



The Role of Neurolinguistics in Teaching Greek as a Second Language: A Comprehensive Review

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Abstract

Neurolinguistics provides crucial insights into the cognitive and neural mechanisms underlying second language acquisition, offering fertile ground for improving the teaching of Greek as a second language (L2). This article presents a comprehensive review of research at the intersection of neurolinguistics and Greek language pedagogy. It discusses findings on cognitive processing, phonological and grammatical challenges, multisensory learning, affective dimensions such as motivation and anxiety reduction, and dynamic assessment methods. Special attention is given to technological innovations, pragmatic competence, and cultural immersion. The review also critically evaluates current research gaps, emphasizing the need for empirical studies specifically on Greek L2 acquisition. By integrating cognitive science, pedagogy, and sociocultural approaches, the article proposes evidence-based directions for teaching methodologies that foster both linguistic competence and cultural integration.

Keywords: Neurolinguistics; Neurolinguistic programming; Artificial intelligence tools; Bilingualism; Longitudinal studies

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INTRODUCTION

Neurolinguistics, by examining how the brain processes and acquires languages, provides valuable insights for teaching Greek as a second language. It also incorporates recent findings from neurology and cognitive neuroscience to provide a more comprehensive understanding of language processing mechanisms (Friederici, 2017). Greek's complex morphology and phonology make it a rich testing ground for cognitively informed pedagogy (Tsimpli, 2017; Protopapas, 2019). However, empirical applications remain limited; this review therefore synthesizes current evidence to bridge neuroscience and classroom practice through a focused literature review of neurolinguistic findings relevant to learning Greek as a second language.

The field has evolved significantly since the foundational discoveries of Broca (1861) and Wernicke (1874), with contemporary neuroimaging techniques (e.g., EEG, fMRI, MEG) further advancing our understanding of how bilingualism and second language learning are represented and processed in the brain (Friederici, 2017; Paradis, 2019). Teaching Greek as a second language poses particular challenges due to the language's morphological richness, phonological complexity, and pragmatic conventions (Thierry, 2016; Zou & Ding, 2022). Nevertheless, studies that directly apply neurolinguistic findings to Greek remain limited, creating a research gap that motivates the present

review. The aim is twofold: (1) to synthesize the available neurolinguistic literature relevant to Greek L2 learning and (2) to critically analyze its pedagogical implications.

RESEARCH METHODS

This section outlines the methodological framework employed in conducting this qualitative literature review. The study employs a systematic and thematic approach to analyze scholarly works at the intersection of neurolinguistics, cognitive science, bilingualism, and the acquisition of Greek as a second language (L2). The methods described below ensure transparency, rigor, and replicability in selecting, classifying, and interpreting the relevant literature.

Research Design

This study uses a qualitative research design, specifically a systematic qualitative literature review. The goal of this design is to critically synthesize theoretical and empirical findings related to neurolinguistic and cognitive perspectives on second language acquisition (SLA), with a focus on Greek L2 learning. The qualitative approach allows for in-depth interpretation of concepts, patterns, convergences, contradictions, and pedagogical implications that emerge across the selected body of literature. Rather than quantifying results, this design emphasizes thematic understanding and critical evaluation.

Research Target/Subject

The “subjects” of this qualitative study are scholarly publications relevant to neurolinguistics, bilingualism, and Greek L2 acquisition. These include empirical studies, theoretical analyses with pedagogical implications, and interdisciplinary works published in peer-reviewed journals.

The criteria for determining the research subjects were as follows:

1. Inclusion Criteria:

Address second language acquisition from a neurolinguistic, cognitive, or psycholinguistic perspective.

1) Present empirical findings or contain clear pedagogical implications.

2) Published in peer-reviewed journals between 2010–2024.

3) Focus on Greek as a second language or languages that are typologically comparable.

2. Exclusion Criteria:

1) Non-peer-reviewed works (e.g., blogs, theses, conference abstracts).

2) Purely theoretical studies without explicit relevance to pedagogy.

3) Publications unrelated to Greek or lacking relevance to L2 acquisition contexts.

The selection of subjects was conducted through purposeful sampling, a common qualitative technique used to identify materials that are most relevant to the research objectives.

Research Procedure

This research procedure followed the steps of a systematic qualitative review aligned with the study's thematic objectives. The initial stage involved keyword development, formulating keywords such as neurolinguistics, bilingualism, Greek language learning, second language acquisition, multisensory learning, affective factors, digital pedagogy, and language attrition based on an initial search of the research scope. Next, a systematic search was conducted across the Scopus, Web of Science, and Google Scholar databases, utilizing a combination of controlled keywords and Boolean operators to ensure comprehensive coverage.

After data collection, a screening process was conducted to review titles, abstracts, and keywords and determine relevance. Studies that did not meet the inclusion criteria were excluded from the analysis. Articles that passed this stage then underwent a full-text review process to assess their methodological quality, analytical depth, and pedagogical relevance. Subsequently, thematic coding of the selected studies was conducted to identify recurring patterns and themes, such as neurolinguistic mechanisms in second language acquisition, cognitive processing, bilingual advantage, affective factors, and pedagogical strategies for L2 Greek learners.

The final stage involves synthesizing the findings and organizing the study results into thematic domains that highlight commonalities, differences, and research gaps. A summary table is also compiled at this stage to provide a comprehensive overview of the main research areas and their pedagogical implications.

Instruments and Data Collection Techniques

As a qualitative desk study, the instruments used consisted of various digital tools and techniques designed to gather, organize, and analyze textual data. The data included published journal articles, empirical reports, and theoretical papers with a clear pedagogical orientation. Data collection was conducted through systematic database searches using predefined keywords, supported by Boolean filtering (AND/OR/NOT) to refine the results, as well as inclusion and exclusion screening based on methodological relevance. The primary instruments employed were academic search engines, such as Scopus, Web of Science, and Google Scholar, complemented by reference management software, including Zotero and Mendeley, to classify, store, and annotate the literature. Thematic coding sheets were also used to categorize emerging patterns across the selected studies. Together, these instruments ensured that the data collection process remained structured, transparent, and traceable.

Data analysis technique

The data analysis followed a qualitative thematic analysis procedure. Each selected study was examined closely to identify its central arguments, methodological approaches, empirical findings, neurolinguistic and cognitive insights, and pedagogical implications for Greek L2 instruction. The analysis progressed through several stages, beginning with open coding to identify key concepts emerging across the sources. This was followed by axial coding, in which related concepts were grouped into broader thematic categories. Selective coding was then used to integrate these categories into major themes aligned with the research objectives. Finally, an interpretive phase synthesized the themes to address the research questions, identify gaps in the current body of knowledge, and evaluate their implications for language pedagogy. This analytical approach ensured that the findings were systematically generated and consistently linked to the study's research problems and objectives.

Table 1. Overview of Key Research Areas, Representative Studies, and Pedagogical Implications

Research Focus	Representative Studies	Key Findings	Pedagogical Relevance
Cognitive/Neural Mechanisms	Abutalebi & Green (2016); Thierry (2016)	L2 recruits shared and distinct neural networks	Supports implicit, communicative grammar teaching
Multisensory Learning	Shams & Seitz (2008); Pulvermüller (2018)	Multi-modal input enhances memory and motivation	Encourages embodied classroom activities
Affective & NLP Approaches	Dörnyei & Ryan (2015); Zhang et al. (2023)	Emotional engagement fosters retention.	Suggests anxiety-reduction & motivation scaffolds
Technology & AI	Li & Lan (2021); Bouras et al. (2024)	AI tools improve pronunciation and personalization.	Integrate adaptive learning platforms.
Pragmatic & Cultural Integration	Citron (2023); María (2023)	Pragmatic competence requires cultural immersion	Promote authentic communication & intercultural tasks

RESULTS AND DISCUSSION

Cognitive and Neural Mechanisms of L2 Acquisition

Neurolinguistic studies show that second language learning recruits both domain-general cognitive functions (e.g., working memory, attentional control) and specialized linguistic networks (Abutalebi & Green, 2016). For Greek L2 learners, challenges arise from its inflectional morphology and phonemic inventory, which differ from many Indo-European and non-Indo-European languages. Phonological

challenges: Greek sounds such as /θ/, /ð/, and /χ/ are often absent in learners' L1 and require targeted perceptual training (Zou & Ding, 2022). Grammatical acquisition: Research supports the learning of grammar through meaningful interaction and implicit learning (Rastelli, 2018), aligning with communicative approaches in Greek teaching. However, most neurolinguistic studies to date have focused on English or other major European languages, making it unclear whether these findings can be generalized to Greek. Elleuch (2024) emphasizes the need for longitudinal, classroom-based research to capture developmental patterns in Greek L2 acquisition better.

Building on this cognitive perspective, neuroimaging studies indicate that second language learning involves the coordinated activity of the left inferior frontal gyrus (Broca's area), the superior temporal gyrus (Wernicke's area), and subcortical structures such as the basal ganglia, which support procedural memory and grammatical pattern formation. Activation patterns in these areas tend to become more native-like as proficiency increases, reflecting neuroplastic adaptation (Ullman, 2016).

Multisensory and Embodied Learning

Multisensory learning enhances encoding and retrieval by integrating auditory, visual, and kinesthetic modalities (Shams & Seitz, 2008). In the context of learning the Greek language, vocabulary retention is shown to improve when words are paired with gestures, visual imagery, or context-rich communicative activities. Moreover, embodied approaches such as dramatization of dialogues or role-play in cultural settings activate sensorimotor systems that reinforce long-term memory formation (Pulvermüller, 2018). Despite strong theoretical and empirical support, however, few studies have explicitly examined multisensory interventions in Greek L2 classrooms, revealing a gap between theoretical claims and pedagogical practice. From a neurological perspective, multisensory input engages overlapping cortical networks, particularly the auditory cortex, visual association areas, and motor regions, thereby promoting stronger neural connectivity and more durable memory traces (Calvert, 2001).

Affective Factors and Neurolinguistic Programming (NLP)

Emotional and motivational factors play a decisive role in shaping neural plasticity and long-term language retention (Dörnyei & Ryan, 2015). Within this context, neurolinguistic programming (NLP) techniques have been employed to reduce anxiety, enhance self-confidence, and promote emotional intelligence in language learners (Zhang et al., 2023; Ahmadian, 2018). For Greek learners, many of whom are migrants or Erasmus students navigating processes of cultural adaptation, affective strategies are essential for maintaining engagement and motivation. Nevertheless, while NLP offers promising tools for affective and interpersonal development, its empirical support remains inconsistent; therefore, a cautious and evidence-based integration into pedagogy is recommended. Finally, emotional engagement itself has been shown to modulate activity within the limbic system, particularly the amygdala and hippocampus, which are critical for memory consolidation and motivation (Immordino-Yang & Damasio, 2007).

Technology, AI, and Personalized Learning

Neurolinguistics intersects with digital pedagogy through adaptive learning platforms, gamified applications, and speech recognition tools (Li & Lan, 2021). For Greek learners, AI-based pronunciation feedback can help train them on difficult phonemes. Online communities offer continuity beyond the classroom, helping to counter language attrition (Köpke & Keijzer, 2019). Bouras, Barkas, & Griva (2024) stress that online learning environments in the digital era must strike a balance between flexibility and human interaction. Critical point: Although technology promises individualized learning, overreliance on it may undermine human interaction, which remains central to pragmatic and cultural competence.

Pragmatics and Sociocultural Integration

Language processing is inextricably linked to cultural and pragmatic competence (Citron, 2023). For Greek L2 learners, politeness strategies, idiomatic expressions, and cultural scripts are essential for achieving effective communication. Cultural immersion through literature, music, and community engagement promotes deeper retention and integration of identity (María, 2023). Critical point:

Neurolinguistic research rarely examines pragmatics explicitly; more interdisciplinary studies are needed to capture this dimension in Greek learning.

Language Attrition, Assessment, and Long-Term Maintenance

Neurolinguistic research indicates that, without consistent practice and exposure, second language proficiency tends to decline over time (Paradis, 2019). Therefore, teachers of Greek as a second language should implement strategies that encourage ongoing use of the language, such as participation in digital learning communities, cultural exchange programs, and heritage language initiatives. Moreover, Roberts et al. (2016) emphasize that assessment methods informed by neurolinguistic principles can capture both the cognitive processes and the communicative skills involved in language learning more effectively. Drawing on this body of evidence, the following section outlines key pedagogical principles that integrate cognitive and neural perspectives into practical approaches for teaching Greek.

Implications for Greek Language Pedagogy

Practical classroom applications of neurolinguistic principles can significantly enhance the learning experience of Greek as a second language. For instance, AI-assisted pronunciation software can provide immediate feedback on challenging Greek phonemes, such as /θ/ and /ð/. Meanwhile, role-play activities that simulate authentic communicative situations, like ordering food or making introductions, help learners develop pragmatic competence. Gesture-based vocabulary practice and rhythm-based music exercises provide additional support for phonological awareness and memory retention.

Multisensory activities, including phonics exercises with AI speech recognition, kinesthetic dramatizations of dialogues, color-coded grammar visualization, and music-assisted pronunciation training, closely align with neurolinguistic evidence that shows multimodal input enhances both encoding and retrieval processes.

To make the pedagogical implications more accessible for teachers and trainers, this section is organized around the following key subthemes: Phonological and Grammatical Training, Multisensory and Embodied Approaches, Affective and Motivational Support, Technology and AI Integration, and Assessment and Lifelong Maintenance.

Finally, brief classroom illustrations highlight how these strategies function in real-world contexts. For instance, Erasmus students in Thessaloniki demonstrated improved vocabulary recall through gesture-based learning activities (Andria, 2022), while refugee learners in community schools reported higher motivation and engagement when participating in culturally contextualized role-play tasks.

The classroom applications and case illustrations discussed above demonstrate how neurolinguistic insights can be translated into effective instructional practice. Building on these examples, the following pedagogical principles synthesize the key findings of the review and outline a coherent framework for teaching Greek as a second language.

From this review, several pedagogical principles emerge:

- 1) Phonological training with neurolinguistic tools (minimal pair discrimination, AI-based pronunciation feedback).
- 2) Grammar in context, focusing on implicit acquisition via communicative tasks.
- 3) Multisensory teaching strategies (gestures, visual imagery, embodied activities).
- 4) Affective scaffolding, balancing motivation, confidence, and reduced anxiety.
- 5) Integration of technology while maintaining interpersonal and cultural dimensions.
- 6) Long-term learner engagement through community involvement and digital platforms.
- 7) Dynamic assessment strategies informed by neurolinguistics to evaluate both processing and performance.

Limitations, Research Gaps, and Future Directions

While the pedagogical directions proposed in this review are promising, it is essential to acknowledge the current empirical limitations. Existing neurolinguistic research relevant to Greek as a second language remains limited, relying primarily on cross-sectional designs and data drawn from English

and other major European languages. There is a clear need for empirical, longitudinal, and classroom-based studies that specifically examine Greek L2 processing and development over time.

Future research should employ neuroimaging techniques such as EEG and fMRI to examine how Greek phonological, grammatical, and pragmatic features are processed in bilingual learners. Moreover, controlled classroom studies are needed to evaluate the effectiveness of multisensory, embodied, online, and AI-based instructional interventions in authentic learning contexts. In parallel, a more systematic exploration of pragmatic competence and cultural immersion within neurolinguistic frameworks is required, together with teacher-training programs that integrate neurolinguistic awareness into instructional design. Finally, assessment practices should be refined to capture not only linguistic outcomes but also the underlying cognitive mechanisms that support real-time language processing and communicative performance. Future studies could also investigate how neural oscillations and connectivity patterns differ between beginner and advanced learners of Greek, contributing to a deeper understanding of language learning plasticity (Pliatsikas & Marinis, 2013).

CONCLUSION

Neurolinguistics offers valuable insights for teaching Greek as a second language, connecting cognitive mechanisms with practical pedagogical approaches. However, while theoretical frameworks are rich, empirical research on Greek remains underdeveloped. A stronger interdisciplinary collaboration between linguists, neuroscientists, and educators is essential to establish evidence-based methodologies. Future studies incorporating EEG, fMRI, longitudinal classroom observations, and neurolinguistically informed assessments can deepen our understanding of Greek L2 acquisition and support innovative teaching practices that integrate cognitive science, culture, and technology.

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