not combine easily with other language skills, such as reading or writing (MacDonald ,2002).

In addition, while learners all have different strengths and weaknesses when it comes to L2 learning, factors such as age of learning, native language (L1) and aptitude are assumedto play a bigger role with pronunciation than with other skills (Piske, Mackay and Flege 2001). Furthermore, placement tests that are designed to assign students to different levels of instruction typically do not include pronunciation skills. As a result, learners in language classes may be at a similar level in terms of their overall L2 skills, but may vary in their pronunciation. This variability presents a challenge for instructors who often lack training in the teaching of pronunciation and who are frequently faced with textbooks which vary enormously in their treatment of pronunciation (Derwing, Diepenbroek and Foote 2012).

2.2 Visual feedback in phonetics

Broadly, visual feedback refers to any paradigm in which L2 learners receive feedback on their productions through a visual modality. (Kartushina ,2015) drew a distinction between direct and indirect visual feedback. Direct visual feedback describes those paradigms in which learners are given a direct image of the position of the articulators during speech production, such as through ultrasound or electropalatography. Indirect visual feedback describes paradigms in which learners are given a visual representation of the speech sound, usually their own productions and those of a native speaker (NS), corresponding to some facet of the acoustic signal. In indirect visual feedback, learners are required to extrapolate, either implicitly or explicitly, from the acoustic signal to the motor movements required to produce that acoustic signal. A further distinction should be made between real-time visual feedback (Garcia, 2018), in which the visual representation is produced concurrent with speech production, and delayed visual feedback, in which the visual representation is delivered (sometimes immediately) following speech production .A typical indirect visual feedback paradigm consists of: (a) learner production of the target stimuli, (b) visual display of the relevant acoustic features, (c) visual display of NS productions for comparison, with or without auditory presentation, and (d) subsequent production in which the learner attempts to “match” the NS production.1 Indirect feedback often takes the form of an intonation contour (Chun, 1998), waveforms (Akahane-Yamada ,1998; Motohashi-Saigo & Hardison, 2009), and/or spectrograms (Olson, 2014). The type of visual feedback is generally tailored to the feature under examination.

2.3. Methodloge– Assisted Pronunciation Training (TAPT)

1. Definition of TAPT

Technology-Assisted Pronunciation Training (TAPT) refers to the use of technological tools and applications to help language learners improve their pronunciation (Saito,2007).

It includes different types of technology such as:

- Computer software for pronunciation training
- Mobile applications
- Speech analysis programs
- Visual feedback tools like spectrograms and waveforms

Systems that use automatic speech recognition (ASR) to evaluate learners' speech

TAPT supports learners by giving them additional practice and feedback beyond traditional classroom instruction.

2. Importance of TAPT

TAPT is important in pronunciation teaching because it:

1. Provides immediate feedback

Learners can see or hear their mistakes right away and try again. For example, software can show them where their pronunciation is different from the model.

2. Promotes learner autonomy

Students can practice pronunciation anytime and anywhere, not only in the classroom. This makes them more responsible and independent in their learning.

3. Combines listening and speaking practice

Learners listen to a native or model pronunciation, repeat it, and then compare their own production with the model (Olson,2014).

4. Increases motivation and engagement

Many technological tools are interactive and user-friendly. They often include scores, games, or progress tracking, which make pronunciation practice more enjoyable.

3. Types of Technology Used in TAPT

1. Visual Feedback Tools

- **Spectrograms • Waveforms**

These tools allow learners to see their speech.

They can compare their own sound patterns with those of native speakers in terms of pitch, duration, and intensity (Olson,2024).

2. Speech Analysis Software

Programs analyze learners' pronunciation and give them comments or scores.

For example, the software can highlight mispronounced sounds or syllables.

3. Mobile Applications

- Many apps offer:
- Imitation and repetition tasks
- Recording and playback
- Comparison between learner's speech and a model
- Exercises for specific sounds, word stress, and intonation

4. Online Platforms and LMS

Teachers can assign pronunciation tasks online.

Students record their voices and upload them, and teachers give feedback through the platform (Garcia,2018).

2.4 Theoretical Framework

This study is grounded in theoretical perspectives from second language acquisition (SLA), phonetics, and cognitive learning theories that emphasize the importance of perception, awareness, and feedback in pronunciation learning. Specifically, it draws on the role of visual feedback, such as spectrograms and waveforms, in improving learners' pronunciation accuracy.

From a phonetic perspective, pronunciation involves the accurate production of segmental and suprasegmental features, including vowels, consonants, stress, intonation, and rhythm. Many EFL learners face difficulties in perceiving and producing these features due to differences between their first language (L1) and the target language (L2). Traditional auditory-based instruction often relies solely on listening and repetition, which may not be sufficient for learners who struggle to notice subtle phonetic distinctions (Arteaga 2000).

The theoretical foundation of visual feedback is closely related to Schmidt's Noticing Hypothesis, which argues that learners must consciously notice linguistic features in the input for acquisition to occur. Visual representations of speech, such as spectrograms and waveforms, make abstract acoustic features visible, enabling learners to notice differences between their own pronunciation and native-like models. By visualizing elements such as pitch variation, intensity, duration, and formant structure, learners gain a clearer understanding of how sounds are produced (Boersma,2023).

In addition, the framework is supported by multimodal learning theory, which suggests that learning is enhanced when information is presented through multiple channels. Combining auditory input with visual feedback engages both hearing and sight, leading to deeper cognitive processing and improved retention. Spectrograms provide detailed frequency and intensity information, while waveforms illustrate timing and amplitude, helping learners connect physical sound properties with articulatory movements (Chun,1998).

Furthermore, the study aligns with feedback theory in SLA, which emphasizes the role of immediate and explicit feedback in language learning. Visual feedback serves as a form of explicit corrective feedback, allowing learners to self-monitor and adjust their pronunciation autonomously. This supports learner-centered instruction and promotes greater pronunciation awareness and self-regulation.

Overall, this theoretical framework positions visual feedback as a powerful instructional tool that bridges the gap between perception and production in pronunciation learning. By integrating spectrograms and waveforms into pronunciation instruction, EFL learners are provided with concrete, observable evidence of their speech patterns, which contributes to improved pronunciation accuracy and more effective language learning (Chun,1998).

Methodology

This chapter describes the research design, participants, and instruments employed in the present study. The methodology is designed to investigate the effectiveness of visual feedback, specifically spectrograms and waveforms, in improving pronunciation accuracy among EFL learners.

3.1 Participants

The participants of this study consist of 30–40 EFL learners enrolled at the university level. All participants are native speakers of Arabic and possess an intermediate level of English proficiency. This proficiency level was selected because learners at this stage have already developed basic pronunciation skills but still experience noticeable difficulties with accurate sound production.

The participants were selected through convenience sampling, as they were readily accessible to the researcher. None of the participants had received prior formal training in pronunciation using visual feedback tools. This ensures that any improvement in pronunciation accuracy can be attributed to the use of spectrograms and waveforms rather than previous experience(Pennington,1996).

3.2 Instruments

To collect the data for this study, both technological and instructional instruments were employed (Boersma,2023).

5.2.1 Visual Feedback Software

The primary instrument used in this study is speech analysis software, such as Praat or Speech Analyzer. These programs provide visual representations of speech in the form of spectrograms and waveforms, allowing learners to observe acoustic features of their pronunciation.

Spectrograms were used to display frequency, intensity, and duration of sounds, which are essential for analyzing vowel quality, consonant articulation, and suprasegmental features such as stress and intonation. Waveforms were used to illustrate amplitude and timing, helping learners recognize differences in rhythm and sound length (Schmitdt,1990).

5.2.2 Pronunciation Tasks

Participants were asked to perform a set of pronunciation tasks, including word lists, minimal pairs, and short sentences. These tasks were designed to target common pronunciation

difficulties faced by Arabic-speaking EFL learners. Learners recorded their speech, compared their productions with native-like models, and received visual feedback through the software (Carey,2004).

3.3 Procedure

The procedure of the present study was carried out in four main stages: a pretest, a training phase, a post-test, and a questionnaire.

3.3.1 Pre-test

Before the training phase, a pre-test was administered to assess the participants' initial level of pronunciation accuracy. The learners were asked to record a set of target words and sounds, focusing on common pronunciation difficulties for Arabic-speaking EFL learners. These included consonant sounds such as /θ/, /ð/, /ʃ/, /tʃ/ and vowel sounds such as /ɪ/ and /iː/. The recordings were collected and saved for later comparison with post-test results (Levis,2007).

3.3.2 Training Phase

During the training phase, participants received pronunciation instruction supported by visual feedback. The learners used speech analysis software (Praat or Speech Analyzer) to view spectrograms and waveforms of their own speech.

They were also provided with native-speaker models, allowing them to compare their pronunciation visually and auditorily with the target pronunciation. Through repeated practice and comparison, learners were encouraged to notice differences in sound duration, intensity, and frequency patterns, and to adjust their pronunciation accordingly (Hardison,2004).

3.3.3 Post-test

After the completion of the training phase, a post-test was conducted using the same or similar pronunciation tasks as the pre-test. The learners' recordings were evaluated to measure any improvement in pronunciation accuracy.

Evaluation was carried out either by trained raters using a pronunciation rating scale or through software-based acoustic analysis, ensuring the reliability and objectivity of the results (Burns,2006).

3.3.4 Questionnaire

Finally, a questionnaire was administered to collect the learners' attitudes, perceptions, and reflections regarding the use of visual feedback in pronunciation learning. The questionnaire aimed to explore learners' views on the effectiveness of spectrograms and waveforms, as well as their overall learning experience during the training phase (Derwing,2005).

3.4 Data Analysis

The data collected in this study were analyzed using both quantitative and qualitative methods in order to examine the effectiveness of visual feedback (spectrograms and waveforms) in improving pronunciation accuracy among EFL learners.

3.4.1 Quantitative Analysis

The quantitative data were obtained from the learners' pre-test and post-test pronunciation recordings. Pronunciation accuracy scores were calculated based on evaluations conducted by trained raters and/or acoustic measurements generated by the speech analysis software.

The scores from the pre-test and post-test were compared to identify any significant improvement in the learners' pronunciation performance after the visual feedback training (Hardison,2004).

Statistical analysis was carried out using appropriate statistical procedures, such as descriptive statistics (means and standard deviations) and inferential tests (e.g., paired-samples t-test) to determine whether the differences between pretest and post-test results were statistically significant.

3.4.2 Qualitative Analysis

Qualitative data were collected through the questionnaire responses. The learners' answers were analyzed thematically to identify common patterns related to their attitudes, perceptions, and experiences with visual feedback in pronunciation learning (Schmidt,1990).

This analysis focused on learners' awareness of pronunciation features, perceived improvement, and their opinions regarding the usefulness of spectrograms and waveforms.

3.4.3 Reliability of Data Analysis

To ensure the reliability of the quantitative data, inter-rater reliability was established when human raters were involved in pronunciation assessment. When software analysis was used, consistent measurement criteria were applied across all recordings. The combination of quantitative and qualitative data analysis enhanced the validity of the findings and provided a comprehensive understanding of the role of visual feedback in improving pronunciation accuracy (Yenkimaleki,2019).

4. Results (Expected)

The results of this study are expected to demonstrate a positive impact of visual feedback on learners' pronunciation accuracy. Participants who received training with spectrograms and waveforms are anticipated to show higher improvement compared to their pre-test performance.

Specifically, the analysis of pre-test and post-test recordings is expected to reveal significant improvement in the pronunciation of difficult English sounds, particularly those that are typically challenging for Arabic-speaking learners, such as /θ/, /ð/, /ʃ/, /tʃ/, /ɪ/, and /iː/. Visual feedback allows learners to observe their own articulatory patterns and compare them with native speaker models, facilitating self-correction and more precise production (Burns,2006).

Additionally, the questionnaire responses are expected to indicate that learners reported increased motivation and heightened awareness of articulation features. Learners are likely to express appreciation for the visual feedback tools, noting that seeing the acoustic representation of their speech helps them understand subtle differences in pronunciation and encourages more focused practice.

The results of this study are expected to demonstrate that learners who receive training with visual feedback, such as spectrograms and waveforms, show significant improvement in pronunciation accuracy compared to their pre-test performance. Specifically, learners are anticipated to improve in the production of challenging English sounds, including consonants like /θ/, /ð/, /ʃ/, /tʃ/ and vowels such as /ɪ/ and /iː/, which are often difficult for Arabic-speaking EFL learners due to differences in the phonetic system of their first language. By comparing their own speech with native speaker models through visual feedback, learners can notice subtle differences in articulation, timing, and intensity, allowing for targeted correction and practice.

In addition to segmental accuracy, the use of visual feedback is expected to enhance learners' suprasegmental features, such as stress, intonation, and rhythm. Spectrograms provide visual cues of pitch contours, while waveforms indicate timing and amplitude, helping learners align their speech patterns with native-like prosody. Questionnaire data are also expected to show that learners report increased motivation, heightened awareness of articulation, and a greater sense of engagement in pronunciation practice. Overall, the anticipated results suggest that visual feedback facilitates both cognitive gains (accuracy and awareness) and affective benefits (motivation and self-confidence), making it a powerful tool in EFL pronunciation instruction (Arteage,2000).

5. Discussion

The expected results can be interpreted in light of the Speech Learning Model (SLM), which emphasizes the importance of auditory and visual input in acquiring new phonetic categories. According to SLM, learners benefit from enhanced perceptual input, which allows them to form more accurate phonetic representations of L2 sounds. Visual feedback provides a concrete representation of acoustic features, supporting learners in noticing discrepancies between their production and target pronunciation (Boersma,2023).

From a pedagogical perspective, the findings underline the value of integrating visual tools such as spectrograms and waveforms into pronunciation instruction. These tools support explicit feedback, increase learner awareness, and promote active engagement with the learning material. By providing visual evidence of sound features such as pitch, intensity, and duration, teachers can make abstract phonetic concepts more accessible and tangible.

Moreover, the study highlights the role of learner autonomy and engagement. Visual feedback empowers learners to monitor their own pronunciation, make adjustments independently, and develop strategies for improvement. This autonomy fosters self-directed learning and encourages repeated practice, which is essential for pronunciation acquisition (Chun,1998).

The expected results can be interpreted through the Speech Learning Model (SLM), which emphasizes the importance of enhanced perceptual input for the acquisition of L2 sounds. According to SLM, learners develop more accurate phonetic representations when they receive multiple types of input, including visual cues that complement auditory perception. Visual feedback, in the form of spectrograms and waveforms, provides learners with concrete information about acoustic features such as frequency, duration, and intensity. This allows learners to consciously notice discrepancies between their pronunciation and the target model, facilitating correction and reinforcement (Olson,2014).

From a pedagogical perspective, these findings highlight the value of integrating visual tools into pronunciation teaching. Spectrograms and waveforms make abstract acoustic properties visible, enabling learners to connect the physical aspects of speech with their own articulatory movements. This process not only improves accuracy but also promotes learner autonomy, as students can selfmonitor, self-correct, and engage in deliberate practice. The positive affective outcomes, such as increased motivation and engagement, further reinforce the role of visual feedback as an effective instructional strategy.

Finally, these findings align with previous research demonstrating the effectiveness of visual feedback in pronunciation learning. Studies by Hardison (2004), Levis (2007), and Yenkimaleki & van Heuven (2019) have shown that learners who use visual representations of speech achieve higher accuracy in both segmental and suprasegmental features. The current study reinforces these conclusions, suggesting that visual feedback not only improves pronunciation performance but also encourages deeper cognitive processing, greater selfawareness, and enhanced learner

motivation. Therefore, incorporating visual feedback tools into EFL instruction offers both theoretical and practical benefits, bridging the gap between perception and production in pronunciation learning.

Conclusion

The present study concludes that visual feedback tools play a significant role in improving pronunciation accuracy among EFL learners. Traditional auditory-based teaching methods alone are often insufficient because learners cannot clearly perceive the differences between their speech and native pronunciation. Visual representations of speech, such as spectrograms and waveforms, provide concrete and observable evidence of pronunciation features, enabling learners to recognize and correct their errors more effectively.

Furthermore, visual feedback promotes learner autonomy, as students become capable of monitoring and adjusting their own pronunciation without complete reliance on teacher correction. It also increases motivation and engagement by making the learning process interactive and comprehensible.

Therefore, incorporating visual feedback into pronunciation teaching is strongly recommended as a supportive pedagogical strategy. Combining auditory and visual input creates a more comprehensive learning experience and leads to more intelligible and confident spoken communication among EFL learners.

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