

Enhancing EFL Speaking Skills Through Dichotic Listening and Low-Pass Filtering: A Neuro Verbotonal Approach

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Abstract—This study investigates the efficacy of a Neuro Verbotonal Approach (NVT) in enhancing the speaking proficiency of Chinese EFL (English as a Foreign Language) learners by optimizing auditory input through acoustic modifications. Grounded in Verbotonal Theory, the approach employs dichotic listening and low-pass filtering to align auditory stimuli with the functional specializations of the brain's hemispheres. A quasi-experimental design was implemented with 64 first-year college students divided into experimental and control groups. Both groups performed identical tasks under identical conditions. However, the experimental group received optimized dichotic auditory input tailored for hemispheric lateralization, while the control group experienced conventional diotic listening. After 12 weeks, the experimental group demonstrated statistically significant improvements in speaking proficiency, with enhancements in phoneme accuracy, fluency, and intelligibility. Statistical analyses, including mean score and change score analyses, revealed the greater efficacy of the NVT approach. These findings demonstrate the potential of integrating neurophysiological features and precision language education principles into language pedagogy. The study also contributes to the advancement of Verbotonal Theory and proposes a scalable, technology-driven model for personalized language learning. Future research should explore broader applications and incorporate neuroimaging for a deeper understanding of brain-language interactions.

Index Terms—Neuro Verbotonal Approach, speaking proficiency, auditory input, dichotic listening

I. INTRODUCTION

Speaking remains one of the most challenging skills for second language (L2) learners, as it requires real-time control of stress, rhythm, intonation, and interaction. Additionally, it demands proficiency across multiple dimensions, including accuracy, fluency, complexity, and intelligibility (Brown, 2001; Derwing et al., 2009; Isaacs & Trofimovich, 2012; Goh & Burns, 2012; De Jong et al., 2012; Thornbury, 2000). To enhance L2 speaking proficiency, researchers have invested considerable effort into expanding learners' vocabulary, mastering grammar, boosting confidence, reducing anxiety, and increasing opportunities for language use (Willis, 1996; Nation, 1990; MacIntyre & Gregersen, 2012; Horwitz et al., 1986; Swain, 1985). Despite these efforts, speaking instruction often emphasizes rote learning of basic pronunciation and grammar rules, prioritizing accuracy over other aspects of performance. Moreover, considerable attention is directed toward minimizing the impact of affective filters through instructional methods and interactive practices (Renandya & Nguyen, 2022). Simultaneously, other researchers have sought alternative approaches to improving speaking skills. Among these, verbotonalists have focused on the role of optimal auditory stimuli in facilitating speaking proficiency.

It is widely recognized that learners' speech production is closely influenced by their perceptual representations of L2 speech sounds (Flege, 1995; McMurray et al., 2009; Bohn, 2017; Melnik-Leroy et al., 2022), as individuals rely heavily on auditory signals and acoustic cues to comprehend and respond appropriately (Goldinger, 1998; Demir, 2017). A substantial body of research indicates that fine phonetic details are not only integral to speech processing (McMurray et al., 2009) but also shape subsequent speech production (Goldinger, 1998), highlighting a strong interdependence between perception and production. However, learners often perceive L2 sounds through the filter of their native language, which can distort or mask their ability to accurately process the sounds of the target language. With the maturation of the brain and the myelination of the two hemispheres, this "mother tongue filter" becomes more entrenched, posing additional challenges for adult learners.

Nevertheless, arguably, adult learners are not precluded from achieving proficiency in a foreign language, provided they have access to an optimal learning environment and can leverage their residual capacities. Verbotonal Theory, a framework centered on perception, posits that modifications in perception result in corresponding improvements in

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speech production. It emphasizes the stimulation of the brain through optimal auditory input and the activation of learners' residual potential to achieve desirable outcomes (Guberina & Asp, 1981). Empirical studies have demonstrated the efficacy of verbotonal methods, particularly in enhancing phonetic accuracy and pronunciation, when learners are exposed to verbotonalized conditions (Lian, 1980; Alazard, 2013; He, 2014; Yang, 2016; Wen et al., 2020). However, earlier Verbotonal Approaches primarily focused on amplifying the perception of speech rhythms through low-pass filtering of auditory stimuli and integrating the auditory and vestibular systems into the learning process, often requiring substantial body movement (Guberina, 1972; Asp, 2006). While effective, such methods may be less feasible for implementation in densely populated or crowded educational settings.

Additionally, verbotonalists emphasize the importance of “the structural functioning of the brain and its optimal responses” (Roberge, 2018, p. 130) and assert that the most effective way to enhance perception is to “stimulate the brain” (García, 2018, p. 260). As the physiological foundation of language acquisition, the brain's pivotal role has gained recognition due to its neuroplasticity and dynamic responsiveness to linguistic stimuli. Scholarly discussions have consistently highlighted the functional dominance of cerebral hemispheres in distinct language-learning processes, offering critical insights into mechanisms of linguistic perception, processing, and target language internalization and production. Notably, despite established knowledge of hemispheric lateralization in language cognition and the brain's centrality to learning, the potential benefits of tailoring EFL instructional signals to learners' hemispheric specialization patterns remain underexplored in pedagogical research. The present study, as the first ever study of its kind, addresses this gap by exploring the effect of signal optimization on the development of EFL learners' speaking proficiency, taking into account the functional differences between the brain's hemispheres. Both theoretically and practically, this research contributes to the application of verbotonal principles within the neurolinguistic field and offers insights into maximizing the potential of Verbotonal approaches for speaking development.

II. LITERATURE REVIEW

A. *The Optimality Principle of Verbotonal Theory*

The Verbotonal Theory, pioneered by Petar Guberina in the 1950s in the field of speech pathology, was initially designed to assist individuals with hearing impairments in improving their speech intelligibility. Guberina's approach leverages residual auditory capabilities through tailored awareness-raising techniques, focusing on critical elements or optimal frequency bands of the sound system. In practice, a variety of treatment strategies have proven effective within the verbotonal framework, particularly vestibular and auditory-based methods such as diotic listening, low-pass filtered auditory signals, and vocalization integrated with whole-body movements. These techniques facilitate the reorganization of auditory perception, enabling clearer and more comprehensible speech production among the hearing impaired (Renard & van Vlasselaer, 1976; Asp, 2006). As articulated by Guberina and Asp (1981), the essence of the Verbotonal Approach lies in the interconnection between perceptual shifts and corresponding changes in speech patterns. A central objective of this methodology is to cultivate an ideal auditory environment to restructure and refine participants' language perception, a principle referred to as “Optimality” (Guberina, 1989).

Due to its substantial technological requirements, the Verbotonal Theory was initially applied in specialized clinical contexts, particularly in speech rehabilitation, diagnostic therapy, and interventions for conditions such as aphasia and autism (Małachowska, 2014; Koike, 2012; Ursache, 2017). Over time, however, the theory has been adapted for use in foreign language learning, where learners' prior experiences with their mother tongue often hinder the acquisition of target language features. When faced with a new language, learners frequently rely on deeply ingrained habits, predisposing them to subconsciously interpret information through the lens of their native language. These habits influence not only perception but also overall learning outcomes, making foreign language acquisition not unlike the rehabilitation of hearing impairment, keeping in mind that learners are far less likely to suffer from physical auditory impairments. Their “impairment” can be thought of not so much as a physical deficit but as a different way of organizing audition (Renard & van Vlasselaer, 1976).

From a verbotonal perspective, therefore, creating optimal learning environments that foster heightened awareness and facilitate perceptual transformation is critical for achieving language proficiency. The ultimate aim is to achieve “optimal learning” under “optimal conditions” and to obtain “optimal values” for acquiring an optimal command of the target language (Ursache, 2017).

B. *Lateralization of the Brain and Optimal Stimuli*

As Guberina posited, “the brain would function best if it were to receive the auditory stimuli for which the ear is most sensitive; it would be enriched by these optimal stimuli; and with time and training, it would be prepared to respond to more difficult tasks, less favorable stimuli” (Guberina & Asp, 1981, p. 2). This assertion underscores the indispensable role of the brain in language learning. A deeper examination of the brain's structure and function reveals a remarkable dichotomy in the form of the cerebral hemispheres, separated by the longitudinal fissure and interconnected by the corpus callosum. These two hemispheres differ not only in physical dimensions—with the right hemisphere often larger than the left (McGilchrist, 2019; Danesi, 2003)—but also in their functional specialization. This lateralization of cognitive processes, refined over millions of years of evolutionary development (Odisho, 2014), assigns

distinct roles to each hemisphere, with certain neural functions predominantly localized to one side (Warren, 1977; Dean, 1984; Levänen et al., 1996).

The human auditory system exhibits contralateral processing dominance, whereby primary neural projections from the left ear preferentially engage right-hemispheric networks, while right-ear inputs demonstrate stronger left-hemispheric connectivity due to the decussation of auditory fibers at the pontomedullary junction. Crucially, hemispheric specialization governs linguistic signal processing: Right-hemisphere dominance emerges for suprasegmental features—including prosodic contours, emotional prosody, and tonal variations—as evidenced by dichotic listening paradigms (Sininger & Bhatara, 2012; Friederici & Alter, 2004), where different auditory stimuli are presented simultaneously to each ear. Conversely, the left hemisphere demonstrates superior segmental-analytic processing, specializing in phonemic discrimination, lexical access, and morphosyntactic decoding (Shankweiler & Studdert-Kennedy, 1967; Gandour et al., 2002). Such functional asymmetry reflects evolutionary adaptations for parallel processing of complementary speech dimensions—the right hemisphere optimizing holistic prosodic parsing, while the left hemisphere prioritizes discrete linguistic unit extraction (Zatorre et al., 2002). This neurofunctional dichotomy presents untapped potential for auditory stimulus optimization in language pedagogy: Strategically lateralized input delivery could amplify neural resource allocation, potentially accelerating L2 phonological and pragmatic competence acquisition.

C. *The Optimality Principle in Prior Verbotonal Studies*

As a pioneer in the field of Verbotonal Theory, Petar Guberina initially applied his framework to the complex rehabilitation of hearing and speech for individuals struggling to develop intelligible speaking abilities. His approach aimed not to impose external stimuli that learners could not process but to maximize their residual potential capacities through various strategies. These included providing low-pass filtered audio signals, selecting favorable prosodic patterns, combining sounds more effectively, modifying the pronunciation of specific sounds, and incorporating optimal body movements to enhance the rhythm and intonation of speech (Asp, 1985; Asp & Kline, 2012; Asp et al., 2012). Despite notable successes, Guberina recognized the need for more effective tools when addressing the severe speech errors often observed among the hearing impaired (Guberina, 1972).

Later, Andrew Lian (1980) extended the application of Verbotonal Theory to teaching French prosodic structures. He devised and refined pedagogical procedures to heighten and reinforce learners' perceptual abilities, placing them in optimal conditions for acquiring the prosodic features of French. This method achieved significant success and established a protocol for the teaching/learning of prosody. With technological advancements, the Verbotonal Theory gradually expanded beyond Europe to other parts of the world, particularly East Asia of late. For example, in Japan, Hu and Uno (2005) applied a body-movement-based teaching method, inspired by verbotonal principles, to help beginners learn Chinese tonal pronunciation. After seven weeks of training, students showed significant improvement in distinguishing and pronouncing tonal patterns. Similarly, Klein (2010) incorporated verbotonal principles into EFL learning, identifying three effective pronunciation correction methods: prosodic correction, nuanced pronunciation, and facilitating surroundings. He described the verbotonal method as a “comprehensive and effective phonetic correction method in class” (Klein, 2010, p. 55).

In Korea, Kim et al. (2007) utilized an Optimal Frequency of Hearing approach to enhance English listening skills among middle school students. The results revealed significant improvement in both word- and sentence-level listening abilities. In China, researchers have increasingly explored verbotonal applications to address the challenges of improving EFL learners' speaking skills. For instance, He (2014) integrated verbotonal, prosody-based, corrective phonetics into a CALL-based (Computer-Assisted Language Learning) autonomous structure to optimize classroom and extracurricular activities. The experimental group outperformed the control group in all tested areas, including phoneme production, word reading, passage reading, oral interviews, pronunciation, comprehensibility, and fluency.

Yang (2016) focused on enhancing the speaking skills and phonological working memory of beginner English learners by reorganizing in-class sensitization sessions and optimizing out-of-class reinforcement. This approach significantly improved learners' phonological working memory and oral performance across various measures, such as vocabulary, grammar, pronunciation, fluency, and comprehensibility. Remarkably, students in the experimental group outperformed their peers and were placed first in provincial examinations, excelling even in content not explicitly taught during the intervention.

More recently, verbotonal research has increasingly intersected with neuroscience. Lian et al. (2020) investigated how the brain processes foreign language stimuli using dichotic listening techniques. They tested three signal modes: FL-R (filtered stimuli in the left ear and unfiltered stimuli in the right ear), L-FR (unfiltered stimuli in the left ear and filtered stimuli in the right ear), and FL-FR (filtered stimuli in both ears). Results showed that the FL-R mode optimally facilitated foreign language comprehension. Cai et al. (2021) further confirmed these findings using event-related potential (ERP) and functional magnetic resonance imaging (fMRI), concluding that the FL-R mode was “best suited for optimal processing” (Cai et al., 2021, p. 17). However, the practical implications of this mode for language learning remain underexplored.

In summary, the Verbotonal Theory has demonstrated significant pedagogical value in foreign language learning, particularly for phonetic correction and improving speaking accuracy and fluency. However, further research is needed

to identify optimal conditions for language learning, especially when incorporating neurophysiological features into pedagogical strategies.

D. The Neuro Verbotonal Approach

Referring to the principle of optimality, the application of Verbotonal Theory could be further enhanced by integrating the functional characteristics of brain hemispheres and the physical properties of input sounds. Building on previous verbotonal studies and guided by its optimality principle, a Neuro Verbotonal Approach (NVT) was proposed, incorporating the FL-R mode into Chinese EFL learning classrooms.

The NVT approach emphasizes two key dimensions. First, it attends to the brain's hemispheric advantages: the left hemisphere's dominance in the processing of linguistic categories (phonemes, morphemes etc.) and the right hemisphere's dominance in melodic and prosodic processing of language. Second, it highlights the pedagogical potential of physically modified auditory signals for second-language acquisition. To achieve this dual optimization, two crucial techniques were employed: dichotic listening and low-pass filtering. Dichotic listening, initially devised by Broadbent (1956) and later refined by Kimura (1961), involves the simultaneous presentation of two auditory stimuli to each ear, enabling a non-invasive exploration of hemispheric lateralization in the intact human brain. Low-pass filtering, a process that removes higher frequencies (typically above 320 Hz) from an auditory signal, preserves low-frequency components, rendering prosodic features more prominent. In low-pass filtered sentences, these prosodic cues help learners become more attuned to sentence intonation and rhythm (Guberina & Asp, 1981).

Compared to earlier Verbotonal Approaches, the newly developed NVT model places greater emphasis on the auditory system for stimulating the brain's perceptual mechanisms, rather than the vestibular system, which often involves substantial body movement. Furthermore, NVT utilizes the dichotic listening technique to optimize auditory input for each hemisphere, moving beyond traditional verbotonal methods that presented identical signals to both ears without accounting for hemispheric lateralization.

In summary, by integrating Verbotonal Theory with the neurological and functional specialization of the brain and leveraging dichotic listening and low-pass filtering techniques, the NVT approach optimizes auditory input at both the physical and neurofunctional levels. This alignment aims to deliver optimal stimuli to the most receptive brain hemisphere, facilitating enhanced language perception and production. In the present study, the NVT approach was applied within a Chinese college EFL learning context.

The study sought to address the following research question: Does NVT improve Chinese EFL learners' speaking performance? If so, in what ways?

III. METHODOLOGY

A. Research Design

The present study employed a quasi-experimental pretest-posttest design to evaluate the effectiveness of applying the NVT Approach in enhancing learners' speaking proficiency. Participants were divided into two groups—an experimental group (EG) and a control group (CG)—randomly assigned from a pool of students with comparable English-speaking proficiency. Both groups attended exactly the same online course but were exposed to different auditory conditions. The only difference was that the EG received optimized dichotic sentences, while the CG was presented with unmodified (natural) diotic sentences.

After completing identical training sessions, both groups were assessed again to evaluate their speaking performance. The comparison between the EG and CG provided insights into the impact of the NVT approach, while the analysis of pretest and posttest scores within each group revealed the extent of improvement in speaking proficiency. This dual comparison offered a comprehensive understanding of the NVT approach's effectiveness in facilitating English speaking development.

B. Participants

Participants in the present study were selected from second-semester, first-year non-English majors at a petrochemical university in Guangdong Province, China. A total of six Chemical Engineering classes were available, and two intact classes were chosen as the participants because they shared the same College English instructor, followed the same pedagogical approach, used identical learning materials, and had similar English proficiency levels as indicated by their English scores. This homogeneous setting minimized external variability.

One of the two selected classes was randomly assigned as the experimental group (EG), while the other was assigned as the control group (CG). To further control for potential confounding variables, additional measures were taken to address handedness (Annett, 1970) and undiagnosed hearing issues, as both factors can significantly influence lateral auditory processing (Khalifa et al., 1998). All participants were required to complete the "Edinburgh Handedness Inventory-Short Form" (Veale, 2014, p. 15) and self-report any hearing impairments prior to the main study. Based on the inventory results and self-reports, participants who were left-handed or reported hearing impairments were excluded from the study. Participants were informed of their right to withdraw from the study at any point. The final participant groups were then established, as shown in Table 1:

TABLE 1
DEMOGRAPHIC INFORMATION OF THE PARTICIPANTS

Groups		EG	CG
Number		32	32
Gender	Male	17(53%)	18(56%)
	Female	15(47%)	14(44%)
Age	<=18	7(22%)	5(16%)
	19	19(59%)	22(69%)
	20	6(19)	4(13%)
	>=21	0(0%)	1(3%)
Handedness		Strongly right-handed	Strongly right-handed
Hearing problems		No	No

C. Online Courseware

The students in the present study were trained using an online courseware developed by the researchers with the aid of several software tools: Audacity (version 3.0, an audio editing software; <https://www.audacityteam.org/>), Articulate 360 (version Storyline 3, an e-learning course-designing software; <https://www.articulate.com/>), and MOODLE (version 4.0, an open-source e-learning Course Management System; <https://moodle.org/>). The online courseware for both the control group (CG) and experimental group (EG) was identical in terms of learning materials, training duration, and pedagogical procedures, but differed in the listening mode. The CG received the unmodified materials, while the EG's materials were optimized into a dichotic listening mode through a modification process.

The learning materials were drawn from authentic conversations found in IELTS trial audio recordings, chosen for their authoritative and high-quality content (Aryadoust, 2013; Golubovskaya & Tikhonova, 2015), which ensured that the auditory cues remained intact despite digital modifications. These conversations were excerpted from the CDs accompanying the published trial books IELTS 11 (2016) and IELTS 12 (2017), issued by Cambridge University Press in China. The selected sentences were isolated, modified, grouped, and then uploaded to the Moodle platform for access.

The modification of the sentences involved a three-step process using Audacity (version 2.3.3): Step 1: "Splitting" the signal into independent left and right channels; Step 2: "Filtering" the left channel while leaving the right channel intact; and Step 3: "Resynthesizing" by combining the filtered left channel and the unmodified right channel, as illustrated below in Figure 1 (using the sentence "Let me just see" as an example). After processing all sentences, they were uploaded to the Moodle platform, completing the online courseware. Participants could then register, access the training, and be automatically directed to their designated content based on group allocation, ensuring that each group had access to the specific listening mode tailored for them.

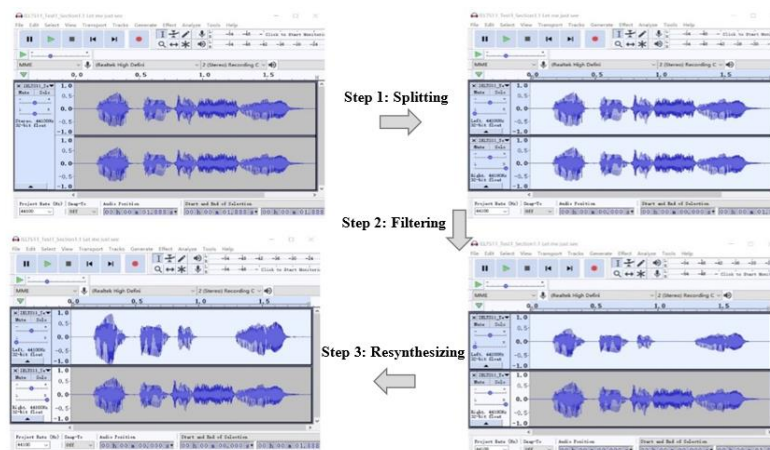


Figure 1. Procedure of Signal Modification

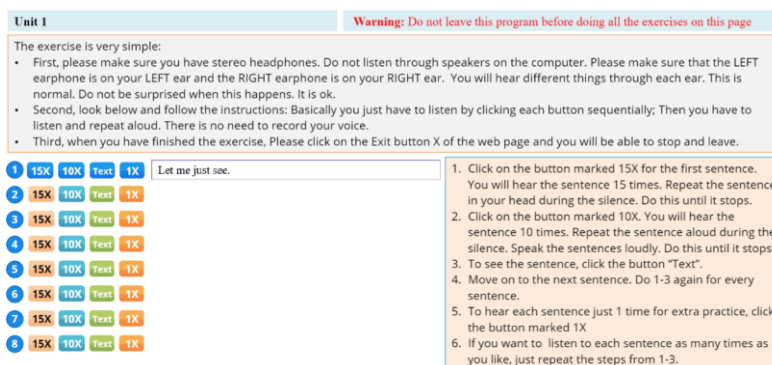


Figure 2: Interface of Unit 1

When the training commenced, students in both groups logged into the online course, where they had been pre-grouped through the Moodle system. The course comprised 24 units, with each unit containing 8 sentences to ensure the training sessions remained within a 45-minute time limit. To proceed through the course, students were required to click each button in sequence, beginning with “15X,” followed by “10X,” “Text,” and finally “1X” This sequence allowed students to unlock the next button while ensuring that each sentence was played the designated number of times, providing sufficient repetition to aid internalization (see Figure 2, using the interface of Unit 1 as an example).

D. Pedagogical Procedure

The present study developed a “3R” training protocol for each unit, drawing from several previous verbotonal studies (Lian, 1980; Zhang, 2006; Yang, 2016). Students in both groups were required to follow a sequential training process of “relaxation, repetition, and reflection” during each session (as shown in Table 2). The Relaxation phase involved students taking deep breaths and listening to a short 5-minute period of soft music, while ensuring their earphones were properly positioned with the “L” and “R” labels correctly aligned. The Repetition phase, lasting 30 minutes, required students to listen to each sentence silently 15 times using the “15X” button, engaging in inner repetition and humming to internalize the sentence’s structure. Following this, students performed “shadowing” (Cherry, 1953), which involved repeating the sentence verbally and loudly to practice vocalization and reconstruct speech (Lian, 1980; Luu et al., 2021). This process was repeated 10 times using the “10X” button to ensure quality shadowing. Students could then confirm their understanding by using the “Text” and “1X” buttons to view the sentence written out or engage in additional listening and repetition. Once students had familiarized themselves with all 8 sentences in the Repetition phase, they moved to the Reflection phase (10 minutes). Here, students shared their thoughts with partners, discussing the accuracy and fluidity of their utterances, further solidifying their perception and articulation of the target sentences. The Reflection phase marked the conclusion of each training unit. Training sessions were scheduled twice a week, lasting one credit hour each in a language lab. In the NVT model, the teacher’s role is limited to primarily setting up a self-managed online system and addressing technical issues.

TABLE 2
STEPS OF A TRAINING SESSION

Steps	Treatment in each step
Step 1 Relaxation (5 minutes)	Deep Breath or Light Music
Step 2 Repetition (30minutes)	Silent Listening (15X, Humming or Inner repetition) Verbal Repetition (10 X, Listening and Shadowing)
Step 3 Reflection (10minutes)	Text and 1X Listening Communication and conversation

E. Data Collection

An overall speaking proficiency test was used to assess participants’ speaking performance both before the training began and after it concluded. Since there was no established consensus on the design of speaking proficiency tests, the present study adapted a test previously used in He’s (2014) study with minor modifications in content. The test comprised four sections: Phoneme Reading, Word Reading, Passage Reading, and Short Question Responding (as shown in Table 3), which incorporated both phonemic and prosodic features. The pretest and posttest were identical in structure and score allocation. In both tests, participants were asked to read aloud the printed contents from Parts 1 to 3 and respond to the questions listed in Part 4. Their responses were audio-recorded in mp3 format for subsequent evaluation.

TABLE 3
TASKS IN PRETEST AND POSTTEST

Tasks	Contents	Time	Scoring
Part 1 Phoneme reading	20 transcriptions	1 minute	20%
Part 2 Word reading	30 words	1 minute	30%
Part 3 Passage Reading	100word passage	2 minutes	25%
Part 4 Short Question Responding	5 questions	3 minutes	25%

The entire rating process was conducted blindly. Three experienced English teachers (two non-native and one native) were invited to assess each audio recording based on factors such as correctness, appropriateness, intelligibility, accuracy, and fluency. The raters were unable to identify the participants or distinguish between pretest and posttest recordings, as the audio files were anonymized, numbered, and randomly reordered. The final score for each participant was calculated by averaging the scores given by the raters. To ensure the reliability of the results, inter-rater reliability was calculated using Pearson's correlation coefficient (as shown in Table 4). The results indicated a high level of consistency among the raters, confirming that the measurements from the pretest and posttest were reliable.

TABLE 4
INTER-RATER CORRELATIONS IN THE PRETEST AND POSTTEST

	Inter-rater Correlations		
	R1&R2	R1&R3	R2&R3
Pretest	.714**	.636**	.739**
Posttest	.789**	.745**	.736**

** . Correlation is significant at the 0.01 level (2-tailed). R=Rater

F. Data Analysis

To evaluate the effect of the optimized language input on participants' speaking proficiency, both mean score analysis and change score analysis were employed. Mean score analysis is valuable for comparing the average performance of the two groups at different time points, while change score analysis provides a more precise measure of improvement by focusing on the difference between pretest and posttest scores for each individual (Dankel & Loenneke, 2021). In the following section, the students' performance in English speaking is first assessed using mean scores derived from the overall speaking proficiency tests before and after the treatment, followed by a change score analysis. All analyses were conducted using SPSS (version 29) and JASP (version 0.16.4.1).

IV. RESULTS AND DISCUSSION

A. Mean Score Analysis

First, to evaluate the intervention's impact on mean scores, descriptive statistics for each group's performance in the pretest and posttest are presented in Table 5. This includes sample size, median, mean, standard deviation, minimum, and maximum scores.

TABLE 5
DESCRIPTIVE STATISTICS FOR PRETEST AND POSTTEST SCORES

Test	Group	Number	Median	Mean	Std	Minimum	Maximum
Pretest	EG	32	57.0	57.06	9.00	35.67	72.67
	CG	32	58.33	57.11	7.16	44.17	72.17
Posttest	EG	32	62.5	63.32	7.91	48.33	78.00
	CG	32	59.83	59.33	5.94	46.17	73.33

Note. EG=Experimental group; CG=Control group

From Table 5, we observe that in the pretest, the mean score of the experimental group (EG) was 57.06, closely aligned with the control group (CG), whose mean score was 57.11. Although the highest scores in both groups were relatively high—72.67 for EG and 72.17 for CG—the average performance in the pretest was unsatisfactory, as both group means were below 60% of the total score.

In the posttest, the EG achieved a mean score of 63.32, surpassing the 60% threshold, while the CG mean score was 59.33, remaining below this threshold. Regarding the scale of improvement, the EG demonstrated an increase of 6.26 points, compared to 2.22 points in the CG, indicating that the EG outperformed the CG in terms of improvement.

The differences in mean scores for the pretest and posttest across both groups are illustrated in the following plot (Figure 3):

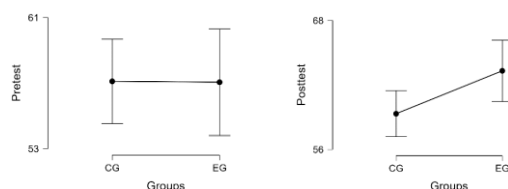


Figure 3. Descriptives Plots in Pretest and Posttest

Descriptive statistics revealed that the EG outperformed the CG. To further analyze the results, pretest and posttest scores for both groups were compared using two methods: an independent-samples t-test for between-group analysis and a paired-samples t-test for within-group analysis.

Between-group analysis: Independent samples t-test

In this study, the significance level was set at 0.05, and the confidence interval at 95%. Before conducting the independent-samples t-test, the normality of the data distribution was assessed using the Shapiro-Wilk test. The results indicated that the p-values for both groups in both the pretest and posttest were greater than 0.05, with $p = 0.40$ for CG and $p = 0.73$ for EG in the pretest, and $p = 0.25$ for CG and $p = 0.48$ for EG in the posttest. This confirmed that the scores for both groups followed a normal distribution in both tests. Details are provided in Table 6.

TABLE 6
TEST OF NORMALITY (SHAPIRO-WILK)

	Group	W	p
Pretest	CG	0.97	0.40
	EG	0.978	0.73
Posttest	CG	0.958	0.25
	EG	0.969	0.48

Note. Significant results suggest a deviation from normality.

As shown in Table 7, a comparison of the pretest scores between EG and CG revealed no statistically significant differences ($p = 0.98 > 0.05$), indicating that the two groups were at a comparable level of overall speaking proficiency prior to the intervention. In contrast, the posttest results showed a statistically significant difference between the groups ($p = 0.03 < 0.05$), with an effect size of $d = 0.57$, indicating a medium-level effect according to Cohen (1988). Moreover, the mean score of the EG exceeded that of the CG by 3.99 points, clearly demonstrating that the EG outperformed the CG following the intervention.

TABLE 7
COMPARISON BETWEEN EG AND CG IN THE PRETEST AND POSTTEST

Test	EG (N=32) Mean (SD)	CG (N=32) Mean (SD)	Difference EG-CG	P-value	Cohen's d
Pretest	57.06 (9.00)	57.11 (7.16)	-0.05	0.98	0.01
Posttest	63.32 (7.91)	59.33 (5.94)	3.99	0.03	-0.57

Note. EG=Experimental group; CG=Control group

Within-group analysis: Paired-samples t-test

To examine whether there were statistically significant differences within each group between the students' performance in the pretest and posttest, a paired-samples t-test was conducted (as shown in Table 8). For the EG, there were significant differences between the pretest scores and posttest scores, with $p < 0.001 < 0.05$, and an effect size of $d = 1.05$ (very large level). For the CG, there were significant differences as well. The means in the posttest were significantly higher than those in the pretest, with $p = 0.04 < 0.05$, and an effect size of $d = 0.39$ (low level).

TABLE 8
COMPARISON WITHIN EG AND CG IN THE PRETEST AND POSTTEST

Group	Pretest Mean (SD)	Posttest Mean (SD)	Difference Posttest-Pretest	P-value	Cohen's d
EG	57.06 (9.00)	63.32 (7.91)	6.26	<.001	1.05
CG	57.11 (7.16)	59.33 (5.94)	2.22	.04	0.39

Note. EG=Experimental group; CG=Control group

The result indicated that both groups' overall speaking proficiency was significantly improved in the experiment by both approaches used. However, in terms of performance improvement, as shown in Table 7, the EG improved by 6.26 whereas the CG improves by only 2.22, and the EG improved by 282.15% of the CG score – the EG generated an improvement almost 3 times greater than the improvement of the CG, which indicates that the NVT approach was much more effective than the traditional diotic method.

B. Change Score Analysis

In contrast to the mean score analysis in the previous part which focuses more in comparing the average performance of two groups at different time points (e.g., pre-test or post-test only), the change score analysis captures how much each participant improves (or regresses) over time, and it can reveal the true effect of an intervention, especially in cases where groups might have different starting points. The change score is usually defined as the difference between post-test and pre-test scores (post-test minus pre-test). In the present study, the descriptive statistics for each group's change scores are shown in the table below (Table 9), including the mean, standard deviation, etc.

TABLE 9
DESCRIPTIVE STATISTICS FOR CHANGE SCORES OF EG AND CG

Group	Number	Mean Change Score	Standard Deviation	Minimum	Maximum
EG	32	6.26	5.97	-4.17	21.66
CG	32	2.22	5.67	-6.50	16.50

Note. EG=Experimental group; CG=Control group

For the CG, the mean change score was 2.22, while for the EG, it was 6.26. The EG had more progress and less regression as indicated by the Maximum and Minimum in change scores.

An independent analysis revealed a statistically significant difference in change scores favouring the EG group, with Welch's t-test yielding $t = -2.78$ and $p=0.01$, and a medium-to-large effect size (Cohen's $d = 0.69$), as shown in Table 10. The p-value is less than the significance level of 0.05, indicating a statistically significant difference in the change scores between the EG and CG. The EG demonstrated a significantly greater improvement in scores compared to the CG after the intervention. This suggests that the optimized training method employed for the EG had a positive and measurable impact on their speaking proficiency.

TABLE 10
INDEPENDENT SAMPLES T-TEST OF CHANGE SCORES

	t	df	p	Cohen's d
Change Scores	-2.78	61.83	0.01	-0.69

Note. Welch's t-test.

Further analyses (as shown in Table 11) found that 84% of EG participants exhibited positive change compared to 69% in CG, and 31% of CG showed regressions versus only 16% in EG. In addition, 20 participants in EG versus 7 in CG achieved a meaningful improvement threshold of five points. Altogether, these metrics substantiate a notable and statistically meaningful advantage in the EG group, suggesting that the intervention produced both measurable and substantial gains in outcomes compared to CG.

TABLE 11
PROGRESS AND REGRESSION IN THE EG AND CG

Group	Number	Percent of Progress	Percent of Regression
EG	32	84%	16%
CG	32	69%	31%

In summary, the statistical analysis, either in terms of the mean score or the change score, revealed that the experimental group demonstrated substantially greater gains both in terms of statistical significance and effect size. The intervention of NVT, therefore, had a meaningful impact on the improvement of learners' overall speaking proficiency.

C. Discussion

The observed enhancement in learners' speaking proficiency substantiates the neuroplastic potential of verbotonal methodologies while expanding their theoretical foundations. This study not only corroborates prior findings on sensory optimization in language acquisition (Lian, 1980; Yang, 2016) but operationalizes the optimality principle through a neuromodulatory framework where engineered linguistic stimuli act as neurofunctional ligands binding to specialized cortical receptors (Poeppl & Assaneo, 2020). The experimental group's superior performance might stem from two neurocognitive innovations: (1) the Input Channel Specialization with the help of dichotic listening technique: Low-pass filtered left-ear inputs selectively engage right-hemisphere prosodic networks (Ethofer et al., 2009), while unfiltered right-ear stimuli optimize left-hemisphere phonological processing (Hugdahl & Westerhausen, 2010), and (2) neural resource decongestion achieved through frequency-specific filtering (low-pass 320Hz) that minimizes interhemispheric competition (Hickok & Poeppel, 2007) and reduces processing load (Lian, 2011). The results demonstrate that both the model of the signal and the mode for sending the signal need to be well-structured based on the receptor.

Moreover, in the verbotonal context, the teacher, by focusing on designing hemispherically optimized learning ecologies, becomes an assistant rather than an authority figure. The quasi-disappearance of the teacher in the NVT approach suggests a potential shift toward teacherless or more autonomous language education. Traditionally, teachers have been viewed as the primary source of knowledge, facilitating its transfer to students (Keiler, 2018). In the NVT

model, where teachers primarily address unforeseen technical issues, students autonomously navigate the brain-based dichotic listening curriculum, thereby minimizing reliance on direct instruction. This shift aligns with the digitalization of education (Kalimullina et al., 2021) and the preferences of digitally native learners, who favor greater independence (Bennett et al., 2008; Szymkowiak et al., 2021; Palfrey & Gasser, 2008).

Finally, and most importantly, a statistically significant improvement in speaking performance on a number of metrics was achieved simply by changing the students' form of auditory input: a substantial and unexpected progress for no additional effort by either teacher or students. This significant outcome occurred only because of the signal modification. The result strongly supports the integration of dichotic input into all pedagogic activities involving second or foreign language learning. The approach is anticipated to accelerate progress beyond the typical rate, enabling a larger proportion of learners to achieve measurable advances compared to conventional methods.

V. CONCLUSION

The present study demonstrates that the NVT approach, which delivers lateralized auditory stimuli aligned with neurocognitive profiles to 64 Chinese college EFL learners, significantly enhanced experimental group speaking proficiency. By leveraging the left hemisphere's phonemic decoding specialization (via right-ear pathways) and the right hemisphere's prosodic integration dominance (through left-ear inputs), NVT fostered interhemispheric synergy that potentiated neuroplastic adaptations in speech motor planning and perceptual-motor coordination. This neurofunctional optimization mechanism explains the observed gains in the EG's improved overall speaking proficiency. Despite its contributions to understanding language learning mechanisms, this study is subject to notable limitations that warrant careful consideration and inform key recommendations for advancing the field.

A. Limitations

The study's limitations stem from its narrowly defined participant pool and methodological constraints. First, the sample comprised exclusively right-handed Chinese college EFL learners, limiting generalizability to left-handed individuals, non-tonal language speakers, or broader age groups. The tonal nature of participants' L1 (Mandarin) introduces a potential bias, as tonal languages engage distinct neural pathways for prosodic processing compared to non-tonal systems, which may confound intervention outcomes related to auditory perception. Second, the reliance on behavioral assessments rather than neuroimaging (e.g., fMRI, EEG) precluded direct observation of hemispheric lateralization dynamics or neuroplastic adaptations during the intervention. Third, the short-term experimental design (12 weeks) failed to capture longitudinal neurocognitive changes, such as sustained cortical reorganization or delayed proficiency gains, while the pretest-posttest framework overlooked real-time fluctuations in language performance. Moreover, this study recognizes that speaking proficiency is a dynamic construct influenced by multiple interdependent factors, including perceptual, motor, social, and cognitive components (Hickok, 2012). However, this paper primarily focuses on perception as the foundational layer in L2 phonological acquisition. These constraints collectively highlight the need for methodological diversification in future investigations.

B. Recommendations

To address these limitations, future research should adopt a multidimensional validation framework encompassing four critical axes. First, expanding participant diversity to include left-handed individuals and non-tonal language groups (e.g., Spanish/English bilinguals, German L1 speakers) would elucidate cross-linguistic variability in auditory strategy development while controlling for typological influences. Second, integration of portable neuroimaging modalities like fNIRS and mobile EEG could map real-time hemispheric dynamics during prosodic processing, particularly within right-hemisphere networks implicated in tonal decoding, thereby bridging current gaps in understanding cortical plasticity mechanisms. Third, longitudinal designs incorporating staggered assessments and wearable technologies (e.g., ambulatory speech recorders) would enable tracking of both consolidation-phase effects and long-term neuroplasticity trajectories, while establishing intervention durability beyond initial acquisition phases. Fourth, systematic cross-linguistic replications comparing tonal (e.g., Thai) versus non-tonal L1 populations should be prioritized to refine neurocognitive typology models and validate NVT's universality as a brain-aligned pedagogical paradigm. Methodologically, synergizing AI-driven linguistic analysis with hyperscanning protocols could advance dyadic interaction research, non-invasively capturing how collaborative learning modulates hemispheric resource allocation. These concerted advancements would not only enhance theoretical models of language lateralization but also empower evidence-based innovations that reconcile neurocognitive individuality with second language acquisition pedagogy.

REFERENCES

- [1] Alazard, C. (2013). *Rôle de la prosodie dans la fluence en lecture oralisée chez des apprenants de Français Langue Étrangère* [Role of prosody in oral reading fluency in learners of French as a foreign language]. PhD thesis, Université Toulouse Le Mirail, Toulouse, France.
- [2] Annett, M. (1970). A classification of hand preference by association analysis. *British journal of psychology*, 61(3), 303-321.
- [3] Aryadoust, V. (2013). *Building a validity argument for a listening test of academic proficiency*. Cambridge Scholars Publishing.

- [4] Asp, C.W. (2006). *Verbo-tonal Speech Treatment*, San Diego, Plural Publishing.
- [5] Asp, C. W. (1985). The verbotonal method for management of young, hearing-impaired children. *Ear and hearing*, 6(1), 39-42.
- [6] Asp, C. W., Koike, K. J., & Kline, M. W. (2012). Breaking News: Verbotonal rehabilitation: Are we doing enough?. *The Hearing Journal*, 65(01), 28-30.
- [7] Asp, C. W., & Kline, M. (2012). Timeless verbotonal corrective body movements. In *Man and speech: Scientific and professional monograph of the 7th International Symposium of the Verbotonal System* (pp. 102-113).
- [8] Bennett, S., Maton, K., & Kervin, L. (2008). The 'digital natives' debate: A critical review of the evidence. *British journal of educational technology*, 39(5), 775-786.
- [9] Bohn, O. S. (2017). Cross-language and second language speech perception. *The handbook of psycholinguistics*, 213-239.
- [10] Broadbent, D. E. (1956). Successive responses to simultaneous stimuli. *Quarterly Journal of Experimental Psychology*, 8(4), 145-152.
- [11] Brown, H. (2001). *Teaching by principles: an interactive approach to language pedagogy*. New York: Longman.
- [12] Cai, X., Lian, A., Puakpong, N., Shi, Y., Chen, H., Zeng, Y., ... & Mo, Y. (2021). Optimizing auditory input for foreign language learners through a verbotonal-based dichotic listening approach. *Asian-Pacific Journal of Second and Foreign Language Education*, 6(1), 1-20.
- [13] Cherry, E. C. (1953). Some experiments on the recognition of speech, with one and with two ears. *The Journal of the acoustical society of America*, 25(5), 975-979.
- [14] Cohen, J. (1988). Set correlation and contingency tables. *Applied psychological measurement*, 12(4), 425-434.
- [15] Danesi, M. (2003). *Second language teaching: A view from the right side of the brain* (Vol. 8). Springer Science & Business Media.
- [16] Dankel, S. J., & Loenneke, J. P. (2021). Effect sizes for paired data should use the change score variability rather than the pre-test variability. *The Journal of Strength & Conditioning Research*, 35(6), 1773-1778.
- [17] De Jong, N. H., Steinel, M. P., Florijn, A. F., Schoonen, R., & Hulstijn, J. H. (2012). Facets of speaking proficiency. *Studies in Second Language Acquisition*, 34(1), 5-34.
- [18] Dean, R. S. (1984). Functional lateralization of the brain. *The Journal of Special Education*, 18(3), 239-256.
- [19] Demir, S. (2017). An Evaluation of Oral Language: The Relationship between Listening, Speaking and Self-Efficacy. *Universal Journal of Educational Research*, 5(9), 1457-1467.
- [20] Derwing, T. M., Munro, M. J., Thomson, R. L., & Rossiter, M. J. (2009). The relationship between L1 fluency and L2 fluency development. *Studies in Second Language Acquisition*, 31(4), 533-557.
- [21] Ethofer, T., Van De Ville, D., Scherer, K., & Vuilleumier, P. (2009). Decoding of emotional information in voice-sensitive cortices. *Current biology*, 19(12), 1028-1033.
- [22] Flege, J. E. (1995). 'Second language speech learning: Theory, findings and problems' in W. Strange (ed.), *Speech Perception and Linguistic Experience: Issues in Cross-language Research*. York Press, pp. 233-77.
- [23] Friederici, A. D., & Alter, K. (2004). Lateralization of auditory language functions: a dynamic dual pathway model. *Brain and language*, 89(2), 267-276.
- [24] Gandour, J., Wong, D., Lowe, M., Dzemic, M., Saththamnuwong, N., Tong, Y., & Li, X. (2002). A cross-linguistic fMRI study of spectral and temporal cues underlying phonological processing. *Journal of cognitive neuroscience*, 14(7), 1076-1087.
- [25] García, X. A. P. (2018). Remarks on verbo-tonal phonetics for a communicative context. *Normas: revista de estudios lingüísticos hispánicos*, 8(1), 259-271.
- [26] Goh, C. C., & Burns, A. (2012). *Teaching speaking: A holistic approach*. Cambridge University Press.
- [27] Goldinger, S. D. (1998). Signal detection comparisons of phonemic and phonetic priming: The flexible-bias problem. *Perception & Psychophysics*, 60(6), 952-965.
- [28] Golubovskaya, E., & Tikhonova, E. (2015). Teaching skills for listening in IELTS test preparation. In *INTED2015 Proceedings* (pp. 5553-5562). IATED.
- [29] Guberina, P. (1972). *Case studies in the use of restricted bands of frequencies in auditory rehabilitation of the deaf*. Zagreb: Institute of Phonetics, Faculty of Arts, University of Zagreb.
- [30] Guberina, P., & Asp, C. W. (1981). The verbo-tonal method for rehabilitating people with communication problems. *Monograph 13, World Rehabilitation*. Retrieved April 8, 2025, from http://www.suvag.com/ang/histoire/autres_textes.html
- [31] Guberina, P. (1989). *Verbotonal method in our time*. Retrieved April 8, 2025, from <http://verbotonal.utk.edu/Documents/Guberina's%20Speech.pdf>
- [32] Han, J., & Yin, H. (2016). College English curriculum reform in Mainland China: Contexts, contents and changes. *Asian Education Studies*, 1(1), 1-10.
- [33] He, B. (2014). *Improving the English pronunciation of Chinese EFL learners through the integration of CALL and verbotonalism*. Retrieved April 8, 2025, from <http://sutir.sut.ac.th:8080/sutir/handle/123456789/5370>
- [34] Hickok, G. (2012). Computational neuroanatomy of speech production. *Nature reviews neuroscience*, 13(2), 135-145. <https://doi.org/10.1038/nrn3158>
- [35] Hickok, G., & Poeppel, D. (2007). The cortical organization of speech processing. *Nature reviews neuroscience*, 8(5), 393-402.
- [36] Horwitz, E. K., Horwitz, M. B., & Cope, J. (1986). Foreign language classroom anxiety. *The Modern Language Journal*, 70(2), 125-132. <https://doi.org/10.1111/j.1540-4781.1986.tb05166.x>
- [37] Hu, Y., & Uno, S. (2005). Effectiveness of a new teaching method based on the verbo-tonal method for Japanese beginners' learning of Chinese voice tones. *Japanese Journal of Educational Psychology*, 53(4), 541-550.
- [38] Isaacs, T., & Trofimovich, P. (2012). Deconstructing comprehensibility: Identifying the linguistic influences on listeners' L2 comprehensibility ratings. *Studies in Second Language Acquisition*, 34(3), 475-505.
- [39] Kalimullina, O., Tarmann, B., & Stepanova, I. (2021). Education in the context of digitalization and culture. *Journal of Ethnic and Cultural Studies*, 8(1), 226-238.
- [40] Khalfa, S., Veuille, E., & Collet, L. (1998). Influence of handedness on peripheral auditory asymmetry. *European Journal of Neuroscience*, 10(8), 2731-2737.

- [41] Kim, H. G., Kim, O. J., Kang, S. K., & Jeon, B. M. (2007). On Improving the Listening Ability of Middle School Students Using Verbotonal Method. *Speech Sciences*, 14(3), 21-29.
- [42] Kimura, D. (1961). Cerebral dominance and the perception of verbal stimuli. *Canadian Journal of Psychology/Revue canadienne de psychologie*, 15(3), 166-171.
- [43] Klein, L. (2010). Phonetic correction in class with verbo-tonal method. *Studies in language and literature*, 30(1), 35-56.
- [44] Levänen, S., Ahonen, A., Hari, R., McEvoy, L., & Sams, M. (1996). Deviant auditory stimuli activate human left and right auditory cortex differently. *Cerebral Cortex*, 6(2), 288-296.
- [45] Lian, A. P. (2011). Reflections on language-learning in the 21st century: The rhizome at work. *Journal of Current Science and Technology*, 1(1), 5-16.
- [46] Lian, A. P., & Sangarun, P. (2017). Precision Language Education: A Glimpse Into a Possible Future. *GEMA® Online Journal of Language Studies*, 17(4), 1-15.
- [47] Lian, A. P., Cai, X., Chen, H., Ou, J., & Zheng, W. (2020). Cerebral Lateralization Induced by Dichotic Listening to Filtered and Unfiltered Stimuli: Optimizing Auditory Input For Foreign Language Learners. *Journal of Critical Reviews*, 7(19), 4608-4625.
- [48] Lian, A. P. (1980). *Intonation Patterns of French (Teacher's Book)*. Melbourne, Auckland: River Seine Publications Pty Ltd.
- [49] Luu, V. T., Lian, A. P., & Siriyothin, P. (2021). Developing EFL learners' listening comprehension through a computer-assisted self-regulated prosody-based listening platform. *Computer-Assisted Language Learning Electronic Journal*, 22(1), 254-271.
- [50] MacIntyre, P. D., & Gregersen, T. (2012). Affect in language learning. In A. Mackey & S. Gass (Eds.), *Second language research: Methodology and design* (2nd ed., pp. 17-32). New York: Routledge.
- [51] Malachowska, E. (2014). Methods used in stimulating speech development in children. *Наукові праці Міжрегіональної Академії управління персоналом. Психологія*, 2(41), 176-181.
- [52] McGilchrist, I. (2019). *The master and his emissary: The divided brain and the making of the western world*. Yale University Press.
- [53] McMurray, B., Tanenhaus, M. K., & Aslin, R. N. (2009). Within-category VOT affects recovery from "lexical" garden-paths: Evidence against phoneme-level inhibition. *Journal of memory and language*, 60(1), 65-91.
- [54] Melnik-Leroy, G. A., Turnbull, R., & Peperkamp, S. (2022). On the relationship between perception and production of L2 sounds: Evidence from Anglophones' processing of the French/u/-/y/contrast. *Second Language Research*, 38(3), 581-605.
- [55] Nation, P. (1990). *Teaching and learning vocabulary*. New York: Longman.
- [56] Odisho, E. Y. (2014). *Pronunciation is in the Brain, Not in the Mouth: A Cognitive Approach to Teaching it*. Gorgias Press.
- [57] Palfrey, J., & Gasser, U. (2008). *Born digital: Understanding the first generation of digital natives*. New York (NY): Basic Books.
- [58] Poeppel, D., & Assaneo, M. F. (2020). Speech rhythms and their neural foundations. *Nature reviews neuroscience*, 21(6), 322-334.
- [59] Renandya, W. A., & Nguyen, M. T. T. (2022). Teaching speaking in L2 contexts. In *Handbook of practical second language teaching and learning* (pp. 269-280). Routledge.
- [60] Renard, R., & Van Vlasselaer, J. J. (1976). *Foreign Language teaching with an integrated methodology: the SGAV (Structuro-Global Audio-Visual) methodology*. Didier.
- [61] Roberge, C. (2018). Introducing Professor Petar Guberina. *上智大学外国語学部紀要* [Bulletin of the Faculty of Foreign Studies, Sophia University], (53), 127-138.
- [62] Shankweiler, D., & Studdert-Kennedy, M. (1967). Identification of consonants and vowels presented to left and right ears. *Quarterly Journal of Experimental Psychology*, 19(1), 59-63.
- [63] Sininger, Y. S., & Bhatara, A. (2012). Laterality of basic auditory perception. *Laterality: Asymmetries of Body, Brain and Cognition*, 17(2), 129-149.
- [64] Swain, M. (1985). Communication and comprehension: Emerging perspectives on language learning. In M. Bygate, P. Skehan, & M. Swain (Eds.), *Research perspectives on task-based learning* (pp. 246-265). Cambridge: Cambridge University Press.
- [65] Szymkowiak, A., Melović, B., Dabić, M., Jeganathan, K., & Kundi, G. S. (2021). Information technology and Gen Z: The role of teachers, the internet, and technology in the education of young people. *Technology in Society*, 65, 101565.
- [66] Thornbury, S. (2000). Accuracy, fluency and complexity. *Readings in Methodology*, 16, 139-143.
- [67] Ursache, L. (2017). Dezvoltarea competențelor de comunicare la copiii cu dizabilități auditive din perspectiva sistemului verbotonal. *Revista Română de Terapia Tulburărilor de Limbaj și Comunicare*, 3(1), 52-60.
- [68] Veale, J. F. (2014). Edinburgh handedness inventory-short form: a revised version based on confirmatory factor analysis. *Laterality: Asymmetries of Body, Brain and Cognition*, 19(2), 164-177.
- [69] Warren, J. M. (1977). Functional lateralization of the brain. *Annals of the New York Academy of Sciences*, 299(1), 273-280.
- [70] Wei, Q., Siriyothin, P., & Lian, A. P. (2018). Improving Chinese university EFL students' speaking skills through digital storytelling. *Suranaree Journal of Social Science*, 12(2), 47-68.
- [71] Wen, F., Lian, A. P., & Sangarun, P. (2020). Determination of corrective optimals for Chinese university learners of English. *Govor*, 37(1), 3-29.
- [72] Westerhausen, R., & Hugdahl, K. (2010). Cognitive control of auditory laterality. In K. Hugdahl & R. Westerhausen (Eds.), *The Two Halves of the Brain* (pp. 469-497). Cambridge, MA: The MIT Press.
- [73] Keiler, L. S. (2018). Teachers' roles and identities in student-centered classrooms. *International journal of STEM education*, 5, 1-20.
- [74] Willis, J. (1996). *A framework for task-based learning*. Harlow, UK: Addison Wesley Longman.
- [75] Yang, Y. (2016). *Improving the phonological working memory and English speaking skills of Chinese primary EFL learners with a verbotonal-based approach*. Retrieved April 8, 2025, from <http://sutir.sut.ac.th:8080/sutir/handle/123456789/6753>
- [76] Zatorre, R. J., Belin, P., & Penhune, V. B. (2002). Structure and function of auditory cortex: music and speech. *Trends in cognitive sciences*, 6(1), 37-46.

- [77] Zhang, F. Z. (2006). *The teaching of Mandarin prosody: A somatically-enhanced approach for second language learners*. University of Canberra. Division of Communication and Education.

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