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Phonetic Training and Orthographic Outcomes in L2 Learners: A Comparative Study of High- and Low-Variability Input

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ABSTRACT

Phonological awareness and spelling accuracy are essential skills in second language (L2) learning, particularly in English, where sound–letter relationships are inconsistent. While high-variability phonetic training (HVPT) has been shown to improve learners' ability to perceive L2 sounds, its influence on orthographic development remains unclear. This study explores how both HVPT and low-variability phonetic training (LVPT) shape learners' auditory categorization and spelling performance. First-semester English learners were assigned to either HVPT, LVPT, or a control group, completing aural oddity tasks followed by dictation-based spelling tests. Results showed that HVPT significantly enhanced phonological categorization, while both HVPT and LVPT led to marked improvements in spelling—both for familiar words and previously unseen vocabulary. The control group showed no progress in either domain, underscoring the need for structured phonetic instruction. These findings suggest that auditory training not only sharpens perception but also supports written accuracy, highlighting the need to reexamine how variability in training design impacts L2 development.

Keywords: Auditory Perception, ESL Learners, Grapheme–Phoneme Correspondence, High-Variability Input, L2 Spelling, Orthographic Learning, Phonetic Training, Phonological Categorization, Second Language Acquisition, Variability in Instruction

INTRODUCTION

Learning a second language (L2) involves more than just memorizing vocabulary or mastering grammar—it requires developing both accurate phonological representations and a strong grasp of how those sounds are written. For learners who are already literate in their first language, this process is mediated by how letters map onto sounds, known as grapheme–phoneme correspondences (GPCs). In English, however, the mapping between sound and spelling is notoriously inconsistent. Learners must not only recognize and distinguish new speech sounds but also connect them to irregular and often unpredictable written forms (Kessler & Treiman, 2001; Frost, 2005). These challenges are particularly acute for beginners, whose limited exposure to the language makes early instructional choices especially critical.

High-variability phonetic training (HVPT), which uses multiple speakers to expose learners to varied pronunciations, has been shown to enhance the perception of unfamiliar L2 sound contrasts (Lively, Logan, & Pisoni, 1993; Thomson, 2018). This variability helps learners develop more flexible and robust auditory categories, improving their ability to distinguish difficult sounds (Flege, 1995). By contrast, low-variability phonetic training (LVPT), which limits exposure to a single voice or a narrow range of speakers, has received less attention. While LVPT may help learners focus on specific contrasts with fewer distractions (Strange, 2011; Bradlow et al., 1997), its broader benefits—especially for reading and spelling—remain less explored.

English offers a particularly rich setting for investigating the link between sound and spelling. As a global language, it's taught in a wide range of contexts, yet its deep orthography makes even common words hard to decode. Distinguishing between sounds like /θ/ and /ð/, or between /ɪ/ and /iː/, requires more than just listening skills. Learners must also understand how these subtle differences are represented in writing (Cook & Bassetti, 2005). Given the complexity of these tasks, it is important to examine whether training that improves sound perception also supports the development of spelling accuracy.

This study focuses on beginner learners of English and asks three central questions:

- Does auditory phonetic training support both sound perception and spelling accuracy? This explores whether improvements in auditory categorization extend to orthographic performance.
- Can learners generalize their GPC knowledge to unfamiliar words? These tests whether training effects transfer to new vocabulary beyond the taught items.
- How much voice variability is optimal for beginners? This investigates whether HVPT or

LVPT yields greater gains in phonological and orthographic learning at early stages of L2 exposure. By addressing these questions, the study aims to clarify how phonetic training—especially the degree of variability in auditory input—shapes both the perception and production of written language. The findings offer practical insights for L2 teaching and highlight the need for instructional approaches that bridge the gap between listening and literacy.

LITERATURE REVIEW

Phonetic training has become a central focus in second language (L2) acquisition research, especially in helping learners develop accurate mental representations of unfamiliar sounds. For learners of English—a language with an irregular and opaque sound–spelling system—both perceptual and orthographic challenges are prominent. Most studies in this area have concentrated on how training enhances auditory discrimination, yet its influence on spelling and grapheme–phoneme correspondences (GPCs) remains less understood.

High- and Low-Variability Phonetic Training

High-variability phonetic training (HVPT) introduces learners to target sounds through multiple voices, typically differing in gender, accent, and speaking style. This method is designed to stretch learners' perceptual boundaries by exposing them to natural variability. As a result, learners tend to develop more flexible and generalized phonemic categories (Lively et al., 1994; Thomson, 2018). Evidence suggests that HVPT facilitates the acquisition of difficult contrasts, such as /r/–/l/ for Japanese learners or front vowel distinctions in English, and that these improvements often extend beyond the training context (Pisoni & Lively, 1995; Earle & Myers, 2014).

In contrast, low-variability phonetic training (LVPT) limits exposure to a single voice or a narrow range of speakers. While it lacks the breadth of HVPT, it may benefit beginners by reducing cognitive load and allowing focused attention on fine phonetic detail (Bradlow et al., 1997; Strange, 2011). Some studies suggest that LVPT can support accurate initial category formation, particularly in early stages of learning (Barcroft & Sommers, 2005), though its transferability and durability have been questioned. Despite emerging interest, direct comparisons between HVPT and LVPT—particularly in relation to both phonological and orthographic learning—are still rare (Brekelmans et al., 2022).

Orthographic Learning and Sound–Spelling Mapping

Orthographic learning in L2 is shaped by the consistency—or lack thereof—between what learners hear and how words are written. In English, with its deep orthography, learners often struggle to align phonological input with written output. The same sound may appear in various spellings (e.g., /f/ in *fun*, *phone*, *cough*), and the same letter combination may represent different sounds across words. This unpredictability complicates GPC acquisition and can result in unstable phonological representations (Hayes-Harb & Hacking, 2015; Bassetti et al., 2015).

Despite these challenges, relatively little research has examined how phonetic training influences spelling. There is reason to believe that improved auditory perception could support more accurate internal mappings between sounds and letters, especially for learners who rely on orthography to scaffold their learning (Frost, 2005; Cook & Bassetti, 2005). The question remains whether training aimed at sound perception can also benefit learners' orthographic accuracy.

Generalization of GPC Knowledge

Generalization—the ability to apply learned sound–spelling mappings to new words—is a key indicator of meaningful learning. HVPT, by design, promotes generalization by offering varied input, training learners to recognize invariant phonetic features across different contexts (Thomson, 2018). For example, Melnik and

Peperkamp (2021) found that HVPT helped French learners of English process unfamiliar lexical items more efficiently, suggesting that variability fosters adaptability.

The potential for LVPT to support generalization is less clear. Its strength may lie in stabilizing early learning rather than enabling transfer. However, this distinction remains underexplored, particularly with regard to orthographic learning. This study aims to address that gap.

Training Variability and the Beginner Learner

An open question in the literature is how much variability is optimal for beginner learners. While HVPT is often considered the most effective training format overall, some research suggests that its benefits depend on learners' proficiency. For example, Wong (2014) observed that advanced learners benefited more from HVPT, whereas beginners sometimes performed equally well with LVPT. One explanation is that early learners may find highly variable input overwhelming, especially when cognitive resources are limited. Understanding which type of input is best suited to different stages of learning remains a key concern for instructional design.

Rationale for the Present Study

To date, few studies have directly compared HVPT and LVPT in terms of their effects on both phonological and orthographic development in beginner L2 learners. Even fewer have examined how training influences the generalization of GPC knowledge to unfamiliar words. By addressing these gaps, the present study contributes to a more comprehensive understanding of how auditory training supports both perception and literacy in L2 acquisition.

METHOD

This study used a mixed-methods design to investigate how high-variability (HVPT) and low-variability phonetic training (LVPT) affect the phonological and orthographic development of beginner-level English learners. A mixed approach was selected to combine quantitative measures of perceptual and spelling performance with qualitative insights from learner feedback. This allowed for a more nuanced view of how learners responded to different training conditions (Creswell & Plano Clark, 2011; Dörnyei, 2007).

The design was grounded in theoretical models that support the role of variability in shaping perceptual categories (Pisoni & Lively, 1995) while also recognizing evidence suggesting that reduced variability may benefit early-stage learners by easing cognitive demands (Barcroft & Sommers, 2005). The following sections describe the participants, procedures, materials, and analytic strategies used in the study.

Participants

Thirty adult learners enrolled in a first-semester English course at a university took part in the study. All had minimal exposure to English and no formal prior instruction. Importantly, they were literate in their first language (L1), which employed a different orthographic system from English. Participants were randomly assigned to one of three groups:

1. HVPT group (n = 12): Received training using auditory stimuli from multiple voices (two male, two female).
2. LVPT group (n = 12): Received training using auditory stimuli from a single voice.
3. Control group (n = 6): Did not undergo any phonetic training but participated in all pre- and post-testing.

Procedure

The study spanned a full 15-week semester, with phonetic training and assessments concentrated in the early part of the term. The procedure consisted of five stages:

Stage 1: Pre-Test. All participants completed baseline measures, which included:

The Language Experience and Proficiency Questionnaire (LEAP-Q) to document linguistic background (Marian et al., 2007).

- A dictation-based spelling task involving 60 real English words, targeting a range of familiar and unfamiliar phonemes.
- An aural oddity task using pseudoword triplets to assess phoneme discrimination.

Stage 2: Training (Experimental Groups Only). Participants in the HVPT and LVPT groups completed six hours of phonetic training over two weeks.

- Training used aural oddity tasks focused on English phonemes known to challenge L2 learners (e.g., /θ/, /ð/, /ɪ/, /iː/).
- Feedback was immediate and visual, with corrective cues for incorrect responses.

- The HVPT group heard the target phonemes produced by four different speakers; the LVPT group heard only one consistent speaker.

Stage 3: Mid-Test. A mid-term assessment followed the training:

- An updated aural oddity task using both trained and novel stimuli measured perceptual generalization.
- A dictation spelling task tested recall of words introduced during training.

Stage 4: Post-Test 1. At the semester's end, all participants completed:

- A four-voice aural oddity task to reassess phonological categorization.
- A dictation spelling task with both trained and untrained words to examine GPC generalization.

Stage 5: Post-Test 2. Two weeks after instruction concluded, a delayed post-test assessed retention:

- Participants completed a final dictation task with novel words using familiar GPCs.
- An additional aural oddity task using new stimuli tested long-term perceptual stability.

MATERIALS

Auditory Stimuli. The study used two types of materials:

- **Pseudowords** for the aural oddity tasks, designed to contrast key English vowel and consonant sounds (e.g., /p/-/b/, /ɪ/-/iː/).
- **Real words** for dictation tasks, selected from beginner-level English textbooks and curated online resources

Feedback System. During training, participants received immediate on-screen feedback: "Correct" or "Incorrect," with additional cues to explain errors when applicable.

Task Design. This included (1) Dictation tasks included familiar course vocabulary and phonotactically plausible but untaught novel words, (2) Tasks were designed to isolate key GPC contrasts, ensuring tight control over phonological and orthographic variables.

Data Analysis

Phonological Categorization. Participants' responses in aural oddity tasks were analyzed using mixed-effects regression models to account for individual and item-level variability.

Orthographic Accuracy. Spelling performance was assessed using the Normalized Damerau-Levenshtein Distance (NDLD), a metric that captures the number of edits needed to match a learner's spelling to the target word. This provided a fine-grained view of spelling errors and their severity.

Comparative Analyses. Training group performance was compared across all test stages using ANOVA and planned contrasts. Effect sizes were computed to assess the practical significance of findings.

Qualitative Data. Participant reflections on training tasks were collected through post-study surveys. These provided insight into perceived task difficulty, engagement, and learner preferences.

RESULTS

This section presents the findings according to the three research questions, focusing on (1) the impact of phonetic training on phonological and orthographic performance, (2) the generalization of grapheme–phoneme correspondence (GPC) knowledge to novel words, and (3) the role of variability in auditory training.

Effects of Phonetic Training on Phonological and Orthographic Domains

Phonetic training significantly enhanced both sound perception and spelling accuracy, though the two training types produced different patterns of improvement.

Phonological Categorization

The HVPT group showed a substantial increase in their ability to discriminate vowel contrasts. Accuracy rose from 79% at pre-test to 91% at post-test ($p < 0.02$). The LVPT group also improved, though less markedly—from 82% to 87%—and this difference was not statistically significant ($p > 0.05$). (see Table 1 for detailed results).

Table 1. Phonological Categorization (Vowel Contrasts)

Group	Pre-Test	Post-Test 1	p-value
HVPT	**79%**	**91%**	**< 0.02**
LVPT	**82%**	**87%**	**> 0.05**

Orthographic Accuracy

Both HVPT and LVPT groups showed strong gains in spelling familiar words. The HVPT group's NDLD score improved from 0.38 to 0.08, while the LVPT group's improved from 0.42 to 0.10. Both gains were highly significant ($p < 0.001$), indicating notable improvements in orthographic encoding, (summarized in Table 2).

Table 2. Spelling Accuracy (Normalized Damerau-Levenshtein Distance)

Group	Pre-Test	Post-Test 1	p-value
HVPT	0.38	0.08	< 0.001
LVPT	0.42	0.10	< 0.001

Generalization to Novel Vocabulary

Training effects extended to untaught words, suggesting successful generalization of GPC knowledge. The HVPT group's NDLD scores for novel words improved from 0.46 at pre-test to 0.10 at post-test 2. The LVPT group showed similar, though slightly smaller, gains—from 0.48 to 0.15. Both groups' improvements were statistically significant (HVPT: $p < 0.001$; LVPT: $p < 0.01$). The control group showed no change (NDLD remained at 0.42), confirming that improvements were not due to incidental exposure. (see Table 3 for group comparisons across test stages).

Table 3. Generalization to Novel Words (NDLD Scores)

Group	Pre-Test	Post-Test 1	Post-Test 2	p-value
HVPT	0.46	0.12	0.10	< 0.001
LVPT	0.48	0.15	0.15	< 0.01
Control	0.42	0.42	0.42	n.s.

Impact of Voice Variability in Auditory Training. Voice variability produced differing effects across the two domains. HVPT yielded superior results in phonological categorization, while both HVPT and LVPT led to significant, comparable gains in spelling.

At Post-Test 1, the HVPT group reached 91% accuracy for vowel contrasts, compared to 87% for LVPT. In spelling, NDLD scores were 0.08 for HVPT and 0.10 for LVPT—both showing strong gains from baseline and sustained at Post-Test 2 (HVPT: 0.10; LVPT: 0.15). The control group's scores remained unchanged. These patterns are also reflected in Figure 1.

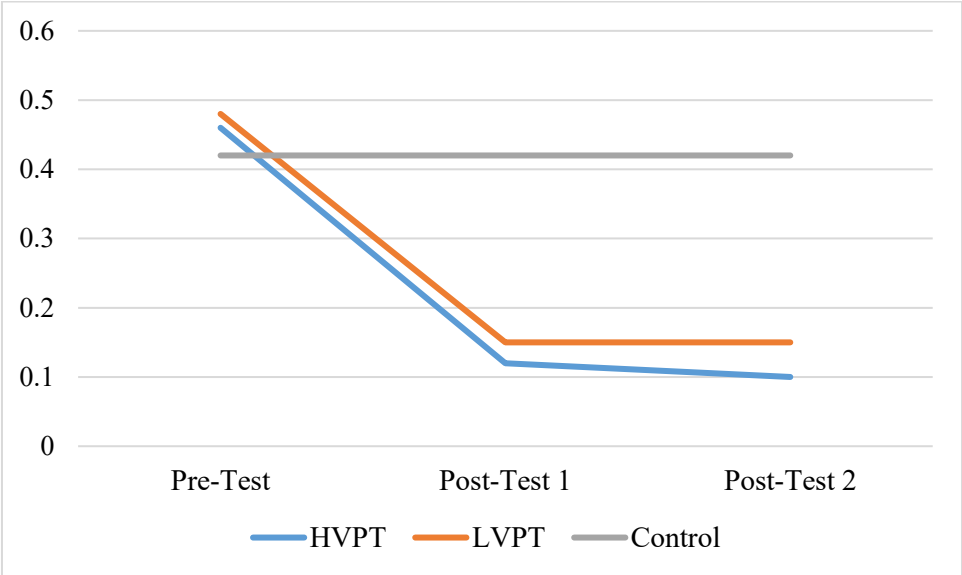

Figure 1. Generalization of GPC Knowledge to Novel Words (NDLD Scores)

Here is the visual summary of NDLD scores across test phases, showing how the HVPT and LVPT groups improved in spelling unfamiliar words over time, while the control group showed no change. Let me know if you'd like a separate chart for phonological accuracy as well. A concise overview is presented in Table 4.

Table 4. Summary of Post-Test Performance

Group	Phonological Accuracy (Vowels)	Orthographic Accuracy (NDLD)
HVPT	91%	0.08
LVPT	87%	0.10

Summary of Key Findings

- HVPT was especially effective for improving phonological perception, with statistically significant gains in vowel contrast discrimination.
- Both HVPT and LVPT led to large, significant improvements in spelling accuracy for both trained and novel words.
- Generalization of GPC knowledge was evident in both groups but was more pronounced in the HVPT condition.
- Voice variability played a critical role in phonological learning, but its impact on orthographic development was less dependent on variability.
- These findings suggest that phonetic training—especially with varied input—supports both perception and spelling, and that learners can extend what they learn to new language contexts.

DISCUSSION

This study set out to examine how auditory phonetic training—particularly the degree of variability in voice input—affects beginner English learners' development in both sound perception and spelling accuracy. The findings offer a nuanced picture of how high- and low-variability training (HVPT and LVPT) support different dimensions of L2 acquisition.

Phonetic Training and Cross-Domain Gains

The results show that phonetic training does more than improve learners' ability to hear new sounds—it also strengthens their ability to spell them. This cross-domain effect was especially clear in the HVPT group, which showed significant improvement in both phonological categorization and orthographic accuracy. Learners exposed to multiple voices developed more flexible auditory categories, likely because varied input helped them focus on essential phonetic features rather than speaker-specific cues (Lively et al., 1994; Thomson, 2018).

In contrast, the LVPT group demonstrated only modest gains in phonological accuracy, but their spelling performance improved just as much as that of the HVPT group. This finding is notable. It suggests that while LVPT may not push learners to generalize sound categories as broadly, it still provides enough stability to support robust sound–spelling mappings—perhaps by reducing cognitive load and allowing more focused attention on consistent input (Strange, 2011; Barcroft & Sommers, 2005).

Generalization to Untaught Vocabulary

A key aim of the study was to assess whether learners could transfer their GPC knowledge to unfamiliar words. Both HVPT and LVPT groups showed such generalization, with HVPT learners achieving slightly better performance. This supports the idea that exposure to variation helps learners abstract rules and apply them flexibly (Melnik & Peperkamp, 2021). However, the success of the LVPT group in this regard deserves attention. Their ability to generalize suggests that even limited input can be effective if training is structured and focused. It also raises questions about the minimum variability needed to trigger generalization in early-stage learners.

Voice Variability: One Size Does Not Fit All

Voice variability clearly influenced outcomes—but not uniformly across learning domains. HVPT was more effective for improving phoneme categorization, aligning with previous studies that stress the benefits of varied auditory input for developing perceptual flexibility (Pisoni & Lively, 1995; Earle & Myers, 2014). However, both HVPT and LVPT led to equivalent gains in spelling. This divergence suggests that while phonological learning benefits from variability, orthographic development may depend more on the consistency and clarity of input than on variability itself.

These findings resonate with Wong's (2014) observation that beginner learners may benefit from simpler, more predictable training formats. Beginners might be more sensitive to input overload when variability is too high, especially when they lack strong phonological or orthographic anchors. In this study, however, the HVPT group appeared to handle variability well, perhaps due to the use of feedback and structured practice.

Contributions to the Field

The study makes several contributions. First, it extends previous research on HVPT and LVPT by showing their differential effects not only on perception but also on orthographic learning. Second, it provides empirical support for the generalization of GPC knowledge—an area often discussed in theory but less commonly tested in practice. Third, by focusing on beginner learners, it adds insight into what type of training is most effective at the early stages of L2 acquisition, where foundational skills are being formed.

Limitations

Like any study, this one has limitations. The sample size was relatively small, and all participants shared a similar educational and linguistic background. Results may not generalize to learners from different L1s, especially those with alphabetic scripts more similar to English. In addition, the training period was short. A longer intervention might yield stronger differences between HVPT and LVPT or reveal delayed effects not captured in this study.

CONCLUSION AND IMPLICATIONS

This study examined how different types of phonetic training—high- and low-variability—affect both sound perception and spelling accuracy in beginner English learners. The findings offer clear evidence that auditory training benefits not only learners' ability to distinguish L2 phonemes but also their capacity to encode those sounds orthographically. High-variability training (HVPT) proved especially effective for phonological categorization, while both HVPT and low-variability training (LVPT) produced substantial and lasting gains in spelling accuracy.

Crucially, learners in both training conditions were able to transfer their grapheme–phoneme correspondence (GPC) knowledge to untaught words, indicating that generalization is possible even with limited input—provided that the training is systematic and targeted.

These results have direct implications for language instruction. First, they highlight the value of integrating phonetic training early in L2 programs, particularly for learners grappling with English's irregular orthography. Second, they suggest that HVPT should be prioritized when the instructional goal is to improve auditory discrimination, while LVPT may be sufficient—and perhaps preferable—for tasks focused on spelling or early decoding. Finally, both approaches appear effective in promoting transferable learning, making them adaptable tools for varied learner profiles

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