

Neuro-Cognitive Architectures of Early and Adult Language Processing: The Role of Multisensory Integration in Overcoming Learning Barriers

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Abstract

Language learning difficulties among adult learners are frequently interpreted as evidence of reduced cognitive ability, declining memory capacity, or age-related limitations. However, contemporary research in cognitive neuroscience suggests that successful learning depends not only on learners' cognitive resources but also on the interaction between instructional approaches and the mechanisms through which the brain processes, organizes, and retrieves information. This article examines the role of multisensory integration and embodied learning in supporting English language acquisition among adult learners. The study is based on a classroom intervention involving 20 English learners aged 30–50 who experienced persistent difficulties in memorizing irregular verb forms through conventional approaches, including translation, explicit explanation, audiovisual materials, and repetition activities. Following the implementation of a multisensory approach involving gestures, physical movement, and oral drilling, learners demonstrated improved recall of irregular verb forms. A notable observation was that learners spontaneously reproduced associated gestures when experiencing retrieval difficulties, suggesting that motor actions functioned as cognitive retrieval cues. The findings support theories of embodied cognition, dual coding, neuroplasticity, and multisensory learning,

demonstrating that adult learners' difficulties may not necessarily indicate reduced learning capacity but may reflect a mismatch between instructional methods and cognitive processing mechanisms. The study argues that understanding neuro-cognitive principles of language learning can help teachers create more inclusive and effective learning environments for learners across different ages.

Keywords: neuro-cognitive architecture; multisensory integration; embodied cognition; adult language learning; irregular verbs; language memory; neuroplasticity; language pedagogy; cognitive processing

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1. Introduction

Language learning is a complex cognitive process involving memory, attention, perception, emotion, and social experience. Traditional methods such as memorization, translation, and repetition provide explicit knowledge but often fail to ensure spontaneous language use. Modern cognitive neuroscience views language learning as a dynamic process involving multiple neural systems responsible for perception, memory, motor activity, and executive control (Friederici, 2012; Hickok & Poeppel, 2007). Learning becomes more effective when linguistic information is connected to meaningful experiences.

A key concept in this field is multisensory integration, which refers to the brain's ability to combine information from different sensory channels. Research suggests that learning supported by visual, auditory, and physical experiences enhances attention, memory, and retention (Shams & Seitz, 2008). Consequently, language items are remembered more effectively when associated with images, actions, emotions, and real-life contexts.

Despite these findings, many adult learners believe that age limits their ability to learn languages. However, studies on neuroplasticity show that the adult brain remains capable of forming new neural connections throughout life (Kandel et al., 2013; Merzenich, 2013). Therefore, learning difficulties should not be viewed as evidence of reduced ability but rather as indicators that instructional methods may need adjustment.

The present study originated from observations of 20 adult English learners aged 30–50 who struggled to memorize irregular verbs despite receiving traditional instruction through translation, explanations, videos,

and songs. Although they understood the meanings of the verbs, they had difficulty recalling them during communication activities. To address this problem, a multisensory approach was introduced in which each irregular verb was linked to a specific physical gesture. Learners practiced the three verb forms while performing the corresponding movements.

An important observation emerged during classroom activities: when learners forgot a verb, they often unconsciously repeated the associated gesture, which helped them retrieve the correct form. This finding suggests that bodily movement can serve as an effective retrieval cue and strengthen language memory.

The study also relates to the broader issue of learner independence. Previous research by Kasimkhodjayeva (2025) demonstrated that excessive reliance on translation tools may limit learners' ability to construct sentences independently. Effective language instruction therefore requires a balance between support and independence, enabling learners to transform external information into durable cognitive representations.

The study addresses three research questions: (1) How does multisensory instruction influence adult learners' retention of irregular English verbs? (2) How do gestures contribute to memory retrieval? (3) What implications do neuro-cognitive principles have for adult language teaching?

2. Literature Review and Theoretical Framework

2.1 Neuro-Cognitive Foundations of Language Processing.

Contemporary neuroscience views language processing as the result of interactions among distributed neural networks responsible for auditory perception, visual processing, motor coordination, memory formation, and cognitive control (Friederici, 2012). The concept of neuroplasticity demonstrates that the adult brain remains capable of developing new neural connections through learning experiences (Kandel et al., 2013). Consequently, language-learning difficulties should be interpreted not as cognitive limitations but as challenges that may require alternative instructional approaches.

2.2 Multisensory Integration and Language Learning.

Multisensory integration refers to the brain's ability to combine information from different sensory modalities into a unified representation (Shams & Seitz, 2008). In language learning, words become easier to remember when they are

associated with sounds, images, actions, and meaningful contexts. Dual Coding Theory (Paivio, 1986) and Multimedia Learning Theory (Mayer, 2009) suggest that information processed through multiple channels creates stronger memory traces and additional pathways for retrieval.

2.3 Embodied Cognition and Language Learning. Embodied Cognition Theory proposes that understanding is grounded in sensory and motor experiences rather than abstract symbols alone (Barsalou, 2008). When learners perform actions associated with language, movement becomes integrated into memory formation. Similarly, Asher's (1969) Total Physical Response approach emphasizes the role of physical actions in language acquisition. Gestures can therefore function as retrieval cues that facilitate vocabulary recall and language production.

2.4 Memory Systems and Retrieval Practice. Language learning involves both declarative memory, which stores explicit knowledge such as vocabulary meanings and grammar rules, and procedural memory, which supports automatic language use (Squire, 2004). Research on retrieval practice demonstrates that actively recalling information strengthens long-term retention more effectively than passive review (Roediger & Karpicke, 2006). Multisensory activities encourage repeated retrieval and may therefore contribute to stronger memory formation.

2.5 Adult Language Learning and Self-Beliefs. Many adult learners believe that age negatively affects their ability to acquire a new language. However, research on mindset and learning demonstrates that beliefs about one's abilities influence persistence and achievement (Dweck, 2006). Neuroscientific evidence further shows that learning remains possible throughout adulthood due to ongoing neuroplasticity. Effective instruction should therefore focus on methods that align with adult learners' cognitive strengths rather than emphasizing age-related limitations.

3. Methodology

This study employed a qualitative classroom-based intervention design. The purpose was to investigate how a change from traditional memorization-based instruction toward multisensory embodied learning influenced adult learners' ability to recall irregular English verbs.

A qualitative approach was selected because the study focused on learners' experiences, classroom behavior, and observable changes in learning processes rather than statistical measurement alone. Classroom

observations were used to examine how learners interacted with the instructional method and how they developed new strategies for retrieving linguistic information.

The participants were 20 adult English learners aged between 30 and 50 years old. The learners were studying English as a foreign language and attended regular language classes.

Before the intervention, participants reported difficulties memorizing irregular English verbs. Several learners expressed the belief that their difficulties were caused by age-related memory problems and that younger learners had natural advantages in language acquisition.

During the initial instructional stage, irregular verbs were introduced through commonly used language teaching techniques: translation into learners' first language; grammatical explanation; written examples; audiovisual materials; song-based repetition activities.

Although learners were able to recognize many verbs during controlled activities, they experienced difficulty recalling the three forms independently during speaking tasks. For example: go – went – gone; take – took – taken; write – wrote – written

The learners demonstrated awareness of the forms but lacked automatic retrieval during communication.

Following the difficulties observed during the initial instructional stage, the teaching approach was redesigned according to principles of multisensory integration and embodied learning. Instead of presenting irregular verbs primarily as written and translated forms, each verb was connected with a meaningful physical action or gesture.

The intervention included three main components:

Gesture-Based Representation: Each irregular verb was associated with a specific movement representing its meaning. Learners performed the gesture while producing all three verb forms orally. For example: go – went – gone → walking movement; write – wrote – written → writing gesture; take – took – taken → taking an object movement. The purpose of the gestures was not to replace linguistic knowledge but to create additional cognitive connections between the verbal form and embodied experience. This procedure reflects the principles of embodied cognition, which suggest that cognitive representations are partly grounded in sensory and motor experiences (Barsalou, 2008; Glenberg, 2010).

Repeated Retrieval Through Drilling: Learners participated in repeated oral drilling activities in which they produced verb forms while performing the associated movements. Unlike mechanical repetition, this activity required learners to coordinate: pronunciation, memory retrieval, physical action, semantic understanding. Retrieval practice research demonstrates that actively reconstructing information strengthens long-term memory more effectively than passive exposure or repeated reading (Roediger & Karpicke, 2006).

Meaning-Based Recall Activities:

After practicing the gestures, learners were asked to recall irregular verbs during communicative activities. The goal was to determine whether physical associations could support spontaneous language production.

The teacher observed whether learners: remembered verb forms independently; used gestures as retrieval support; demonstrated increased confidence during recall.

4. Results

The classroom intervention produced several important findings related to adult language learning and memory retrieval. After the introduction of gesture-based learning activities, learners showed noticeable improvement in recalling irregular verb forms and were able to produce the three forms of previously challenging verbs with greater accuracy, particularly during oral tasks without written support. This improvement suggests that successful learning depends not only on exposure to information but also on the ways information is encoded and retrieved (Paivio, 1986; Mayer, 2009).

A particularly significant observation was that learners began using gestures spontaneously when they struggled to remember a verb. Many unconsciously performed the associated movement before producing the correct form and later reported that the gesture helped trigger recall. This indicates that physical actions became integrated into memory representations and served as effective retrieval cues, supporting theories of embodied cognition, which emphasize the connection between cognitive processes and sensorimotor experiences (Barsalou, 2008).

The intervention also influenced learners' perceptions of their own abilities. Prior to the study, several participants attributed their difficulties to age or poor memory. Following their success with the multisensory approach, many reconsidered these beliefs and recognized that the

challenge was not an inability to learn but a mismatch between traditional teaching methods and their cognitive learning processes. This finding aligns with growth mindset research, which highlights the role of beliefs in shaping motivation, persistence, and learning outcomes (Dweck, 2006).

5. Discussion

The findings show that adult learners remembered irregular verbs more effectively when gestures and movement were added to translation and repetition. Activating sensory and motor pathways improved recall and suggests that language learning depends on the interaction of perception, action, memory, and emotion rather than verbal memorization alone. This supports multisensory integration theory and dual coding theory, which propose that information connected through both verbal and non-verbal systems is easier to retrieve (Shams & Seitz, 2008; Paivio, 1986).

An important result was that learners began using gestures spontaneously when they forgot a verb. The movements became personal retrieval cues, indicating that the body had become part of the remembering process. This finding is consistent with embodied cognition theory and Total Physical Response principles, which emphasize that physical experience can strengthen language understanding and memory (Barsalou, 2008; Asher, 1969).

Another key implication concerns adult learners' beliefs about age and learning ability. Many participants initially thought their difficulties were caused by poor memory or being too old to learn. After succeeding with the multisensory approach, they began to see that the problem was not a lack of ability but a mismatch between traditional teaching methods and their cognitive learning processes. Research on neuroplasticity supports this view by showing that adults remain capable of developing new skills throughout life (Kandel et al., 2013; Merzenich, 2013).

For language teachers, the study suggests that explanation and translation alone may not be enough for long-term retention. Instruction becomes more effective when language is connected to gestures, movement, visual support, meaningful contexts, and active retrieval. Teachers should also pay attention to learners' beliefs about their abilities, because successful experiences can increase confidence, motivation, and persistence. Overall, the teacher's role is not only to present language but also to create learning environments that align with how the human brain naturally learns and remembers.

6. Conclusion

This study explored how multisensory and embodied learning strategies influenced adult learners' ability to acquire irregular English verbs. A group of 20 learners aged 30–50 initially experienced difficulties despite receiving traditional instruction through translation, explanation, audiovisual materials, and repetition. However, after implementing gesture-based learning and physical drilling, learners demonstrated improved recall and developed spontaneous movement-based retrieval strategies.

The findings suggest that adult language learning difficulties should not automatically be interpreted as evidence of limited cognitive ability. Instead, they may reflect a mismatch between instructional methods and the ways in which learners encode, store, and retrieve information.

The human brain processes language through complex interactions among sensory systems, memory networks, motor experiences, and emotional engagement. By understanding these neuro-cognitive mechanisms, teachers can create more effective and inclusive learning environments for learners of different ages.

The central implication of this study is that successful language teaching requires moving beyond the question:

“Can this learner learn?”

toward a more productive question:

“How can learning be designed according to the way this learner’s brain processes information?”

Multisensory and embodied approaches provide one possible answer by transforming language from an abstract system of forms into a meaningful cognitive and experiential process.

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