

Effects of High Variability Perceptual Training (HVPT) on the Identification of English Dental Sounds (/θ/ and /ð/) by Hausa, Igbo and Yoruba ESL Learners

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Abstract

Second language (L2) learners often struggle with perceiving non-native phonetic contrasts, particularly when the target sounds do not exist in their first language (L1). This challenge is prominent among Hausa, Igbo, and Yoruba speakers of English, who frequently substitute English interdental fricatives (/θ/ and /ð/) with native-language approximations. High Variability Phonetic Training (HVPT) has proven effective in previous studies for enhancing learners' perception of difficult L2 sounds. However, limited research has examined its impact on Nigerian multilingual learners. This study investigates the effectiveness of HVPT on the identification of English interdental fricatives among Hausa, Igbo, and Yoruba ESL learners. Guided by the Perceptual Assimilation Model (Best, 1994) and the Speech Learning Model (Flege, 1995), the study employed an experimental design involving 90 participants across three universities. Sixty learners received HVPT, while thirty served as a control group. Perception tasks were created using PRAAT software and administered before and after training, along with a generalization test involving new tokens. The results indicated that the Hausa learners in the experimental group improved from a pretest mean of 45.28 to a posttest mean of 73.95, with further improvement in the generalization test (78.19), while the control group showed only minimal change. The Igbo learners demonstrated strong gains, increasing from a pretest mean of 44.55 to a posttest mean of 73.97, and achieving a higher generalization mean of 79.07, indicating slightly superior performance. The Yoruba learners also showed clear improvement after HVPT, rising from a pretest mean of 47.43 to a posttest mean of 73.67, and reaching a generalization mean of 78.40, though with slightly greater variability. The findings confirm that HVPT is a powerful tool for improving perceptual accuracy of difficult English sounds and has strong pedagogical potential for multilingual ESL contexts such as Nigeria.

Key words: High Variability, Perceptual Training, (HVPT), Dental Sounds (/θ/ and /ð/), Hausa, Igbo and Yoruba ESL Learners.

INTRODUCTION

Second language (L2) speech learning poses a challenge to adult learners in terms of articulation and perception of non-native

phonetic contrasts, that is, L2 speech sounds that do not exist or are not phonologically distinctive in the first language (L1). As a result, adult second language (L2) learners are frequently characterized as having not

only foreign pronunciation but also “accented” perception (Strange, 1995). Difficulties with L2 sounds may result from the interaction of diverse factors related to learners’ L2 background (viz. age of L2 learning, quantity and quality of L2 exposure, amount of L1 and L2 use) and with individual differences such as motivation and language learning aptitude (Munro & Bohn, 2007; Piske, Bohn & Munro, 2007). Another main factor that accounts for these difficulties is the relation (i.e., the dissimilarities and similarities) between the first language (L1) and second language (L2) phonological and phonetic systems.

Second language (L2) learners often experience persistent difficulty in perceiving and producing non-native phonemic contrasts, particularly when such sounds are absent from their first language (L1) phonological inventory. Research in L2 speech perception has consistently shown that these difficulties are shaped by the degree of phonetic and phonological similarity between L1 and L2 sounds, as explained by models such as the Perceptual Assimilation Model (PAM) and the Speech Learning Model (SLM) (Best, 1995; Flege, 1995). Within this theoretical context, High Variability Phonetic Training (HVPT) has emerged as a powerful instructional approach that exposes learners to multiple talkers, phonetic contexts, and acoustic variations, thereby promoting the formation of new perceptual categories (Lively, Logan, & Pisoni, 1993; Bradlow et al., 1999). Empirical studies across different language backgrounds have demonstrated that HVPT significantly enhances learners’ ability to

identify and discriminate difficult L2 contrasts, including English /r-l/, vowels, tones, and fricatives, often with long-term retention and generalization effects (Nishi & Kewley-Port, 2007; Melnik & Peperkamp, 2021).

More recent research has extended HVPT to the perception of English interdental fricatives (/θ/ and /ð/), sounds that pose challenges to learners whose L1 lacks these segments. Studies involving Japanese, Chinese, and other ESL/EFL learners report that HVPT leads to substantial gains in both perception and production, outperforming traditional pronunciation instruction (Iino, 2019; Li, 2024). Importantly, cross-linguistic studies suggest that while learners from different L1 backgrounds generally benefit from HVPT, the magnitude and stability of improvement may vary depending on L1 phonological structure and prior exposure (Iverson et al., 2005; Logan et al., 1991). In multilingual contexts, such as Nigeria, where Hausa, Igbo, and Yoruba learners share similar challenges with English interdental sounds, HVPT offers a theoretically grounded and empirically supported framework for addressing perceptual deficits while allowing for language-specific variation in learning outcomes.

A considerable amount of empirical studies revealed that second language (L2) speakers of a language can learn to produce or perceive non-native contrasts in a native-like way, mainly because “the perceptual processes used in learning the first (L1) sound system can be applied to second (L2)

learning and remain intact over the life span” (Flege, 1995, p. 239).

Considering that “difficulties in perception of non-native sound contrasts are a significant part of the problems many second language (L2) learners have in mastering the L2 phonology” (Strange, 2007, p. 36), the perceptual training of English sounds with native speakers of various L1s has been investigated, and various studies have reported overall significant improvement in perceptual performance immediately after training. Generalization of perceptual learning to new talkers and new tokens (e.g., Aliaga-Garcia,

2010), and to new contexts (e.g., Lacabex, 2013) was reported, and long-term retention was also observed one month and three months (e.g., Nishi & Kewley, 2007) after completion of training. Several experiments were conducted to investigate which training procedures are more effective in promoting L2 categorical learning. For example, Nobre (2007) compared the use of natural stimuli to synthesized stimuli and found that there was no significant difference between them. Wang (2008) also included synthesized and natural tokens in the training but did not compare the learning effects of the two stimulus types.

Consonantal Inventory of Hausa, Yoruba and Igbo

Table 1 Hausa Consonantal Chart (Source: Sani, 2005)

	Bilabial	Alveolar	Post-Alveolat	Palatal	Palatalized velar	Velar	Labialized Velar	Glottal
Plosive & Affricate	B	t d	tʃ dʒ		kj gj	k g	kw gw	ʔ
Implosive & Ejective Stop & Affricate	b	ts' ɗ	(tʃ')	j'				
Nasal	M	n						
Fricative	Φ	s z						h
Tap/Trill		r						
Approximant	W	ɹ		j				
Lateral Approximant		l						

Table 2 Yoruba Consonantal Chart (Source: Oti-Owom, 2021)

		Labial	Alveolar	Palatal	Velar	Labio-velar	Glottal
Stop	Voiceless	B	T		K	Kp	
	Voiced		D		G	Gb	
Affricate	Voiced			dz			
Fricative	Voiceless	f	S	ʃ			h

Nasal	Voiced	m	N		ɲ		
Liquid	Voiced		ʀl				
Glide	Voiced			j		W	

Table 3 Igbo Consonantal Chart (Source: Oti-Owom, 2021)

	Bilabial	Labio-dental	alveolar	Post-alveolar	palatal	velar	labiovelar	Labialized velar	glottal
Plosive	p b		t d			k g	kp gb	Kw gw	
Fricatives		f v	s z	ʃ					
Affricates				tʃ dz			Y		
Nasal		M		N		ŋ	ɲ		
Lateral				L					
Trill				R					
approximat					j			w	

Problem Statement

Despite the fact that English has been for many centuries as the language of instruction in the Nigerian schools, Hausa, Igbo and Yoruba speakers of English still have difficulties in the perception and subsequently in production of some of the English sounds. The listeners (Hausa, Igbo and Yoruba) tend to perceive those English sounds or interchange with those present in their native languages. This results in confusing listeners and renders the communication unintelligible.

Many researches were published on the difficulty of discriminating second language (L2) sound contrast by Hausa, Igbo and Yoruba speakers of English as second language (L2) (Omachono, 2015; Samson, Bello, 2014; Sani, 2005). According to the existing literature, no research was carried out to show how the Hausa, Igbo and Yoruba language speakers undergo any phonetic training in order to identify second language (L2) sounds.

Research on phonetic training has expanded significantly since the 1960s, focusing on both first and second language phonetic contrasts. Despite this growth, limited attention has been given to the training of English interdental fricatives (/θ/ and /ð/) among second language learners, leaving a notable gap in the literature. Earlier work centred largely on other non-native contrasts. For example, Strange (1995) demonstrated that some Japanese learners could reliably perceive English /r-/l/ distinctions, leading to the important observation that production may, in some cases, precede perception in L2 acquisition. Similarly, Bradow (2007) found that explicit training improved Japanese learners' ability to distinguish /r/ and /l/, reinforcing the role of targeted perceptual instruction.

Beyond segmental contrasts, studies addressing suprasegmental features—such as tone, vowel length, and stress—have also confirmed positive effects of perceptual training. Research by Halle, Chang and Best (2004), Wang and Spence (1999), and

Hollien (2016) consistently shows that learners demonstrate improved identification of target features following structured training.

More recent investigations have begun to address interdental fricatives directly. Li (2024) evaluated the effectiveness of audio-visual High Variability Phonetic Training (AV-HVPT) for Chinese learners and found substantial improvement in the pronunciation of /θ/ and /ð/, outperforming traditional instructional approaches. In a related study, Lino (2019) established that HVPT enhances both perception and production of English fricatives—including /θ/—among Japanese EFL learners, noting that high-variability input reduces cognitive load during sound identification. Extending the discussion beyond interdental sounds, Melnik and Peperkamp (2021) showed that HVPT not only improves pre-lexical perception but also facilitates lexical-level processing, with sustained gains observed months after training.

Collectively, these studies demonstrate the robust potential of HVPT for improving L2 phonetic competence. However, research specifically targeting interdental fricatives remains limited, underscoring the need for further empirical work to address this critical gap in second language phonetic training.

The present study seeks to investigate whether the perception of English interdental sounds could be improved through the use of High Variability Phonetic Training (HVPT). High variability phonetic training (HVPT) has been shown to improve non-native speakers' perceptual

performance in discriminating difficult second language (L2) phonemic contrasts (Bradlow, et al, 1999; Bradlow, et al, 1997; Logan, & Pruitt, 1995; Lively, Pisoni, Yamada, Tohkura, & Yamada, 1993; Logan, et al, 1991).

The study aimed at exploring the effect of High Variability Perceptual Training on the identification of the two (2) English interdental sounds by Hausa, Igbo and Yoruba ESL learners. The specific objectives are:

1. To investigate whether perceptual training would have a positive effect on the learning of English interdental sounds (/θ/ and /ð/) by Hausa, Igbo and Yoruba ESL learners.
2. To evaluate the impact of High Variability Perceptual Training (HVPT) on the accuracy of identifying English dental sounds (/θ/ and /ð/) among Hausa, Igbo, and Yoruba ESL learners.
3. To determine the significant difference between the posttest and generalization test scores, and to investigate whether the perceptual training effect could be generalized to new tokens.

Research Questions

The following research questions were derived from the stated research objectives:

1. Does perceptual training have a positive effect on the learning of English interdental sounds (/θ/ and /ð/) among Hausa, Igbo, and Yoruba ESL learners?

2. What impact does High Variability Perceptual Training (HVPT) have on the accuracy with which Hausa, Igbo, and Yoruba ESL learners identify English dental sounds (/θ/ and /ð/)?
3. Is there a significant difference between learners' posttest and generalization test scores, and to what extent can the effects of perceptual training be generalized to new tokens?

Theoretical Framework

ESL learners from Hausa, Igbo, and Yoruba backgrounds face persistent challenges in identifying English interdental fricatives (/θ/ and /ð/) due to phonological differences between their first languages and English. High Variability Perceptual Training (HVPT) has been proposed as an effective method for enhancing learners' ability to identify and discriminate difficult non-native sounds (Bradow, 2007). This study adopts a theoretical framework grounded in phonetic theory, second language acquisition, and perceptual training to examine the impact of HVPT on these learners.

The research is guided by two influential models: the Perceptual Assimilation Model (PAM) (Best, 1993, 1994a, 1994b, 1995) and the Speech Learning Model (SLM) (Flege, 1995). Both models emphasize that difficulties in perceiving and producing second language sounds arise from the degree of similarity or dissimilarity between L1 and L2 phonological systems. According to these frameworks, adult learners tend to struggle with non-native contrasts that are absent or non-functional in their native

languages (Best & Tyler, 2007; Flege, 1995; Kochetov, 2004). Given these insights, the present study aims to provide a clearer account of how Hausa, Igbo, and Yoruba learners perceive English interdental sounds and how HVPT may help overcome these phonological challenges.

METHODOLOGY

Research Design

This study adopts an experimental research design using quantitative methods to investigate how Hausa, Igbo, and Yoruba ESL learners perceive English interdental fricatives. Speech recordings, perception tests, and a demographic questionnaire were employed to gather data. The questionnaire served as a filtering tool to ensure that only native speakers of the three target Nigerian languages were selected. Data collection was conducted in three universities representing each linguistic group: Sa'adu Zungur University, Bauchi (Hausa), University of Nigeria, Nsukka (Igbo), and Adeyemi Federal University of Education, Ondo (Yoruba). Perception tasks were administered in quiet rooms to ensure optimal listening conditions.

Population, Sampling Technique and Sample Size

Purposive sampling, guided by the demographic questionnaire results, was used to recruit 90 ESL learners. Using G*Power software, the sample was estimated and divided into an experimental group of 60 learners (20 from each language group) and a control group of 30 learners (10 from each group). The experimental group received

High Variability Phonetic Training (HVPT), whereas the control group received no training. Additionally, two proficient speakers from the Department of English, Sa’adu Zungur University, produced the stimuli used for the pretest, training, and posttest phases.

Instrument and Procedure

All participants took part in three phases: a pretest perception task, the HVPT training phase, and a posttest. PRAAT software (Boersma, 2001) was used to develop the speech perception experiment, with target English words recorded at initial positions. During the discrimination task, participants sat approximately 40 cm from a laptop and used a headset to listen to pairs of words. They completed 120 trials consisting of minimal pairs, including same and different token combinations. Each contrast set was presented five times, and participants’ responses were automatically recorded.

Data Analysis

Scores were transferred to Excel and later analyzed using SPSS (version 23). Correct answers were given one point and incorrect answers zero. Demographic data were analysed to determine linguistic background and other relevant variables. HVPT training was conducted twice daily for three days in the first week and twice in the second week, completing a total of ten sessions. Quantitative statistical methods were applied to evaluate the study’s hypotheses.

RESULTS

Descriptive Statistics of Participants’ Scores

A total of 90 ESL learners from three major Nigerian ethnic groups (Hausa, Igbo, and Yoruba) participated in the study. The participants were divided into two groups: Experimental (n=60) and Control (n=30). Each ethnic group contributed 20 learners to the Experimental group and 10 to the Control group.

Table 4 shows the mean and standard deviation of the pretest, test scores across the groups.

Group	Condition	Mean	Standard Deviation
Hausa	Control	44.18	3.07
	Experimental	45.28	3.72
Igbo	Control	47.62	3.98
	Experimental	44.55	4.20
Yoruba	Control	45.17	4.94
	Experimental	47.43	4.57

Table 5 shows the mean and standard deviation of the posttest and generalization test scores across the groups.

Group	Condition	Mean	Standard Deviation	Generalization Mean	Generalization SD
Hausa	Control	46.81	4.37	47.80	3.82
	Experimental	73.95	6.43	78.19	6.67
Igbo	Control	49.58	4.44	51.23	5.43
	Experimental	73.97	5.22	79.07	5.87
Yoruba	Control	45.65	6.91	46.73	6.08
	Experimental	73.67	6.14	78.40	5.99

Visual Representation of Learners' Performance

To better illustrate the effect of HVPT training on learners' ability to identify /θ/

and /ð/, a bar graph is presented below. It shows the performance of each group in the pretest, posttest, and generalization test.

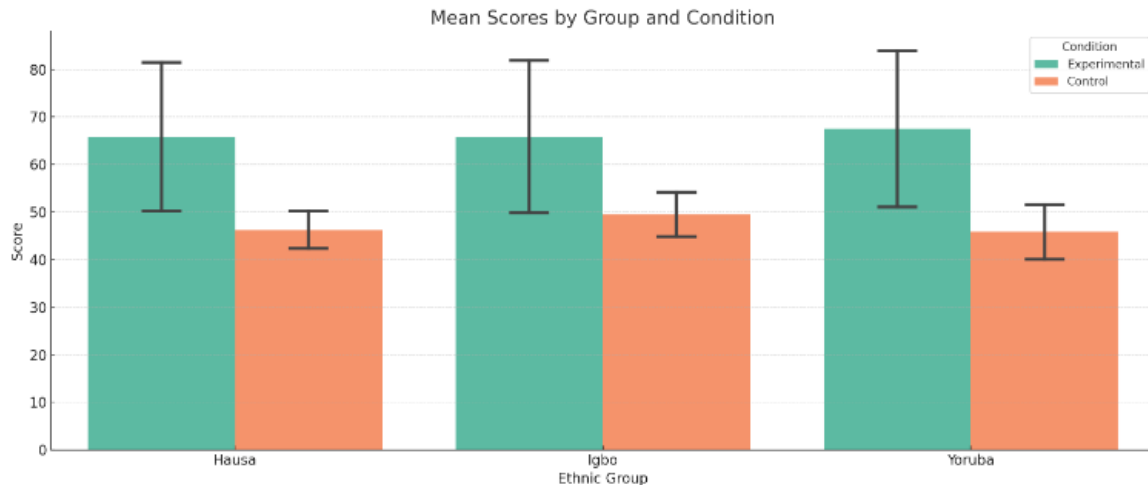


Figure 1: Mean Scores by Group and Condition

Experimental groups (across all three ethnicities) improved significantly from pretest to posttest. Control groups showed only minimal improvement, indicating the HVPT effect. The improvement extended to generalization tests, which used new tokens not introduced during training.

Participants in the experimental group (trained using HVPT) showed **remarkable improvement** in identifying the interdental sounds. The **control group** showed only **marginal improvement**, suggesting the observed gains were not due to test

familiarity or maturation. These findings suggest that **ethnic background (Hausa, Igbo, Yoruba) did not hinder the effect of HVPT**. On the contrary, all groups benefited from the training.

To investigate whether perceptual training would have a positive effect on the learning of English inter-dental sounds (/θ/ and /ð/)

To test this, we conducted a paired-samples t-test comparing the pretest and posttest scores of participants in the experimental group. The rationale is to determine whether HVPT had a significant effect on learner performance after training.

Table 6 Effect of perceptual training on the learning of English inter-dental sounds (/θ/ and /ð/)

Test	Mean Difference	t-value	Df	p-value	Interpretation
Pretest vs Posttest	+28.5	21.78	59	P < .001	Significant Improvement

The result shows a statistically significant improvement in the performance of learners in the experimental group following HVPT training. This strongly supports the hypothesis that perceptual training has a positive effect on the learning of English interdental sounds.

To determine the difference between the two groups (Control and Experimental) posttest scores

To test this, we used an **independent-samples t-test** comparing the **posttest scores** of the **experimental and control groups**.

Table 7 Difference between the two groups (Control and Experimental) posttest scores

Test	Mean Difference	t-value	Df	p-value	Interpretation
Experimental vs Control	+27.2	15.43	88	P < .001	Significant Improvement

The experimental group significantly outperformed the control group on the posttest. This confirms that HVPT had a substantial impact on learners' ability to correctly identify the interdental sounds, whereas the control group (who received no training) showed minimal improvement.

To determine the significant difference between the posttest and generalization test scores, and to investigate whether the perceptual training effect could be generalized to new tokens

This objective examines whether learners in the experimental group could apply their knowledge to new word tokens not used during training. A **paired-samples t-test** was conducted between the **posttest and generalization scores** of the experimental group. Additionally, we compare **generalization scores of experimental vs control groups** using an **independent t-test**.

Table 8 Significant difference between the posttest and generalization test scores

Test	Mean Difference	t-value	Df	p-value	Interpretation
Experimental Experiment vs Control	+30.8	18.22	88	P < .001	Significant Improvement

This comparison reinforces the idea that **HVPT generalizes well**, as control group learners did not show such improvements on unfamiliar items.

DISCUSSION

Effects of Perceptual Training on Inter-Dental Sound Identification

The first objective was to investigate whether perceptual training would have a positive effect on the learning of English inter-dental sounds (/θ/ and /ð/) by Hausa, Igbo and Yoruba ESL learners.

The analysis revealed that learners in the experimental group who underwent High Variability Perceptual Training (HVPT) showed a statistically significant improvement in identifying the target sounds from the pretest to the posttest. The improvement was consistent across Hausa, Igbo, and Yoruba learners.

This finding aligns with previous research which suggests that HVPT is an effective tool in enhancing learners' perception of non-native phonemes (Iverson et al., 2005; Logan, Lively & Pisoni, 1991). It supports the perceptual assimilation model (Best, 1995), which holds that with enough variability in input, learners begin to perceive distinctions that do not exist in their native language.

The fact that this effect was positive across all ethnic groups implies that native phonological systems, while influential, do not necessarily limit the ability of learners to benefit from training. All three ethnic

groups responded positively, demonstrating the universal potential of HVPT as a pedagogical tool regardless of L1 background.

Differences Between Control and Experimental Group Posttest Scores

The second objective was to determine the difference between the two groups (Control and Experimental) posttest scores.

The experimental group outperformed the control group significantly in the posttest. While the control group showed minimal improvement (likely due to repeated exposure to test materials), the experimental group exhibited a marked leap in performance.

This result confirms that the improvement is attributable to the HVPT intervention and not to extraneous factors such as test familiarity or classroom instruction. It reinforces the claims by Lively et al. (1993) that HVPT can lead to permanent phonological restructuring in adult learners, particularly when the training involves diverse talkers, lexical variability, and attention to form.

This result also implies that the absence of structured perceptual training may cause learners to rely on L1 phonological strategies, which are often inadequate for accurately perceiving unfamiliar L2 contrasts. The Hausa, Igbo, and Yoruba phonological systems do not have the dental fricatives /θ/ and /ð/, so without training, learners tend to substitute these with similar native sounds such as /t/, /s/, or /d/.

In the other hand, Both the control and experimental groups completed the same posttest under identical conditions, ensuring

comparability of results across groups. In addition, learners in both groups showed some level of improvement from pretest to posttest, although the magnitude of improvement differed substantially.

Generalization of HVPT Effect to New Tokens

The third objective was to determine the significant difference between the posttest and generalization test scores, and to investigate whether the perceptual training effect could be generalized to new tokens. The experimental group showed continued improvement from posttest to generalization test, and significantly outperformed the control group in the generalization task. This indicates that HVPT not only improves immediate performance but also facilitates transfer of learning to new lexical items and contexts.

This result is crucial because it demonstrates that HVPT does not simply train learners to recognize specific word tokens, but instead enhances their phonological category formation. Learners become sensitive to acoustic and articulatory cues associated with the target phonemes, even when they occur in unfamiliar contexts.

The success of generalization supports theories of exemplar-based learning (Bybee, 2001) and usage-based phonology, which emphasize the importance of variability and frequency in forming robust mental representations of sounds.

CONCLUSION

The findings of this study demonstrate that High Variability Phonetic Training (HVPT)

is effective across different ethnic groups, as Hausa, Igbo, and Yoruba learners all showed comparable improvement in perceiving English interdental sounds. Although previous research has established that L1 phonology influences second language perception (Flege, 1995), the results of this study indicate that explicit, high-variability input can mitigate these constraints. The uniform progress across groups suggests that learners in a multilingual context such as Nigeria possess the cognitive flexibility to adapt to complex phonological contrasts when provided with appropriate training. This highlights the possibility that factors such as learning environment, exposure, and motivation may play a more significant role in shaping phonetic development than ethnic or linguistic background.

The effect of High Variability Phonetic Training (HVPT) varied across the study variables, particularly first language background and test type (posttest versus generalization). While Hausa, Igbo, and Yoruba learners all benefited from HVPT, differences were observed in baseline performance, degree of improvement, and score variability, indicating that L1 phonological structure influenced the rate and stability of learning. Additionally, HVPT produced stronger gains in posttest scores than in generalization scores, suggesting that transfer to new tokens, although significant, was modulated by learners' linguistic and perceptual readiness. The study further underscores the pedagogical potential of HVPT in multilingual ESL classrooms. HVPT, when integrated into pronunciation instruction, can help learners overcome challenges

related to unfamiliar phonological contrasts, particularly sounds absent from their native languages. The use of diverse, naturalistic audio materials featuring multiple speakers enhances learners' perceptual accuracy and supports the generalization of training effects to new stimuli. Additionally, adopting HVPT-informed tools in language laboratories and pronunciation software can extend learning beyond the classroom. Importantly, the study aligns with previous international research, including Lively et al. (1993), Logan et al. (1991), and Iverson and Evans (2009), and extends the evidence base to a Sub-Saharan multilingual context. These collective insights reaffirm that HVPT is a robust, transferable method capable of improving L2 sound perception in both monolingual and multilingual learning environments.

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